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Climate in Nordic historical research – a research review and future perspectives

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ABSTRACT

This article assesses the development and current state of climate history research conducted in the five Nordic countries and Estonia. The possible societal impacts of past climatic changes already interested a handful of Nordic historians in the early twentieth century, but the lack of data on past climate fluctuations constrained scholarship in this field until recently. The data availability has increased fundamentally over the past decades due to the advances of palaeoclimatology. However, these advances have created new challenges, related to the ability to utilize data from the natural sciences in historical research as well as acquiring a basic knowledge on climatology. In many European countries, climate history has established itself as a strong academic subfield and consequently has created approaches as to how to overcome some main pitfalls, like climate determinism, related to the early works in the field. These epistemological advances are just beginning to gain a foothold in Nordic historical research. Thus, the article concludes with ten recommendations to improve future research in Nordic climate history.

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Introduction

Ongoing climate change, and related environmental changes, will affect – and have already affected – human societies. A profound understanding of climate–society interactions over long time scales provides an essential perspective to contemporary challenges.[1] Historical research can offer multiple examples of complex pathways and patterns between changes in climate and human societies. These examples, in turn, may help us to anticipate the plurality of the challenges of anthropogenic climate change in the imminent future. The academic subfield of climate history (or historical climatology) explores these past interactions. This field started to develop, in its more modern form, from the 1960s onwards, when works by Emmanuel Le Roy Ladurie and Hubert H. Lamb, among others, demonstrated what written sources might reveal about past climatic variations and how they might have influenced human well-being and livelihoods in the past.[2] Historians such as Christian Pfister and Astrid E.J. Ogilvie contributed

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significantly to the field by emphasizing the importance of analysing historical sources for climate reconstruction.[3]

Advances in palaeoclimatic research in the Nordic countries over the past few decades have produced quantitative climate reconstructions, which also provide potential material for historians to examine the role of climate in influencing the human past. Furthermore, due to their northern location and dependency on climate-sensitive crop cultivation in historical times, the Nordic countries provide a relevant study location for climate history research. However, interest in this research field has been relatively modest. Encyclopaedias and handbooks on the history of the Nordic countries barely include environmental or climatic aspects – and even fewer discussions about the possible influence of climate variability on human history. An exception is the latest encyclopaedia of Swedish history, to which Fredrik Charpentier Ljungqvist contributed short articles on climate history.[4] The Danish, Norwegian, Swedish, and Finnish multi-volume handbooks on agricultural histories address rather moderately the possible impacts of climate variability and change on crop yields.[5] Despite the comparably good documentary source material covering the past ca 500 years, new high-quality palaeoclimate data from natural archives, and the promising environmental context, climate history has remained a comparatively marginal research area in the Nordic countries in the past two decades. During this time the field has experienced a large expansion and has drawn considerable interest in most of the rest of Europe.[6] The marginal state of Nordic climate history research is evident in the recent handbook in the field, *The Palgrave Handbook of Climate History* (2018), in which the Nordic countries and Estonia are treated very briefly. Hitherto, from the Nordic countries, only Norwegian research on climate history has been summarized in a state-of-the-art review. This publication also includes, to a limited extent, an overview of the research in other Nordic countries.[7]

In the present review, we assess studies of relevance for climate history, from the first pioneering efforts in the early decades of the twentieth century to the most recent works, for all five Nordic countries, as well as Estonia to some degree. We place particular emphasis on studies written in Danish, Estonian, Finnish, Icelandic, Norwegian, and Swedish, rather than on works in English, as they are arguably less accessible for the international research community. Our hope is that this review will act both as an orientation to the state of research in the Nordic countries and serve as an overview for scholars elsewhere to allow them to better include results from the Nordic countries in a larger transnational context. We include studies which (1) are fully or partly conducted by historians and/or (2) rely entirely or mainly on documentary sources. This limits the temporal extent of this literature review to the period back to the thirteenth century. Consequently, the increasing number of high-quality archaeological, palaeoecological, and geographical studies exploring older times are not assessed here. The rationale for this limitation is lack of space, despite our full acknowledgement that these studies can be highly relevant for the understanding of past climate–human links. We concentrate on research exploring the medieval and early modern periods, yet we include some studies focusing on the nineteenth and early twentieth centuries as well. We refrained from addressing nineteenth to twenty-first century climate–society interactions in the Nordic countries in more detail because of the very different nature of these relationships with increasing agrarian modernization, industrialization, urbanization, and globalization.

Nevertheless, these more recent linkages are very important matters and would, no doubt, deserve a review article of their own.

What is climate history?

Climate history[8] is traditionally considered to have three main objectives: (1) reconstructing past climate variability, (2) studying climate–human relationships, and (3) exploring discourses and written or pictorial representations of climate and weather (Figure 1). As the third objective has barely been studied for the Nordic countries, this review focuses on the first two objectives. The first objective covers the reconstruction of past climate and weather variability from written sources as well as the study of occurrence of extreme events and climate-related natural disasters. The second objective, the study of climate–human relationships, includes both sides of this relationship: the agency of climate in human history and the agency of humans in adapting to changing climate and coping with extreme weather events. In particular, the dynamics of societal and economic vulnerability to climate variability are at the centre of the investigation.[9]

One of the major problems related to climate history concerns climate determinism and reductionism. The concept of climate determinism originates from the early twentieth century, when certain scholars aimed to justify, for example, colonialism or theories on race by climatic circumstances.[10] Consequently, considering climate as a 'historical determinant' has received strong objections from historians and especially so since the Second World War.[11] Recently, the field has been criticized for practicing climate 'reductionism' – removing climatic consequences from their social and environmental contexts.[12] However, the majority of more recent studies presenting such an approach

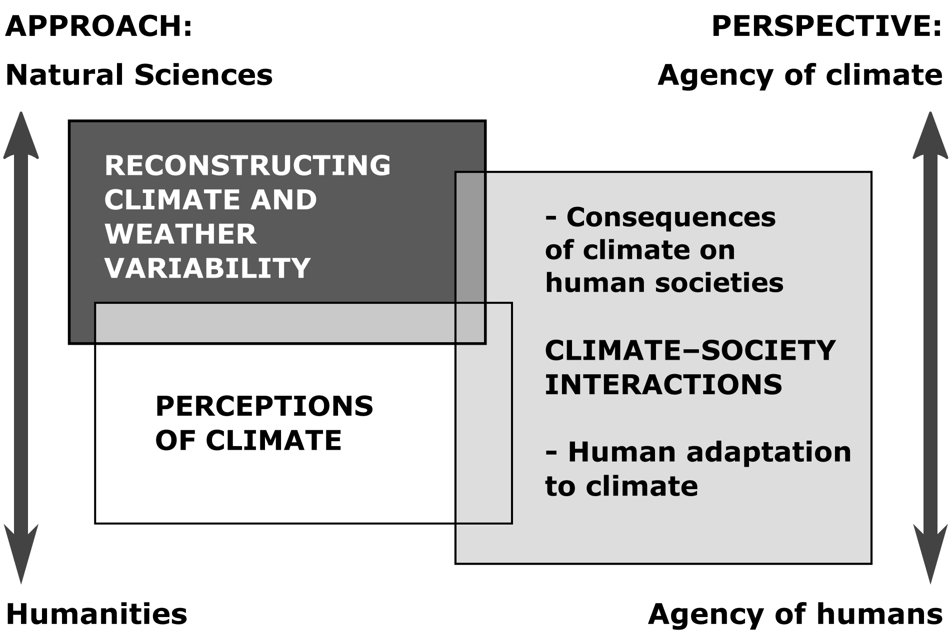

Figure 1. The three main objectives of climate history and related dominant approaches and perspectives on agency.

are not conducted by academic historians but either by physical scientists or by non-academic writers of popular history.[13] Commonly, these studies explore the links between climate and human activities by seeking correlations among large datasets, erroneously equating correlation with causation, or focus solely on single dramatic events and ignore the available evidence concerning the complexity of human responses to climate.[14] Historians specializing in climate history are well aware of such pitfalls of climate determinism and reductionism and have developed approaches to avoid monocausal interpretations. Some of these approaches are presented later in this article in a Nordic context.

Climate history is an interdisciplinary field. Depending on the objectives of a particular study, conducting research might require knowledge of physical, social, and/or cultural sciences. Information from palaeoclimate reconstructions helps historians to date and quantify past climatic variability and change. This helps us to place studied historical events and phenomena in a climatic context. Yet, the climatic periodization do not always match with a historical one and the used terminology can be misleading. For example, the so-called Medieval Warm Period (MWP) ended in Finland before the historical Middle Ages in this region had begun. Furthermore, these reconstructions reveal that although the so-called Little Ice Age (LIA) was, on average, colder than, for example the eleventh or twentieth centuries, this period also included multi-decadal periods of moderately warm conditions. Above all, the LIA was not a glacial period in geophysical sense. Nevertheless, most of the Nordic reconstructions indicate that the coldest phase of the LIA was between the late sixteenth and the end of seventeenth century (Figure 2).

Documentary-based climate reconstruction

Basics of historical climate reconstruction

The measuring of different weather parameters, like temperature, precipitation, and air pressure, with meteorological instruments began in the Nordic countries during the first half of the eighteenth century. Collection of these early observations from archival material, and analysing and homogenizing them, constitutes its own subfield of climate history: *historical meteorology*.[15] Another subfield focuses on reconstructing past climate variability from written descriptive observations and proxy records. Proxies are indirect climate data, materials which have been influenced by the climate of the time when they were written or laid down, formed, or grown. These proxies can be found either in the 'archives of nature', like in tree rings or sediment and ice layers, or in the 'archives of societies', which are the written sources.[16]

Chronicles, annals, diaries, and newspapers, among other sources, can contain written descriptions of climate and weather. These include extreme and unseasonal events records, like floods and frosts, as well as descriptions of day-to-day weather. These *qualitative materials* can be commonly transformed into climate reconstructions with the so-called index method. This method gives the descriptions an ordinal scale value, e.g. from – 3, indicating extremely cold, to +3 indicating extremely warm.[17] A recent example of an application of this method is a study by Dag Retsö and Lotta Leijonhufvud (2021), who reconstructed drought in Sweden back into the Middle Ages.[18] Besides the index approach, a calibration–verification procedure is another method used in historical

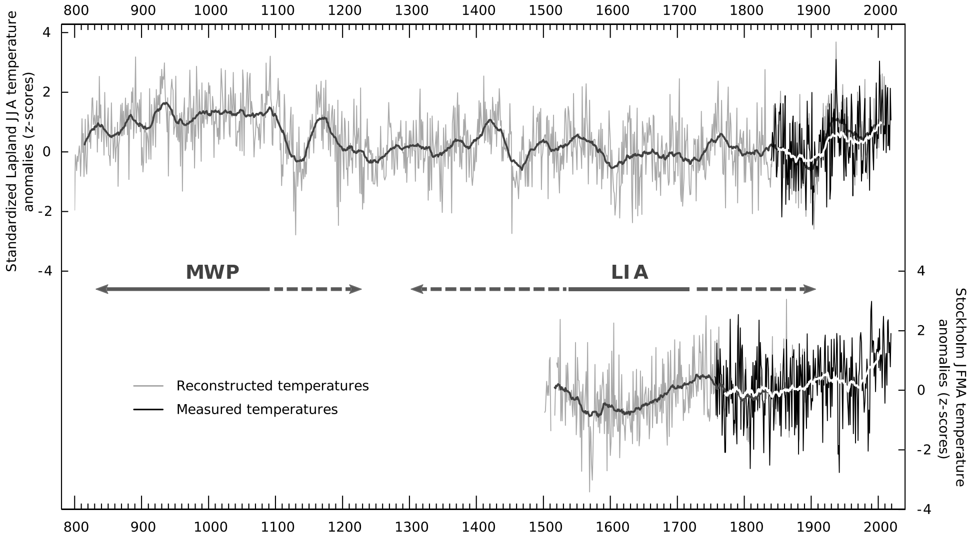

Figure 2. Reconstructed (grey lines) and measured (black lines) June–August northern Fennoscandia and January–April Stockholm mean temperature anomalies, with 31-year moving average (black and white lines, respectively). The temperature data have been standardized over overlapping 1841–1890 period. The lines indicate approximate timing of the 'Medieval Warm Period' (MWP) and the 'Little Ice Age' (LIA), with dashed lines indicating the debated extent of the periods. *Source*: Matskovsky and Helama, 'Testing long-term summer'; Leijonhufvud et al., 'Five centuries of Stockholm'; Berkeley Earth; Moberg, A. 'Stockholm historical weather observations'.The measurement-based temperature data (Berkeley Earth) is averaged over 63–69°N, 18–24°E.

climate reconstructions. This latter method commonly employs *quantitative materials*. Early scholars, private individuals, and state authorities kept records of different events, like the onset dates of harvest or when the harbours were free from ice. As these so-called phenological dates are commonly sensitive to climate variations, it allows them to be transformed into meteorological units, like degrees Celsius. This method requires an overlapping period of meteorological measurement data, preferably divided into two sub-periods, one period that is used to calculate the reconstruction model (calibration) and another that is used as an independent check of the model (verification).[19] After the model is validated with this procedure, it can be applied over the whole historical time-series. For example, Per Øyvind Nordli employed this method when reconstructing central Norway spring–summer temperatures from the first day of grain harvest, compiled from farmers' diaries.[20] The index method identifies primarily year-to-year climate variability, whereas the calibration–verification method can also detect slow and gradual, so-called low-frequency, changes.

Historiography of Nordic climate reconstructions

Nordic research has a long tradition of employing ice-phenological observations in historical climatology. Various written sources offer information on the freezing and ice break-up dates of harbours, rivers, and lakes. Much early work consisted of source compilations of these events, conducted by researchers from the physical sciences. Danish meteorologist Christian J.H. Speerschneider presented in 1915 a catalogue of winter ice conditions around Denmark and in the Baltic Sea back into medieval times, concluding that the average winter severity had not changed much over time.[21] Similarly, Icelandic geologist and geographer Þorvaldur Thoroddsen produced in 1916 a compilation of many types of documentary sources concerning weather and sea ice variability in Iceland and concluded that the climate has not changed much since early medieval times.[22] This interpretation, however, was hotly contested.[23] A number of early Nordic compilations were closely analysed by W.T. Bell and Astrid E.J. Ogilvie in 1978, who were able to show that they contained considerable amount unreliable material.[24] The work of Thoroddsen is better than many other similar compilations, but still contains much that is erroneous or at least questionable. Nevertheless, for its time it must be deemed an outstanding pioneering work.[25] Later Thoroddsen's compilation was the sole source for two other works. One of these is a book by Lauge Koch entitled *The East Greenland Ice* (1945). This includes a reconstruction of sea-ice conditions back to the ninth century (although with many gaps prior to the seventeenth century) from documentary data. From this Koch concluded that a warm period occurred ca 930–1030, a somewhat colder climate ca 1200–1400 and cold conditions ca 1600–1900.[26] These conclusions cannot be deemed reliable as they were based on the mix of reliable and unreliable data to be found in Thoroddsen's work and did not have the advantage of many data that were unknown to Thoroddsen.[27] In the late 1690s Icelandic climatologist and meteorologist Páll Bergþórsson wrote an article outlining a sea-ice and temperature reconstruction from c. 870 CE (the traditional date for the first settlement of Iceland) that was also based solely on information taken from Thoroddsen.[28] Thus, it unfortunately also contains much unreliable information. What was novel concerning Bergþórsson's reconstruction, however, was his conclusion that there is a strong correlation between temperature and the presence of sea ice which has also been confirmed by later researchers.[29]

Considerable progress in Nordic research on ice-observations and historical documentary based climate reconstructions were made in the late twentieth and early twenty-first centuries. Having unravelled the textual relationships of the works described above, and added many novel sources unknown to them, Astrid E.J. Ogilvie presented a much more source-critical and updated documentary-based sea-ice reconstructions for Iceland, covering 1500–1800, along with winter/spring thermal indices for Iceland at decadal resolution.[30] She also published discontinuous documentary-based climate estimates for Iceland, extending back to the Viking Age.[31] Anders Tarand gathered spring ice break-up dates from the port of Tallinn back to the fourteenth century in 1992, although the time-series are continuous only from 1600 onwards.[32] A year later, Juha Kajander compiled an ice break-up date series from the Torne river back to 1693.[33] Both publications demonstrated the unique climatic signal embedded within these historical time-series and how, for example, the colder conditions of the Little Ice Age are evident in later ice break-up dates during the early modern period. Other long Nordic ice break-up series include Lake Mälaren in Sweden since 1712 and the Finnish river Aura since 1749. Both series noted later eighteenth and nineteenth century break-up dates compared to the twentieth century dates.[34]

Other reconstructions have attempted, following the pioneering efforts of Speerschneider, to reconstruct the sea-ice extent rather than its duration. Gerhard

Koslowski and Rüdiger Glaser reconstructed the areal ice volume over the period 1701–1993 in the Western Baltic Sea from various documentary sources, finding, in opposition to Speerschneider, considerable multi-decadal variability in winter ice extent. They later extended the sea-ice reconstruction back to 1501, finding even larger multi-decadal variability in areal ice volume.[35]

Since the compilation of these long ice break-up and ice extent series, these data have been used in several quantitative climate reconstructions employing calibration–verification methods. Tarand and Nordli reconstructed the Tallinn winter temperature from the ice break-up dates, and Svetlana Jevrejeva reconstructed the severity of winter seasons in the northern Baltic Sea from documentary data for the ice break-up date at the port of Riga since 1529.[36] Both studies found considerable variability across all time-scales in addition to a long-term trend towards milder winters. Dag Retsö assessed the climatological information on winter weather during the early sixteenth century in Swedish correspondence letters, finding a mixture of winter severity.[37] Later, Dag Retsö and Johan Söderberg reconstructed winter severity in medieval Sweden from various types of documentary evidence, including ice break-up dates.[38]

Besides direct observations of freezing and break-up, various administrative accounts, especially those documenting different harbour activities, contain indirect information on these dates. Leijonhufvud and others employed these extensive materials for their Stockholm January–April temperature reconstruction extending back to 1502 (Figure 2). The reconstruction identified that the coldest conditions occurred during the late sixteenth and early seventeenth centuries and in the early nineteenth century.[39] Beside ice-phenological observations, Nordic researchers started to implement harvest-related material in historical climate reconstructions in the 2000s. Tarand and Nordli combined the beginning of rye harvest dates with the river Palmse ice break-up dates in Estonia to reconstruct April–July temperature variability.[40] Jari Holopainen and others extended the possible sources of phenological proxy data in Nordic reconstructions further by including observations of the flowering dates of various herbs, shrubs and trees in their southwest Finland spring temperature reconstruction.[41] Nordli reconstructed spring and summer temperature variability in Trøndelag of Norway back to 1701, and for Vestlandet back to 1734, from peasant diaries. When comparing these Norwegian reconstructions with early instrumental temperature measurement series, he found very close correlations in the eighteenth and nineteenth centuries between the temperature and time of both the sowing and harvest.[42]

Climate–human interactions: key themes and debates

Norwegian historiography

Within the context of the Nordic countries, Norwegian historians can be considered as the pioneers in the field of climate history. As early as 1913, Norwegian historian Edvard Bull published a short article 'Klima og historie' ['Climate and history'], where he argued that the consideration of past climate variability offered an additional dimension to a materialistic understanding of history. Bull identified several research problems in the study of climate–history relationships, with emphasis on medieval agrarian history in Norway.[43] He also anticipated the potential offered by dendroclimatology – a science still in its very infancy – as a key source of annual past climate information to utilize in historical scholarship. In the same year Otto Pettersson triggered a debate that marked Norwegian climate history research for a long time by proposing that the climate in north-western Europe became more irregular during the fourteenth century, rather than colder and wetter, and increasingly so towards the north. He argued that Norway and Iceland became more severely affected than Denmark and Sweden due to a larger climate sensitivity owing to the more marginal agricultural conditions in the former countries. This, in Pettersson's opinion, could explain why Norway and Iceland were affected more strongly and for a longer time by farm desertion and population decline during the fourteenth and fifteenth centuries, today commonly referred to as the Late Medieval Crisis.[44]

The scholarly debate during the 1920s, which nevertheless did not result in actual empirical studies on the topic, determined the viewpoints and lines of argument concerning the role played by climate for the Late Medieval Crisis in Norway, which have persisted into the twenty-first century. Both natural scientists and historians were active in this debate. Norwegian geologist and geographer Werner Werenskiold acknowledged the existence of late medieval climatic cooling but expressed scepticism that it played a major role in the crisis.[45] Conversely, meteorologist Anton Røstad found it plausible that the fourteenth century crisis was initiated by cooling, which caused poorer grain yields and decreased pasture productivity, and which was later amplified with the arrival of the Black Death.[46] Agrarian historian Sigvald Hasund questioned the evidence for a causal relationship between cooling and the crisis, despite acknowledging the presence of climate-related crisis symptoms elsewhere in Europe at the time. He expressed a view, which was firmly entrenched in later scholarship, that the demographic and economic crisis in Norway was entirely a result of the Black Death. Hasund's main argument was that the temperature decrease was very small and, as such, incapable of explaining the magnitude of the crisis.[47] Røstad and Bull instead argued that the Black Death alone hardly could suffice to explain the extraordinary magnitude and the long duration of the crisis in Norway, finding it very plausible that climatic cooling was a *contributing factor*, considering Norway's northern marginal location for agriculture.[48] However, the lack of palaeoclimate data at this time precluded testing these arguments with empirical studies. In this regard, historian Oscar Albert Johansen explicitly argued against invoking climate as an explanatory factor on the grounds that available climate data from medieval times were inadequate. Future progress within the natural sciences might change this, he recognized, but until then historians had better to avoid invoking climatic change.[49]

To summarize the debate in Norway during the 1920s, three principal objections were raised against climate being a significant contributing factor to the Late Medieval Crisis. First of all, it was acknowledged that the lack of quantitative climate data hindered the critical investigation of the hypothesis at the time. Second, the late medieval cooling was nonetheless considered to be too marginal to play a significant role for agriculture and pastoral farming. Third was the hesitation to seek explanations for societal change beyond human agency. These views were further reinforced by Halvdan Koht, as well as by a number of further works by Sigvald Hasund, which emphasized the plague as the sole cause of the crisis.[50] Nevertheless, some later historians, such as Andreas Holmsen and Johan Schreiner, maintained that the role of climatic changes was one of the most pressing issues in Norwegian medieval history, and they advocated that advances within the natural sciences, especially in dendroclimatology, would allow for resolving the dispute at some point.

The possible role of climatic change for the Late Medieval Crisis in Norway was extensively revisited in the *Scandinavian Research Project on Deserted Farms and Villages*.[51] However, the results were as inconclusive as before, with a tendency to downplay the possible role of climatic change in favour of emphasizing the role of the Black Death and subsequent recurrent plague outbreaks. The lack of reliable palaeoclimate data at that time for Norway in particular, and Scandinavia in general, was again stressed. Jørn Sandnes and Andreas Salvesen concluded, when synthesizing the main project results for Norway, that no new findings had been made with regard to the possible role played by climate.[52]

In a more recent piece of Norwegian historical scholarship, Salvesen argued that climate could have been a *contributing* factor, especially acting as a catalyst, to societal change, whereas Kåre Lunden concluded that long-term climatic changes during the past millennium were too small to have had an influence on agriculture or pastoralism in most farm locations in Norway.[53] Audun Dybdahl concluded in several publications that climatic change was unlikely to have played any major role in demographic development or settlement structure over the long run, while at the same time recognizing that historians have *underestimated* the importance of adverse climate conditions for harvest failures, food shortages, famines, and high mortality epidemic events. Dybdahl emphasized the spatio-temporal variations in societal climate sensitivity. Furthermore, he stressed the role of clusters of consecutive years of adverse climate conditions for agriculture that contributed directly or indirectly to mortality peaks in pre-modern Norway.[54] Moreover, by employing climate sensitive tree-ring material, he found a good correspondence between narrow tree-ring growths and documentary reports of poor harvests and high mortality in epidemics – although his methods are more qualitative than quantitative in their nature.[55] Dybdahl concluded that consecutive late springs and/or wet and cold summers were the major challenge for agriculture in Norway, frequently resulting in widespread epidemics among an undernourished population.[56]

Icelandic historiography

An early twentieth century debate between Icelandic geologist and geographer Þorvaldur Thoroddsen and Norwegian historian Edvard Bull encapsulates some of the key aspects of contemporary debates on climate history: how reliable is the climatic information that written sources provide, what was the amplitude of past climatic changes, and were these changes of an amplitude big enough to influence human history?[57] Thoroddsen took frequent fodder failures and cattle losses mentioned in written sources as proof that the periods of Icelandic settlement and the early Middle Ages were not significantly warmer than the centuries thereafter.[58] Bull, in contrast, maintained that the medieval period must have been considerably warmer than later centuries because the sources mention grain cultivation being practised across the island until the fourteenth century.[59] Both scholars based their argumentation mainly on the saga literature. Today, however, we have much more detailed knowledge of past climate variability on Iceland from natural proxy data in combination with written sources. Climate history researchers in Iceland, being a small scholarly community, have utilized interdisciplinary approaches by integrating archaeological, natural, and documentary sources for much longer than the other Nordic countries.[60]

Although in popular media the colonization and end of crop cultivation in Iceland are commonly brought up as anecdotal evidence of medieval warmth and the cooling LIA, respectively, scholars have demonstrated that in reality the causality between climate conditions and Icelandic society was more complex.[61] Astrid E.J. Ogilvie, in particular, has been a leading scholar in Icelandic climate history research since the 1990s.[62] It has been demonstrated that the presence of sea ice close to the coasts of Iceland had an adverse effect on pasture productivity and hay yields, and that sea ice had a generally adverse effect on cod fisheries.[63] Lower ocean water temperatures, typically associated with more sea ice, around Iceland contributed to reducing cod fish stocks, thereby causing economic hardships. Furthermore, the presence of thick sea ice at times prevented Icelandic fishermen from reaching the cod banks off the coast.[64] The prevailing view has been that climate variability had a great effect on human livelihood in Iceland, with cold conditions inducing hardships, along with other environmental hazards like the severe erosion on the island, volcanic eruptions and earthquakes.[65] However, at least one scholar, economic historian Gísli Gunnarsson, has questioned both the amplitude and the importance of past climate variability, and has instead stressed socio-economic factors for hardships on Iceland.[66] However, his publications lacked any quantitative assessment of the possible climatic influences – or the lack of thereof – among the historical Icelandic population.

Danish historiography

The influence of climate and weather has been addressed only to a very small extent in Danish historical research. Gunnar Olsen provided an overview of climatology and its relevance for agricultural history in 1939, but offered no insights into the possible impact of climate variability on Danish history.[67] The first scholar to actually invoke climate as an explanatory factor in Danish history was Axel Steenberg in 1951, who argued that the Late Medieval Crisis in Denmark had already begun by ca 1300. He based his argument on pollen analysis and archaeological evidence of deserted farmsteads, which he linked to an increased wetness.[68] Nevertheless, this research was later largely overlooked and not followed up. A short article from 1978 by Svend Gissel notes the limited attention drawn to climate, and knowledge thereof, among medieval historians in Denmark.[69]

The first longer treatment of climate by a Danish historian, since that of Olsen in 1939, was a review article by Flemming Mikkelsen in 1983.[70] He maintained that the lack of interest in climate variability among historians was related to the erroneous presumption that the climate has been more or less stable for centuries – if not for millennia. Furthermore, he showed that climate had not fit into the theoretical and methodological frameworks of Danish historians. Finally, Mikkelsen argued that increasing interdisciplinary collaboration was necessary for research in climate history.

In more recent times, Nils Hybel has been perhaps the only Danish historian who has dealt more extensively with climate history. He first addressed climate in 1997 when he argued, on the basis of information from few documentary sources, that the weather-triggered Great Famine (1315–1322) presumably hit Denmark as it did elsewhere in north-western Europe.[71] Hybel subsequently explored the possible impacts of climate on medieval famines in Denmark and concluded that climatic factors likely had more severe societal consequences in the high than in the late medieval times. Furthermore, he claimed that the timing of the Medieval Warm Period varied spatially across Europe and was rather modest in comparison to the abrupt twentieth-century warming. Consequently, he proposed that the medieval warmth likely played a minor role in medieval history but argues instead that short-term climate extremes were more important triggers of past events.[72]

Swedish historiography

The Swedish ethnologist and agrarian historian Åke Campbell maintained that assessing the relationship between climate and agricultural production belonged to the natural sciences and not to the humanities or social sciences.[73] This remained, more or less, the prevailing view for a long time. However, economic historian Gustaf Utterström made an exception in 1954 in the Swedish scholarship, when he linked changing climatic conditions to harvest variations and demographic fluctuations in eighteenth-century Sweden. The next year, in 1955, Utterström published his internationally famous, and still frequently cited, article 'Climatic fluctuations and population problems in early modern history', which can be considered as a manifesto for invoking climate variability in historical research.[74] His key point was that the coldest decades, and especially the coldest years, appeared to correspond to most of the large-scale harvest failures. In particular, Utterström emphasized how cold springs and summers triggered agricultural crises, which were in turn capable of inflicting significant economic and demographic consequences. Furthermore, he suggested that a cold climate might have contributed to the crisis of the seventeenth century. Nevertheless, he simultaneously pointed out the importance of socio-political factors in explaining the past population fluctuations.[75] However, presumably because of the lack of palaeoclimate data during his time, Utterström never followed up his hypotheses with empirical studies. Overall, the inclusion of climatic aspects in late twentieth-century Swedish historical research is rather marginal. For example, Erik Husberg mentioned the possible role of colder, and also wetter, climate conditions in the decreasing production of wax during the last three decades of the sixteenth century.[76] In his agrarian history of Sweden, Janken Myrdal more generally consider the impact of climate change and variability.[77]

The late 1990s saw the re-emergence of climate in historical research, especially within the field of agrarian history. Lennart Andersson Palm found that the climatic signal in eighteenth- and nineteenth-century southwestern Swedish yield ratio data was mixed but, importantly, the farmers were shown to have adjusted the timing of agricultural work with changes in temperature and precipitation.[78] Sven Lilja investigated the associations between climate, harvest and demographic crises in the early modern Swedish Realm in three articles published between 2006 and 2012.[79] He concluded that unfavourable climatic conditions, causing poor harvests, were a recurrent problem in early modern Sweden. These problems, in turn, occasionally triggered mortality crises. Furthermore, Lilja anticipated that multi-annual periods of cold climate anomalies and related harvest losses could be considered one reason why the Swedish Realm had such difficulties in upholding its status as a great power.[80] However, these studies lacked statistical assessments of the degree to which climate variability actually explained harvest fluctuations.

The first large-scale quantitative climate historical assessment in Sweden was published by Rodney Edvinsson and co-authors in 2009, in which they assessed the influence of monthly and seasonal temperature and precipitation variability on the output and quality of grain harvest in 1724–1955. They found cold summers dictating harvest success only in the northern parts of Sweden, whereas winter–spring temperatures and summer precipitation variability were more decisive for grain yields in the main crop cultivation regions of present-day Sweden.[81]

Finnish and Estonian historiography

The Finnish studies on climate–human interactions have a strong focus on the links between weather, climate, and food crises during the early modern period. This connection has been widely recognized in Finnish agricultural history since the latter half of the nineteenth century.[82] The climatic conditions in Finland were understood as the main limiting factors for agriculture, but the weather events causing crop failures were considered as occurring haphazardly. The possible connection between the *frequency* of weather events causing the crop failures and *climatic* variability was not addressed until the 1970s. Instead, prior to that, climate was essentially seen as rather stable throughout time.

Eino Jutikkala was in 1976 the first Finnish historian to criticize his predecessors for ignoring long-term climate fluctuations. Furthermore, he highlighted the importance of historians employing climate data from the natural sciences to better understand past climate fluctuations, such as the 'Little Ice Age' (LIA). However, although he recognized the link between cooler temperatures and declining harvest output in the late medieval and early modern times in the Nordic countries, he emphasized that past population fluctuations were not direct consequences of climate-driven harvest failures, but the mortality crises were always mediated by the spread of hunger-related infectious diseases.[83] These views were recurrent also in his later publications and have strongly dictated the perceptions of the Finnish scholarship on the role of climate in human history.[84]

Although Jutikkala brought the question of climate into the Finnish discussion, the pioneering quantitative analyses within the field were done by Matleena Tornberg, who explored the possible impacts of the LIA on grain yields in early modern south-western Finland.[85] Also Susanne Lindgrén contributed to the early development of the field by examining, for example, the relationship between climate and warfare-related sea-ice crossings over the Baltic Sea and the weather conditions contributing to the 1695–1697 famine.[86] Other early works on Finnish climate history include articles by Roger Kvist, who explored the link between the cooling temperatures and the declining seal hunt in Ostrobothnia, and Jorma Keränen, who linked the LIA with the increased frequency of crop failures in the seventeenth and eighteenth centuries Finland.[87] Since then, the LIA has widely been connected to early modern Finnish famines, especially those in the seventeenth century and in 1867.[88] Timo Myllyntaus further developed this perception by arguing that the cooling climatic conditions, in addition to poor soils and primitive cultivation methods, handicapped early modern agricultural production, which explains the increasing frequency of the seventeenth- and eighteenth-century famines in Finland.[89] Most recently, Heli Huhtamaa and others have quantified the relationships between weather and crop yields in nineteenth-century Finland, studied long term-agricultural adaptation to changing climate, and further conceptualized understanding the role of the LIA within historical research in general.[90] Finnish crop yields were found to be sensitive especially to spring and summer temperature variability, which dictated the length, onset, and thermal conditions of the growing season, although the relationship weakened towards southernmost parts of the country.[91]

Even though the great majority of Finnish historians associate the LIA's colder climatic conditions and the related shortening of the growing season with the early modern famines, one contrary opinion exists. Economic historian Miikka Voutilainen argued in his monograph on famines that '*including the Little Ice Age in historical research is a kind of a fifth-wheel, irrelevant part of the cause–effect relationship, [just] a rhetorical backstory*'.[92] However, Huhtamaa challenged this argument by reasoning that the mean temperatures, especially in Finland, were indisputably colder during the LIA than in the centuries before or after. The growing season began later and was colder and shorter than during warmer climatic phases. Consequently, the agricultural production was more vulnerable to disturbances, such as societal distress (like raids and hording of staple crops) or weather events (like summer frosts). Thus, she argued that the prevailing climatic conditions, such as the average conditions during the LIA, are not irrelevant. Instead, climate gives a context to the studied phenomena, as to years of food shortage in this case.[93]

Similarly to historians in Finland, Estonian historians have mainly focused on the links between climate, agriculture, and famines. Priit Raudkivi, in particular, has explored the climate- and weather-driven subsistence crises in Livonia and Estonia, from the 1310s famine to the nineteenth-century crises.[94] In his publications, Raudkivi specifically emphasizes the importance of studying socio-environmental vulnerability within the field of climate history. In their thorough book on Estonian climate, Tarand and others also included a rigorous weather catalogue spanning from the eleventh to the end of the nineteenth century. Although focusing mostly on past meteorological and climatological events collected from written sources, the catalogue also contains records of weather-related human affairs, such as occurrences of crop failures, famines, and disease epidemics.[95]

Besides the history of subsistence crises, Finnish and Estonian historians have barely addressed the agency of climate in their research. Instead, meteorologists, dendroclimatologists and geographers have been prominent in the field. For example, Reijo Solantie has published widely on the role of climate with respect to the settlement history, livelihoods and population in historical Finland and Jari Holopainen and others have explored the impacts of climate variability on grain yields and prices in early modern and nineteenth century Finland and Sweden.[96] Furthermore, Holopainen and others have proposed the possible impact of the LIA cooling climate as an explanation for why so many stone churches were left unfinished in late medieval Finland.[97] In recent years, Finnish historians and natural scientists have started to co-operate, and for example Huhtamaa and dendroclimatologist Samuli Helama have utilized tree-ring material to study long-term agricultural adaptation to climate.[98]

Inter-Nordic comparison

Nordic climate history research has two main emphases (1) reconstructing past climate variability from written sources and (2) investigating past climate–agriculture relationships and their societal implications. The former research is mainly conducted by physical scientists (with the exception of some Swedish-speaking historians), and the latter by mainly historians. At the moment, only a handful of Nordic and Estonian scholars conduct research on climate history.[99] Even fewer historians provide university-level teaching in the field. Because of the lack of teaching of climate history only a small number of master's and doctoral theses focusing on the topic have been written. Consequently, this hampers the emergence of a new generation of researchers in climate history and, in the long term, progress in the field.

The main debate within the early documentary-based reconstruction research was centred on whether the climate in the past had distinctive colder or warmer phases. Along with the re-emergence of historical climatology in the 1990s, new reconstructions showed colder climatic phases overlapping with the late medieval and early modern period in the Nordic countries, in agreement with the results from palaeoclimatological research utilizing tree-ring measurements and other natural proxy data.[100] On the other hand, these document-based reconstructions have not provided much evidence for the so-called Medieval Warm Period due to the scarcity of pre-fifteenth century documentary sources for the Nordic countries. Consequently, reconstructions derived from natural proxy data remain the only material for assessing climate variability throughout the Middle Ages and earlier periods in the Nordic countries.

Although agricultural production has been a connecting theme in Nordic historical research about climate–society interactions, Danish, Icelandic, and Norwegian research has primarily assessed the possible contribution of climatic cooling in connection with the Late Medieval Crisis and associated farm desertion, while Estonian, Finnish, and Swedish research has focused primarily on early modern famine crises along with quantitative assessments of the relationships between various weather/climate parameters and harvest yields. Overall, the spatial focus is commonly restricted by current national borders and inter-Nordic research on climate history is, surprisingly, extremely rare. Nordic cooperation might provide a more comprehensive and versatile understanding of the past, considering the inter-linked history of many Nordic countries and the fact that climatic regimes do not follow present-day national borders. Furthermore, the Nordic research has focused only on the causal linkages between climate, harvest failures, food shortages, and population crises. Questions considering whether climate variability has played a role in the outbreak of violent conflicts, in the development of societal institutions, or in migration fluctuations, for instance, are greatly absent in the research.[101]

The Nordic research on climate–society interactions has been hindered until the last couple of decades by (1) a lack of quantitative data on past climatic variability, (2) a presumption that climatic changes have been too small to play a role for agriculture, and (3) the belief that explanations for historical change should be sought in factors related to human agency alone. Since the 1990s, the increasing number of high-resolution climate reconstructions provide answers to the first challenge and helps in assessing the second. Consequently, recent historical research has been able to detect many Nordic famines and population crises coinciding with climatic anomalies, which has shed new light on the third challenge. However, research conducted over the past decades has had its own shortcomings.

Bridging history and climate sciences

Conducting climate history research requires at least basic understanding of (palaeo)-climatology. Climate reconstructions on annual-to-seasonal resolution are today adequately available for the Nordic countries, at least for winter severity and growing season temperatures and hydroclimatic conditions (like precipitation and droughts). However, this type of material can pose new challenges as historians can '*struggle with evaluating [these] highly technical scientific analyses and methods, sometimes failing to understand them at an elementary level*.'[102] In Nordic studies on climate history, this 'struggle' materializes, for example, by integrating unsuitable palaeoclimate time-series or presenting them in an improper way in the analysis. For instance, some of the studies reviewed above plot different climate-sensitive series without any scale besides an annual timeline.[103] Such a practice makes the climate data incomparable with any other studies and leaves the reader puzzled regarding whether the climate variations presented in the graphs are of a small or big amplitude. Furthermore, many studies have failed to clearly define what weather or climate variables and processes the data indicate. In the worst case, the reader does not even know if the graphs include raw measurement proxy data or if the time-series have already been transformed into climate estimates presenting, for example, variations in degrees Celsius or millimetres of precipitation.[104] Consequently, although the results might be interesting, their validity is easy to question. Another common shortcoming is the inclusion of irrelevant climate data considering the topic and geographical focus of a particular historical study. For example, Jutikkala used an ice-core-based temperature reconstruction from Greenland to demonstrate a link between temperature variability and crop failures in Finland.[105] However, employing Greenland ice-core time-series is questionable when studying short-term temperature variability in Finland as it has been demonstrated that in years when the temperatures in Greenland are considerably higher than normal, frequently the temperatures in northern Europe are lower, and vice versa.[106]

The practice of rigorous critical source assessment is the fundamental cornerstone of historical research. This criticism should be practiced also with (palaeo)climate data if used in historical research, yet only a few studies reviewed here assessed whether the climate data used were relevant, reliable, and valid for the studied area and questions. At least the spatial domain and temporal precision of the climate reconstructions used should be relevant for the object of study.[107] For example, studying annual yield responses to climate at a specific location with the help of hemispheric-scale climate data on decadal resolution makes little sense. As critically assessing the appropriateness of physical science data can be far beyond the expertise of a historian, an easy way to avoid using unsuitable climate data is co-operation with (palaeo)climatologists.

Climate, weather, and weather damages

Since the pioneering works of Le Roy Ladurie in the 1960s, most studies in climate history have agreed that the triggers of past human calamities were short-term climatic extremes and weather events, rather than long-term climatic regimes like the LIA.[108] Therefore, understanding the difference between climate and weather is extremely important in climate history research. Additionally, it is essential to remember that the triggering weather events, like frosts or heavy rains, may or may not be typical for the prevailing climate, as one would expect. If one is proposing a causality between the prevailing climate and occurrence of extreme weather events in the past, this relationship needs to be detected and attributed.

For example, Utterström proposed already in 1961 that due to the severe winters of the early modern period, the onset of the growing season was delayed and consequently the ripening of the crops was postponed to the period when the first autumn frosts commonly occur. A similar argument was made later by Jutikkala, who associated the cold winters with the typical conditions of the LIA.[109] Both Utterström and Jutikkala associated the cold winters with long-term climatic fluctuations – but treated the yield-damaging frosts as disassociated weather phenomena. Nevertheless, some Finnish historians have claimed that late summer night-frosts began to occur more frequently from the beginning of the seventeenth century because of the cooling climate.[110] However, this interpretation failed to make a distinction between frost *damage on yields* and the frost *phenomenon itself*. In many parts of the Nordic countries, the first night-frosts by the end of the summer are commonly radiation frosts. The occurrence of these night-frosts is dictated by daily micro-weather. Therefore, instead of large-scale climate fluctuations, the elevation, proximity of water bodies, soil type, and vegetation cover influence the date of the first frosts.[111] For example the known dates of night-frosts in Finland during the seventeenth and nineteenth centuries fell between late August and early September.[112] These dates, in fact, do not differ considerably from the first frost dates of the warmer mid-twentieth century.[113] Thus, there is no evidence that frosts occurred, on average, more frequently or earlier during the LIA. Nevertheless, we do know that frost damage on grain yields occurred more frequently during the LIA than during the following warmer period. However, one should further *attribute* the causality of this connection. In the case of crop failures and night-frost in the Nordic countries, the typical LIA climatic conditions explain the link. Average LIA growing seasons in the region (1) were colder, (2) started later, and/or (3) were shorter than during the warmer climatic phases. These conditions often delayed the ripening of the crops to a period when the first night-frosts commonly occurred (Figure 3).[114]

Nevertheless, the geography of the Nordic countries is versatile. Thus, the relationships between climate and agriculture also vary from region to region, as demonstrated in Finnish and Swedish research on eighteenth- to early twentieth-century meteorological and crop-yield data.[115] For example in Denmark, which is located further south and influenced by a marine climate, the relative shortening of the growing period due to cooler and/or wetter conditions of the LIA might not have caused any major frost-related problems during the late medieval and early modern periods.[116] Consequently, more research is needed on assessing the relationships between historical agricultural production and weather/climate on a regional or local scale across the Nordic countries. Due to numerous technical developments in agriculture over the past century, as well as because of changes in the genetic plant material, the climate sensitivity of medieval and early modern agriculture might have differed from today's. Thus, such assessments need to be undertaken with pre-industrial agricultural source material.[117]

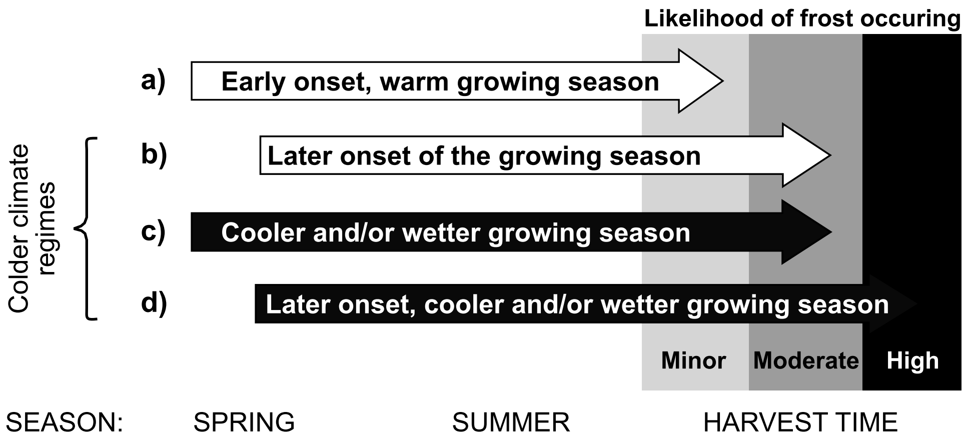

Figure 3. Simplified illustration of the link between the onset and thermal conditions of the growing season, delay of ripening of crops, and frost damage. (a) The growing season starts early, and warm conditions prevail (typical for the mid-twentieth century). (b) The onset of the growing season is delayed, but the growing season is warm. (c) The growing season starts early but the growing season remains cool and/or wet. (d) The onset of the growing season is delayed and the growing season remains cool and/or wet. In the last case the ripening of the crops is delayed to a period when the firsts night frosts commonly occur. The latter three conditions are commonly associated with the LIA in the Nordic countires.

Human agency in climate history

Although the Nordic research has proven that crop failures were more common during colder climatic phases in the past, this does not *automatically* mean that the crop failures culminated in subsistence crises. Nevertheless, Myllyntaus, for example, has interpreted records of crop failure inevitably meaning the presence of famine in early modern Finland.[118] This perception can be criticized, however, as the role of individuals, institutions, local environments, politics, and multiple other factors influence how climatic and weather events can materialize on a societal level.[119] For example, much of Europe was struggling with the weather-triggered Great Famine from 1315 onward. Raudkivi demonstrated that this was likely also the case in Livonia. In this region environmental factors, like the soil type, and socio-economic systems, like the dependency on the Hanseatic League relations, increased social vulnerability to food crises.[120] Consequently, the cold and rainy weather extremes in the mid-1310s triggered a chain of events, which escalated into the famine crisis. Yet, the situation was likely very different north and east of medieval Livonia. Huhtamaa has shown that, although the harvest was presumably badly damaged in 1314 in Finland and north-west Russia (Novgorod), here man-made factors increased the resilience for coping with a bad harvest. In Finland, multiple livelihood options, and in north-west Russia food system diversity and strength in trade and economy decreased the regions' vulnerability to subsistence crises. Thus, as the written sources from the region do not mention a severe famine taking place in the 1310s, Huhtamaa concluded that it is unlikely that the crisis would have extended beyond Livonia to the north-easternmost corner of Europe.[121]

In international climate history research, the concepts of *adaptation, vulnerability*, and *resilience* are important tools to understand the complex and dynamic relationships between climate variability and human societies.[122] Rather than the prevalence or amplitude of unfavourable weather and climatic conditions, the human capacity to cope and respond to these anomalies explains whether they may or may not influence the society.[123] Hybel has concluded that the 1315–1317 Great Famine must have also occurred in Denmark, although contemporary sources do not record the subsistence crisis in the country.[124] Indeed, several sources from the surrounding regions document that heavy rains in 1314–1316 destroyed the crops, and tree-ring-based reconstruction shows that these years were also extremely wet in Denmark.[125] However, as discussed above, the prevalence of unfavourable weather, or even documented crop failures, cannot be used as proof of a subsistence crisis. Thus, assessing the resilience and vulnerability of the 1310s Danish society might help to evaluate if the extremely wet conditions had the potential to trigger a hunger crisis in the country.

Climate history has been criticized for its determinism, explaining past societal events as resulting directly from weather or climatic conditions.[126] In this regard, we propose that by bringing human agency more profoundly into the analysis, for example, by assessing the vulnerability, resilience, and adaptation capacity of the studied societies, we can perhaps avoid some of these monocausal interpretations. Nevertheless, we wish to emphasize that the agency of climate and the agency of humans can be interlinked as, for example, climatic conditions, among other environmental and societal factors, can also influence human vulnerability, resilience, and adaptation capacity.

Outlook

Considering the published studies in the field of climate history for the five Nordic countries and Estonia from the early twentieth century to today, and the research gaps we have identified, we propose ten recommendations for the advancement of the field: (1) increase the number of collaboration among historians and (palaeo)climatologists to ensure that interpretations rest on a thorough and up-to-date knowledge of both past climate variability and human history; (2) increase collaboration across present-day national and language boundaries in research on both documentary-based climate reconstructions and climate–society interactions; (3) publish more of the Nordic climate history research in international peer-reviewed journals to achieve higher visibility and impact outside the Nordic countries and to contribute to the vibrant European research front; (4) practise a more rigorous source criticism when using climate data to understand and interpret past climate variations and the role they have played for human societies; (5) pay more attention to what distinguishes weather from climate, and attempt to attribute whether certain extreme weather events occur more frequently (or cause more damage) under specific climatic regimes (as during especially cold periods); (6) focus more strongly on the local/regional differences of agricultural responses to climate variability to better understand spatio-temporal differences; (7) give more attention to societal vulnerability and resilience to climate-induced adverse effects of food production; (8) pay more attention to the human responses (such as agricultural adaptation) to climate variability instead of a narrower focus on human consequences; (9) expand the research on climatic change–human history linkages to areas other than agricultural and famine history; and (10) provide more university education in climate history to increase awareness about the field and train future historians.

Notes

1. Adamson, Hannaford, and Rohland, "Re-thinking the Present," 197–98.
2. See, e.g. Le Roy Ladurie, *Histoire du climat depuis*; Lamb, *Climate: Present, Past and Future*; Lamb, *Climate, History and the Modern World*; Pfister, "Climate and Economy"; Pfister, *Das Klima der Schweiz*; and Pfister, "Fluctuations Climatiques." State-of-the-art overviews of more contemporary climate history may be found in, for example, Jones, "Historical Climatology"; Brázdil et al., "Historical Climatology in Europe"; Brázdil et al., "European Climate of the Past 500 Years"; Ogilvie, "Historical Climatology, Climatic Change"; Lockwood, "Frost Fairs, Sunspots"; Degroot, *The Frigid Golden Age*; and Degroot, "Towards a Rigorous Understanding."
3. See, e.g. Bell and Ogilvie, "Weather Compilations as a Source."
4. Ljungqvist, "Från is till värme," 213–20; Ljungqvist, "Den medeltida värmeperioden i Skandinavien"; Ljungqvist, "Det kaotiska klimatet"; Ljungqvist, "1600-talet – det kallaste århundradet"; Ljungqvist, "Klimat och väder i Sverige"; and Ljungqvist, "Klimat, missväxt och extremt väder." There are also some other examples, e.g. Ogilvie, "The Climate of Scandinavia in Medieval Times."
5. For Denmark: Bjørn and Dahlerup, *Det danske landbrugs historie*; for Norway: Lunden, *Norges landbrukshistorie*; for Sweden: Myrdal, *Det svenska jordbrukets historia*; Myrdal and Morell, *The Agrarian History of Sweden*; for Finland: Rasila et al., *Suomen maatalouden historia 1*. The work by Myrdal does consider climate variability and change to some extent, see, e.g. Myrdal, "Farming and feudalism 1000–1700," 102–3, 107–8, 117, as well as the works by Eino Jutikkala within Rasila et. al. (see Jutikkala, "Halla aina uhkana," "Katovuodet").
6. For a review, see Ljungqvist, Seim, and Huhtamaa, "Climate and Society in European History."
7. Pedersen, "Klimaets plass i norsk historie." In addition, a review article has recently been published in French about climate history relating to the early modern Swedish Realm, see Ljungqvist and Huhtamaa, "Histoire du climat."
8. The definition here follows the tradition of the humanities. In the physical sciences, climate history is understood as past climatic events, periods, and variations (without the examination of the possible societal impacts).
9. Pfister, White, and Mauelshagen, "General Introduction," 6–11.
10. Adamson, Hannaford, and Rohland, "Re-thinking the Present," 197–8.
11. Ibid.
12. Hulme, "Reducing the Future to Climate," 3–4.
13. For one Nordic example, see Rosenlund, *Väder som förändrade världen*.
14. Ljungqvist, Seim, and Huhtamaa, "Climate and Society in European History"; and van Bavel et al., "Climate and Society in Long-term Perspective."
15. We have, however, excluded the majority of those studies in historical meteorology from this review as they have been conducted mostly by non-historians. For further information about historical meteorology, Brönnimann et al., "Unlocking Pre-1850 Instrumental Meteorological Records" provides a good summary on the state-of the art. For Nordic examples, see Jónsson, "Early Instrumental Meteorological Observations in Iceland"; and Moberg et al., "Daily Air Temperature and Pressure Series."
16. Brönnimann, Pfister, and White, "Archives of Nature and Archives of Societies," 27.
17. Pfister, Camenisch, and Dobrovolný, "Analysis and Interpretation," 117.
18. Retsö and Leijonhufvud, "Documentary Evidence of Droughts."
19. Brázdil et al., "Historical Climatology in Europe," 380–2.

20. Nordli, "Spring and Summer Temperatures"; Nordli, Lundstad, and Ogilvie, "A Late-Winter to Early-Spring Temperature"; and Nordli, "Norwegian Farmers' Diaries."
21. Speerschneider, *Om isforholdene*.
22. Thoroddsen, *Árferði á Íslandi*.
23. Bull, "Islands klima i oldtiden."
24. Bell and Ogilvie, "Weather Compilations as a Source."
25. See, in particular, Ogilvie, *Climate and Society in Iceland*; and Ogilvie, "Historical Climatology, Climatic Change."
26. Koch, *The East Greenland Ice*.
27. See discussion of his conclusions in Ogilvie, "Local Knowledge and Travellers' Tales"; and Ogilvie and Jónsson, "'Little Ice Age' Research."
28. Bergþórsson, "Kuldaskeið um 1300?"; and Bergþórsson, "An Estimate of Drift Ice." Bergþórsson's work was based entirely on Thoroddsen's compilation. For the dangers of using such compilations, see Bell and Ogilvie, "Weather Compilations as a Source."
29. The source relationships between these three authors were first noted by Vilmundarson, "Evaluation of Historical Sources" and explained in detail by Ogilvie, *Climate and Society in Iceland*. The strong relationship between temperature and sea ice has been confirmed by, for example, Ogilvie and Jónsson, "'Little Ice Age' Research."
30. Ogilvie, *Climate and Society in Iceland*; Ogilvie, "The Past Climate and Sea-Ice"; Ogilvie, "The Climate of Iceland, 1701–1784"; and Ogilvie, "Documentary Evidence for Changes." In addition, these publications encompassed many sources not used by Thoroddsen.
31. Ogilvie, "Climatic Changes in Iceland."
32. Tarand, "Ice Cover in the Baltic."
33. Kajander, "Methodological Aspects on River Cryophenology."
34. Eklund, "Long Observation Series"; and Norrgård and Helama, "Historical Trends."
35. Koslowski and Glaser, "Reconstruction of the Ice"; and Koslowski and Glaser, "Variations in Reconstructed Ice."
36. Tarand and Nordli, "The Tallinn Temperature Series"; and Jevrejeva, "Severity of Winter Seasons."
37. Retsö, "A Contribution to the History."
38. Retsö and Söderberg, "Winter Severity."
39. Leijonhufvud et al., "Documentary Data as Proxy"; and Leijonhufvud et al., "Five Centuries of Stockholm."
40. Tarand and Nordli, "The Tallinn Temperature Series."
41. Holopainen, Helama, and Timonen, "Plant Phenological Data"; and Holopainen et al., "A Multiproxy Reconstruction."
42. Nordli, *Spring and Summer Temperatures*.
43. Bull, "Climate and History." It should be noted, however, that Bull was clearly inspired by, and refers to, the studies of 'climate pulses' and large-scale human history proposed by the American geographer Ellsworth Huntington – later infamous for his climate determinism as well as climate–race theories (see, e.g. Huntington, *Civilization and Climate*).
44. Pettersson, *Klimatförändringar i historisk och förhistorisk tid*.
45. Werenskiold, "Klimavekslinger som historisk faktor."
46. Røstad, "Verumskifte fyre nedgangstida i Noreg"; and Røstad "Var det auking i luftstrøyminga?"
47. Hasund, "Var det eit klimatumskifte?"; and Hasund, "Grønland og klimat-teorien." Hasund stated that a few years of very adverse climate conditions, resulting in harvest failures and even outright famines, are unlikely to have affected the long-term demographic development. He used eighteenth-century cases as his example, highlighting the disastrous years 1740–1742 and 1771–1773, and pointed to the fact that despite considerable famine mortality during those years, the eighteenth century experienced a vast population increase and settlement expansion in Norway in the longer run.

48. Røstad, "Var det auking i luftstrøyminga?"; and Bull, "Klimaskifte og nedgang i Noreg i seinmillomalderen."
49. Johnsen, *Norgesveldets undergang*.
50. Koht, "Edv. Bull"; and Hasund, *Det norske folks liv og historie gjennem tidene*.
51. Gissel, *Desertion and land colonization*.
52. Sandnes and Salvesen, *Ødegårdstid i Norge*, 167; and Salvesen, *Jord i Jemtland*, 36, 40–2, 95–7, 173.
53. Salvesen, "The Climate as a Factor," 232; and Lunden, *Norges landbrukshistorie II*, 16, 32, 35–40, 51, 151–9.
54. Dybdahl, "Klima og demografiske kriser." A shorter, essentially similar article in English has been published by Dybdahl, "Climate and Demographic Crises in Norway." See also Dybdahl, "Om uår og ødegårder i Kongespeilet."
55. By studying the sparse documentary indications for pre-Black Death farm desertion, Dybdahl assigned adverse climate conditions a considerable role in the explanation of the settlement development during the thirteenth and fourteenth centuries. Dybdahl, "Klima og demografiske kriser."
56. Dybdahl, "Sult eller sykdom?" 18–22; and Dybdahl, "Klimatiske sjokk," 64–74. See, in addition, Dybdahl, *Klima, uår og kriser*.
57. Thoroddsen, "Islands klima i oldtiden"; Thoroddsen, *Árferði á Íslandi í þúsund ár*; and Bull, *Islands klima i oldtiden*. The early Icelandic debate, with a comparison between the perspective of the various scholars, is further discussed in Ogilvie and Jónsson, "'Little Ice Age' Research," 21–5.
58. Thoroddsen, "Islands klima i oldtiden," 207–9.
59. Bull, *Islands klima i oldtiden*, 2.
60. Several new projects of an interdisciplinary nature, related to Icelandic climate history, are now ongoing, including "Reflections of Change: The Natural World in Literary and Historical Sources from Iceland ca. AD 800 to 1800 (ICECHANGE)" (http://www.svs.is/en/projects/icechange) and "Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies (ARCPATH)" (http://www.svs.is/en/projects/arcpath).
61. See, e.g. McGovern et al., "Landscapes of Settlement"; and Hartman et al., "Medieval Iceland."
62. See, e.g. Ogilvie, "Climatic Changes in Iceland"; Ogilvie, "Documentary Evidence for Changes"; Ogilvie, "Sea-ice Conditions"; Ogilvie and Jónsson, "'Little Ice Age' Research"; and Ogilvie, "Climate and Farming in Northern Iceland."
63. Friðriksson, "The Effects of Sea Ice"; Ogilvie, "Famines, Mortality, Livestock Deaths"; and Ogilvie and Jónsson, "'Little Ice Age' Research."
64. Ogilvie and Jónsdóttir, "Sea Ice, Climate, and Icelandic Fisheries."
65. Thórarinsson, *The Thousand Years Struggle*; Bergþórsson, "Hitafar og búsæld á Islandi"; and Ogilvie, *Climate and Society in Iceland*.
66. Gunnarson, *A Study of Causal Relations*; and Gunnarson, *Monopoly Trade and Economic Stagnation*.
67. Olsen, "Klima og Historie."
68. Steensberg, "Archæological Dating."
69. Gissel, "What Historians Know."
70. Mikkelsen, "Klimaændringer og samfund."
71. Hybel, "Klima, misvækst og hungersnød."
72. Hybel, "Klima og hungersnød," 265. A similar, though more extensive and updated treatment of the role of climate variability for medieval Denmark is provided in English in Hybel and Poulsen, *The Danish Resources*, 59–78.
73. Campbell, *Äldre svensk brödkultur*.
74. Utterström, "Some Population Problems"; and Utterström, "Climatic Fluctuations and Population Problems."
75. Utterström, "Population and Agriculture," 193–4.
76. Husberg, *Honung, vax och mjöd*.

77. Perhaps most explicitly in Myrdal, “Farming and feudalism 1000–1700,” 103: ‘The period from the 1570s to the 1640s saw a series of crop failures due to cold weather and heavy rainfall; thereafter the climate gradually changed so that drought became a greater problem in bad years. The most difficult years came at the start of the 1570s, around 1600, and at the end of the seventeenth century. In simple terms, the cold struck harder in the north of Sweden, the drought harder in the south.’
78. Palm, *Gud bevare utsädet!*, 142. Vestbö-Franzén, *Råg och rön*, 119–23, 145, 229–30, may also be mentioned that addresses rye cultivation in the province of Småland connection with climate conditions.
79. Lilja, “Klimatet, döden och makten”; Lilja, “Lokala klimatkriser”; and Lilja, “Klimat och skördar.”
80. Lilja, “Klimat och skördar.”
81. Edvinsson et al., “Väder, skördar och priser.”
82. See, e.g. Manninen, *Mietteitä katovuosista Suomessa*; Voipio, “Katovuosi 1601”; Johanson, *Finlands agrarpolitiska historia*; Melander and Melander, “Katovuosista Suomessa”; and Kovero, *Katovuosista Suomessa Ruotsin vallan aikana*.
83. Jutikkala, “Ilmaston muutosten,” 9–12.
84. See, e.g. Jutikkala, *Kuolemalla on aina syynsä*; Jutikkala, “Ilmaston muutokset ja historia”; and Jutikkala, “Halla aina uhkana.”
85. Tornberg, “Ilmaston- ja sadonvaihtelut”; and Tornberg, “Ilmastohistoria – nyt.”
86. Neuman and Lindgrén, “Great Historical Events”; Lindgrén and Neumann, “The Cold and Wet Year”; and Lindgrén and Neumann, “Crossings of Ice-Bound Sea.”
87. Kvist, “Klimathistoriska aspekter”; and Keränen, “Hyviä ja huonoja vuosia.”
88. See, e.g. Neuman and Lindgrén, “Great Historical Events”; Muroma, *Suurten kuolovuosien*, 8; Soikkanen, “‘Miekalla, nälällä ja rutolla’,” 14–8; Katajala, *Nälkäkapina*, 192–4; Lappalainen, *Jumalan vihan ruoska*, 23–5; and Huhtamaa and Helama, “Distant Impact.”
89. Myllyntaus, “Summer Frost.”
90. Huhtamaa et al., “Crop Yield Responses”; Huhtamaa, “‘Kewät kolkko, talwi tuima’”; and Huhtamaa, “The Good, Bad, Undefined.”
91. Huhtamaa et al., “Crop Yield Responses,” 713.
92. Voutilainen, *Nälän vuodet*, 141: “Pienen jääkauden kuljettaminen mukana historiantutkimuksessa on eräänlainen viides pyörä, tarpeeton osa syy-seurausketjua, retorinen taustatarina.”
93. Huhtamaa, “‘Kewät kolkko, talwi tuima’,” 55–6.
94. See, e.g. Raudkivi, “Maa meie ema”; Raudkivi, “Ilm teeb ajalugu”; and Raudkivi, “Die Erde unter einer Aschewolke.”
95. Tarand et al., “Eesti kliima,” 31–335.
96. Solantie, *Hallojen loppuminen keväällä*; Solantie, *The Climate of Finland*; Solantie, “Maataloutta pakkaspirun maassa”; Solantie, *Ilmasto ja sen määräämät luonnonolot*; Solantie, “Klimatperioder och Finlands kolonisering”; Holopainen and Helama, “Little Ice Age Farming”; and Holopainen, Rickard, and Helama, “Climatic Signatures in Crops.”
97. Holopainen and Helama, “Suomen keskiajan kivikirkot”; and Holopainen et al., “Keskiaikaisten kivikirkkojen keskeneräisyys.”
98. Huhtamaa and Helama, “Reconstructing Crop Yield.”
99. Such projects include, in particular, ‘Disentangling socio-political and climatic factors for food insecurity in early modern Europe (*c.* 1500–1800)’ led by Fredrik Charpentier Ljungqvist (Stockholm University) and ‘ClimateCultures: Socionatural Entanglements in Little Ice Age Norway (1500–1800)’ led by Dominik Collet (University of Oslo). The first project is only partly addressing the Nordic countries.
100. See, e.g. Helama et al., “A Palaeotemperature Record”; Helama et al., “Reconciling Pollen-Stratigraphical”; Lindholm et al., “The Height-Increment Record”; and Matskovsky and Helama, “Testing Long-Term Summer.”
101. However, we acknowledge that there are some exceptions, like Kimmo Katajala’s assessment on prolonged unfavourable weather conditions contributing to the peasant uprising in the 1690s Karelia (Katajala, *Nälkäkapina*, 292–8).
102. McCormick et al., “Climate Change During,” 170.

103. See, e.g. Jutikkala, *Kuolemalla on aina syynsä*, 58.
104. See, e.g. Dybdahl, "Klima og demografiske kriser," 208, 210, 212, 215, 218.
105. Jutikkala, "Halla aina uhkana," 293.
106. "Hurrell et al., "An Overview," 17–8; and Holopainen and Helama, "Suomen keskiajan kivikirkot," 216. This 'seesaw' between Greenland and northern Europe and its relation to the atmospheric dynamics, like the North Atlantic Oscillation (NAO), is well-known, especially with regard to winter temperatures. See, Dawson et al., "Late-Holocene North Atlantic Climate," 382 for more information.
107. Huhtamaa, *Exploring the climate–society nexus*, 32.
108. Le Roy Ladurie, *Histoire du climat depuis*, 92.
109. Jutikkala, "Ilmaston muutosten," 9–10.
110. Myllyntaus, "Summer Frost," 81.
111. Solantie, "Hallojen loppuminen keväällä ja alkaminen syksyllä," 1987, 37–9.
112. Jutikkala, "Ilmaston muutosten," 9; Huhtamaa, *Exploring the Climate–Society Nexus*, 37; and Huhtamaa, "'Kewät kolkko, talwi tuima'," 52.
113. Solantie, "Hallojen loppuminen keväällä ja alkaminen syksyllä," 26–7.
114. Soikkanen, "'Miekalla, nälällä ja rutolla'," 16–7; Edvinsson et al., "Väder, skördar och priser," 130; Dybdahl, "Klimatiske sjokk?" 64–8; and Huhtamaa, "Combining Written," 52.
115. Edvinsson et al., "Väder, skördar och priser," 121–6; and Huhtamaa et al., "Crop Yield Responses," 713.
116. Utterström, "Population and Agriculture," 187.
117. Holopainen and Helama, "Little Ice Age Farming," 217; and Huhtamaa and Helama, "Reconstructing Crop Yield," 4.
118. Myllyntaus, "Summer Frost," 80.
119. Huhtamaa, "The Good, Bad, Undefined," accessed 3 December 2020; See van Bavel et al., *Disasters and History* for state-of-the art discussion on the topic.
120. Raudkivi, "Maa meie ema," 9–16.
121. Huhtamaa, "Climate and the Crises," 92–8.
122. See, e.g. Soens, "Resilient Societies, Vulnerable People"; Adamson et al., "Re-thinking the Present."
123. Degroot et al. "Towards a Rigorous Understanding."
124. Hybel, "Klima, misvækst og hungersnød," 37–9; and Hybel, "Klima og hungersnød," 272–3.
125. Jordan, *The Great Famine*, 17–9; and Cook et al., "Old World Megadroughts."
126. Pfister, White, and Mauelshagen, "General Introduction," 6–7.

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References

Adamson, G.C.D., M.J. Hannaford, and E.Rohland, J. 'Re-thinking the present: The role of a historical focus in climate change adaptation research'. *Global Environmental Change* 48 (2018): 195–205.
Bell, W.T., and A.E.J. Ogilvie, 'Weather compilations as a source of data for the reconstruction of European climate during the medieval period'. *Climatic Change* 1 (1978): 331–348.
Bergþórsson, P., 'Hitafar og búsæld á Islandi'. *Veðrið* 11 (1966): 15–20.
Bergþórsson, P., 'Kuldaskeið um 1300?'.*Veðrið* 12 (1967): 55–58.
Bergþórsson, P. 'An estimate of drift ice and temperature in Iceland in 1000 years'. *Jökull* 19 (1969): 95–101.
Berkeley Earth, Air Surface Temperature Anomaly database, accessed 14.10.2020. http://berkeleyearth.org/data
Bjørn, C., and T. Dahlerup. *Det danske landbrugs historie* 1–4. Odense: Landbohistorisk selskab, 1988.
Brázdil, R., C. Pfister, H. Wanner, H. von Storch, and J. Luterbacher. 'Historical climatology in Europe – the state of the art'. *Climatic change* 70 (2005): 363–430.
Brázdil, R., P. Dobrovolný, J. Luterbacher, A. Moberg, C. Pfister, D. Wheeler, and E. Zorita, 'European climate of the past 500 years: new challenges for historical climatology', *Climatic Change* 101 (2010): 7–40.
Brönnimann, S., C. Pfister, and S. White. 'Archives of Nature and Archives of Societies.' In *The Palgrave Handbook of Climate History*, edited by S. White, C. Pfister, and F. Mauelshagen, 27–36. London, Palgrave Macmillan, 2018.
Brönnimann, S., R. Allan, L. Ashcroft, S. Baer, M. Barriendos, R. Brázdil, Y. Brugnara, M. Brunet, M. Brunetti, B. Chimani, and R. Cornes et al. 'Unlocking pre-1850 instrumental meteorological records: A global inventory'. *Bulletin of the American Meteorological Society* 100 (2019): ES389–ES413.
Bull, E. 'Klima og historie'. *Samtiden* 24 (1913): 200–208.
Bull, E. 'Islands klima i oldtiden'. *Geografisk Tidsskrift* 23 (1915–1916): 1–5.
Bull, E. 'Klimaskifte og nedgang i Noreg i seinmillomalderen'. *Syn og segn* 31 (1925): 12–19.

Campbell, Å. *Äldre svensk brödkultur i belysning av 1880-talets allmogebröd.* Stockholm: P.A. Norstedt & Söner, 1945.

Cook, E.R., R. Seager, Y. Kushnir, K.R. Briffa, U. Büntgen, D. Frank, P.J. Krusic et al. 'Old World megadroughts and pluvials during the Common Era.' *Science Advances* 1 (2015): e1500561.

Dawson, A.G., L. Elliott, P. Mayewski, P. Lockett, S. Noone, K. Hickey, T. Holt, P. Wadhams, and I. Foster. 'Late-Holocene North Atlantic climate 'seesaws', storminess changes and Greenland ice sheet (GISP2) palaeoclimates'. *The Holocene* 13 (2003): 381–392.

Degroot, D. *The Frigid Golden Age: Climate Change, the Little Ice Age, and the Dutch Republic, 1560–1720*. Cambridge: Cambridge University Press. 2018.

Degroot, D., K. Anchukaitis, M. Bauch, J. Burnham, F. Carnegy, J. Cui, K. de Luna, et al. 'Towards a rigorous understanding of societal responses to climate change'. *Nature* 591 (2021): 539–550.

Dybdahl, A. 'Klima og demografiske kriser i Norge i middelalderen og tidlig nytid'. *Historisk tidsskrift* 89 (2010): 183–222.

Dybdahl, A. 'Climate and demographic crises in Norway in medieval and early modern times'. *The Holocene* 22 (2012): 1159–1167. doi:10.1177/0959683612441843

Dybdahl, A. 'Om uår og ødegårder i Kongespeilet og andre skriftlige kilder fra høymiddelalderen'. *Collegium Medievale* 26 (2013): 89–106.

Dybdahl, A. 'Sult eller sykdom? Hva var årsaken til den demografiske krisen i Norge først på 1740-tallet?' *Michael* 11 (2014): 9–27.

Dybdahl, A. 'Klimatiske sjokk, uår, sykdom og demografiske kriser i Trøndelag på 1600- og 1700-tallet'. *Historisk tidsskrift* 93 (2014): 243–275.

Dybdahl, A. *Klima, uår og kriser i Norge gjennom de siste 1000*. Oslo: Cappelen Damm Akademisk. 2016.

Edvinsson, R., L. Leijonhufvud, and J. Söderberg. 'Väder, skördar och priser i Sverige'. In: B. Liljewall, I. A. Flygare, U. Lange, L. Ljunggren, and J. Söderberg (eds.), *Agrarhistoria på många sätt: 28 studier om människan och jorden. Festskrift till Janken Myrdal på hans 60-årsdag.* Stockholm: Kungl. Skogs- och lantbruksakademien, 2009: 115–136.

Eklund, A. Long observation series of ice freeze and break-up dates in Swedish lakes. In *12th Northern Research Basins Symposium and Workshop,* 35–43. Reykjavik, Kirjubaejarklaustur and Hofn, Hornafjordur, Iceland, 1999.

Friðriksson, S. 'The effects of sea ice on flora, fauna, and agriculture'. *Jökull* 19 (1969), 146–157.

Gissel, S. 'What historians know about the climate in Denmark during the Middle Ages'. In Proceedings of the Nordic symposium on climatic changes and related problems. Copenhagen: The Danish Meteorological Institute, 1978.

Gissel, S. *Desertion and land colonization in the Nordic countries c. 1300–1600*: *comparative report from the Scandinavian Research Project on Deserted Farms and Villages*. Stockholm: Almqvist & Wiksell International, 1981.

Gunnarson, G. *A study of causal relations in climate and history with an emphasis on the Icelandic experience*. Lund: Lunds universitet, 1980.

Gunnarson, G. *Monopoly trade and economic stagnation: Studies in the foreign trade of Iceland 1602–1787*. Lund: Ekonomisk-Historisk Föreningen, 1983.

Hartman, S., A.E.J. Ogilvie, Jón Haukur Ingimundarson, A.J. Dugmore, G. Hambrecht, and T. H. McGovern. 'Medieval Iceland, Greenland, and the new human condition: a case study in integrated environmental humanities.' *Global and Planetary Change* 156 (2017): 123–139.

Hasund, S. 'Var det eit klimat-omskifte?' *Syn og segn* 30 (1924): 289–299.

Hasund, S. 'Var det eit klimatumskifte?' *Syn og segn* 31 (1925): 8–11.

Hasund, S. 'Grønland og klimat-teorien'. *Syn og segn* 31 (1925): 69–73.

Hasund, S. *Det norske folks liv og historie gjennem tidene: Tidsrummet 1280 til omkring 1500*. Oslo: Aschehoug, 1934.

Helama, S., H. Seppä, J.B. Birks, and A.E. Bjune. 'Reconciling pollen-stratigraphical and tree-ring evidence for high-and low-frequency temperature variability in the past millennium.' *Quaternary Science Reviews* 29, (2010): 3905–3918.

Helama, S., M. Vartiainen, J. Holopainen, H.M. Mäkelä, T. Kolström, and J. Meriläinen. 'A palaeotemperature record for the Finnish Lakeland based on microdensitometric variations in tree rings.' *Geochronometria* 41, (2014): 265–277.

Holopainen, J., S. Helama, and M. Timonen. 'Plant phenological data and tree-rings as palaeoclimate indicators since AD 1750 in SW Finland'. *International Journal of Biometeorology* 51 (2006): 61–72.

Holopainen, J., and S. Helama. 'Little Ice Age farming in Finland: Preindustrial agriculture on the edge of the Grim Reaper's scythe'. *Human Ecology* 37 (2009): 213–225.

Holopainen, J., S. Helama, J.M. Kajander, J. Korhonen, J. Launiainen, H. Nevanlinna, A. Reissell, and V. P. Salonen, 'A multiproxy reconstruction of spring temperatures in south-west Finland since 1750'. *Climatic Change* 92 (2009): 213–233.

Holopainen, J., and S. Helama. 'Suomen keskiajan kivikirkot pikku jääkauden kourissa'. *Alue ja ympäristö* 41 (2012): 108–112.

Holopainen, J., S. Helama, and H. Huhtamaa. 'Keskiaikaisten kivikirkkojen keskeneräisyys ympäristöhistoriallisessa tarkastelussa'. *SKAS* 1 (2016): 3–10.

Huhtamaa, H., S. Helama, J. Holopainen, C. Rethorn, and C. Rohr. 'Crop yield responses to temperature fluctuations in 19th century Finland: Provincial variation in relation to climate and tree rings'. *Boreal Environment Research* 20 (2015): 707–23.

Huhtamaa, H. *Exploring the climate-society nexus with tree-ring evidence: Climate, crop yields, and hunger in medieval and early modern north-east Europe*. Joensuu: University of Eastern Finland, 2017.

Huhtamaa, H, and S. Helama. 'Reconstructing crop yield variability in Finland: long-term perspective of the cultivation history on the agricultural periphery since AD 760'. Holocene 27 (2017): 3–11.

Huhtamaa, H., and S. Helama. 'Distant impact: tropical volcanic eruptions and climate-driven agricultural crises in seventeenth-century Ostrobothnia, Finland'. *Journal of Historical Geography* 57 (2017): 40–51.

Huhtamaa, H. '"Kewät kolkko, talwi tuima" – Ilmasto, sää ja sadot nälkävuosien taustalla'. In *Nälkävuodet 1867–1868*, eds. T. Jussila and L. Rantanen. Helsinki: Suomalaisen Kirjallisuuden Seura, 2018: 33–65.

Huhtamaa, H. 'Combining written and tree-ring evidence to trace past food crises: A case study from Finland'. In *Famines during the 'Little Ice Age' (1300–1800): Socionatural entanglements in premodern societies*, edited by D. Collet, and M. Schuh, 43–66. Cham: Springer, 2018.

Huhtamaa, H. 'The good, bad, undefined Little Ice Age'. Feature article on Historical Climatology, 3.6.2020, https://www.historicalclimatology.com/features/the-good-bad-undefined-little-ice-age.

Hulme, M. 'Reducing the future to climate: a story of climate determinism and reductionism'. *Osiris* 26 (2011): 245–266.

Huntington, E. *Civilization and climate*. Yale: Yale University Press, 1924.

Hurrell, J.W., Y. Kushnir, G. Ottersen, and M. Visbeck. An overview of the North Atlantic Oscillation. In *The North Atlantic Oscillation: Climatic Significance and Environmental Impact*, edited by Hurrell, J. W., Y. Kushnir, G. Ottersen, and M. Visbeck, 1–35. Washington: American Geophysical Union, 2003.

Husberg, E. *Honung, vax och mjöd: Biodlingen i Sverige under medeltid och 1500-tal*. Gothenburg: University of Gothenburg, 1995.

Hybel, N. 'Klima, misvækst og hungersnød i Danmark 1311–1319'. *Historisk Tidsskrift* 97 (1997): 29–40.

Hybel, N. 'Klima og hungersnød i middelalderen'. *Historisk Tidsskrift* 102 (2002): 265–281.

Hybel, N., and B. Poulsen. *The Danish Resources c. 1000–1550*: Growth and Recession. Leiden: Brill, 2007.

Jevrejeva, S. 'Severity of winter seasons in the northern Baltic Sea between 1529 and 1990: reconstruction and analysis'. *Climate Research*, 17 (2001): 55–62.

Johanson, V.F. *Finlands agrarpolitiska historia: en skildring av det finländska lantbrukets ekonomiska betingelser. 1, Från 1600-talet till år 1870*. Helsinki: Suomen Maataloustieteellinen Seura, 1924.

Johnsen, O.A. *Norgesveldets undergang: Et utsyn og et opgjør. Nedgangstiden*. Oslo: Aschehoug, 1924.

Jones, P. 'Historical climatology – a state of the art review'. *Weather* 63 (2008): 181–186.

Jónsson, T. 'Early instrumental meteorological observations in Iceland'. *Climatic Change* 48 (2001): 169–187.

Jordan, W.C. *The Great Famine: Northern Europe in the Early Fourteenth Century*. Princeton, N.J.: Princeton University Press, 1996.

Jutikkala, E. *Kuolemalla on aina syynsä: maailman väestöhistorian ääriviivoja.* W. Söderström. Keränen, J. 1989.

Jutikkala, E. 'Ilmaston muutokset ja historia'. In *"Pane leipään puolet petäjäistä" Nälkä ja pulavuodet Suomen historiassa*, edited by P. Karonen, 9–24. Jyväskylä: University of Jyväskylä, 1994.

Jutikkala, E. 'Halla aina uhkana'. In *Suomen maatalouden historia. Osa 1: Perinteisen maatalouden aika: esihistoriasta 1870-luvulle*, edited by V. Rasila, E. Jutikkala, and A. Mäkelä-Alitalo, 292–299. Helsinki: Suomalaisen Kirjallisuuden Seura, 2003.

Jutikkala, E. 'Katovuodet'. In *Suomen maatalouden historia. Osa 1: Perinteisen maatalouden aika: esihistoriasta 1870-luvulle*, edited by V. Rasila, E. Jutikkala, and A. Mäkelä-Alitalo, 504–513. Helsinki: Suomalaisen Kirjallisuuden Seura, 2003.

Kajander, J. 'Methodological aspects on river cryophenology exemplified by a tricentennial break-up time series from Tornio'. *Geophysica* 29 (1993): 73–95.

Katajala, K. *Nälkäkapina: veronvuokraus ja talonpoikainen vastarinta Karjalassa 1683–1697*. Helsinki: Suomen Historiallinen Seura, 1994.

Keränen, J. 'Hyviä ja huonoja vuosia: Ilmastonvaihtelut historiallisten ilmiöiden selittäjänä'. In *Pysy lujana omalla maalla! Erkki Lehtiselle omistettu juhlakirja*, edited by E. Markkanen. Jyväskylä: University of Jyväskylä, 1989.

Koch, L. *The East Greenland Ice*. Copenhagen: C. A. Reitzel, 1945.

Koht, H. 'Edv. Bull'. *Scandia* 6 (1933): 142–152.

Koslowski, G., and R. Glaser. 'Reconstruction of the ice winter severity since 1701 in the western Baltic'. *Climatic Change*, 31 (1995): 79–98.

Koslowski, G., and R. Glaser. 'Variations in reconstructed ice winter severity in the Western Baltic from 1501 to 1995, and their implications for the North Atlantic Oscillation'. *Climatic Change* 41 (1999): 175–191.

Kovero, M. *Katovuosista Suomessa Ruotsin vallan aikana isonvihan jälkeen*. Helsinki: Kansantaloudellinen yhdistys, 1945.

Kvist, R. 'Klimathistoriska aspekter på sälfångst i Österbotten 1551–1610'. In A. Sander, P. Hallinder, S. Jansson, and S.H. Viklund (eds.) IV, 86–95 *Bottnisk kontakt IV*: maritimhistoriska konferens, 1989. Skellefteå: Skellefteå museum.

Lamb, H. H. *Climate: Present, past and future*. *Vol. 2*, Climatic history and the future. London: Methuen, 1977.

Lamb, H. H., *Climate history and the modern world*. London: Routledge, 1982.

Lappalainen, M., *Jumalan vihan ruoska: suuri nälänhätä Suomessa 1695–1697*. Helsinki: Siltala, 2012.

Leijonhufvud, L., R. Wilson, A. Moberg, J. Söderberg. 'Documentary data as proxy variables for Stockholm late winter to early spring temperatures in the 18th and 19th centuries'. *The Holocene* 18 (2008): 333–343.

Leijonhufvud, L., R. Wilson, A. Moberg, J. Söderberg, D. Retsö, and U. Söderlind. 'Five centuries of Stockholm winter/spring temperatures reconstructed from documentary evidence and instrumental observations'. *Climatic Change* 101 (2010): 109–141.

Le Roy Ladurie, E. *Histoire du climat depuis l'an mil*. Paris: Flammarion, 1967.

Lilja, S., 'Lokala klimatkriser och kronans intressen – en fallstudie av Södertörns kustsocknar ca 1570–1620', in *Människan anpassaren – människan överskridaren: Natur, bebyggelse och resursutnyttjande från sen järnålder till 1700-tal med särskild hänsyn till östra Mellansverige och Södermanlands kust*, edited by S. Lilja, 95–144. Huddinge: Södertörns högskola, 2006.

Lilja, S., 'Klimatet, döden och makten – 1690-talets klimatkris'. *Leva vid Östersjöns kust: En antologi om naturförutsättningar och resursutnyttjande på båda sidor av Östersjön ca 800–1800* edited by S. Lilja, 23–79. Huddinge: Södertörns högskola, 2008.

Lilja, S., 'Klimat och skördar ca 1530–1820'. In *Fiske, jordbruk och klimat i Östersjöregionen under förmodern tid*, edited by S. Lilja, 59–119. Huddinge: Södertörns högskola, 2012.

Lindgrén, S., and J. Neumann. 'The cold and wet year 1695. A contemporary German account'. *Climatic Change* 3, no.2 (1981): 173–187.
Lindgrén, S., and J. Neumann. 'Crossings of ice-bound sea surfaces in history'. *Climatic Change* 4, no.1 (1982): 71–97.
Lindholm, M., R. Jalkanen, H. Salminen, T. Aalto, and M. Ogurtsov. 'The height-increment record of summer temperature extended over the last millennium in Fennoscandia.' *The Holocene* 21, no. 2 (2011): 319–326.
Ljungqvist, F.C. 'Från is till värme'. In *Sveriges historia 1: 13 000 f.Kr.–600 e.Kr*., edited by D. Harrison and S. Welinder, 213–220. Stockholm: Norstedts, 2009.
Ljungqvist, F.C. 'Den medeltida värmeperioden i Skandinavien'. In *Sveriges historia 2*: 600–1350, edited by D. Harrison, 147–148. Stockholm: Norstedts, 2009.
Ljungqvist, F.C. 'Det kaotiska klimatet under senmedeltiden och Vasatiden'. In *Sveriges historia 3*: 1350–1600, edited by B. Eriksson, and D. Harrison, 83–86. Stockholm: Norstedts, 2010.
Ljungqvist, F.C. '1600-talet – det kallaste århundradet'. In *Sveriges historia 4*: 1600–1721, edited by N. E. Villstrand, 441–445. Stockholm: Norstedts, 2011.
Ljungqvist, F.C. 'Klimat och väder i Sverige 1721–1830'. In *Sveriges historia 5*: 1721–1830, edited by E. Mansén, 124–126. Stockholm: Norstedts, 2011.
Ljungqvist, F.C., and H. Huhtamaa. 'Histoire du climat du Royaume de Suède à l'époque modern'. *Revue d'Histoire Nordique* 27 (2020): 3–27.
Ljungqvist, F.C., A. Seim, and H. Huhtamaa. 'Climate and society in European history'. *Wiley Interdisciplinary Reviews Climate Change* 12 (2021): e691.
Lockwood, M., M. Owens, E. Hawkins, G.S. Jones, and I. Usoskin. 'Frost fairs, sunspots and the Little Ice Age'. *Astronomy & Geophysics* 58 (2017): 2.17–2.23.
Lunden, K. *Norges landbrukshistorie II, 1350–1814. Frå Svartedauden til 17. mai*. Oslo: Det Norske Samlaget, 2002.
Manninen, A. *Mietteitä katovuosista Suomessa*. Kuopio: Aschan, 1860.
Matskovsky, V. V., and S. Helama. 'Testing long-term summer temperature reconstruction based on maximum density chronologies obtained by reanalysis of tree-ring data sets from northernmost Sweden and Finland.' *Climate of the Past* 10, (2014): 1473–1487.
McCormick, M., U. Büntgen, M.A. Cane, E. Cook, K. Harper, P. Huybers, T. Lit, S.W. Manning, P.A. Mayewski, A.F.M. More, K. Nicolussi, and W. Tegel. 'Climate change during and after the Roman Empire: Reconstructing the past from scientific and historical evidence'. *Journal of Interdisciplinary History* 43 (2012): 169–220.
McGovern, T. H. et al. 'Landscapes of settlement in northern Iceland: historical ecology of human impact and climate fluctuation on the millennial scale'. *American Anthropologist* 109 (2007): 27–51.
Melander, K.R., and G. Melander. In *Katovuosista Suomessa*, edited by E.G. Palmèn. Oma Maa V. Porvoo: WSOY, 1924: 350–359.
Mikkelsen, F. 'Klimaændringer og samfund ca. 1500 til 1850'. *Landbohistorisk Tidsskrift* 5 (1983): 9–41.
Moberg, A., H. Bergström, J. Ruiz Krigsman, and O. Svanered. 'Daily air temperature and pressure series for Stockholm (1756–1998)'. *Climatic Change* 53 (2002): 171–212.
Moberg, A. 'Stockholm Historical Weather Observations', Dataset version 3.0, Bolin Centre Database, accessed 14.10.2020. https://doi.org/10.17043/stockholm
Muroma, S. *Suurten kuolovuosien (1696–1697) väestönmenetys Suomessa*. Helsinki: Suomen historiallinen seura, 1991.
Myllyntaus, T. 'Summer frost. A natural hazard with fatal consequences in pre-industrial Finland'. In *Natural disasters and cultural responses: case studies toward a global environmental history*, edited by C. Mauch, and C. Pfister, 7–102. Lanham: Lexington Books, 2009.
Myrdal, J. (ed.). *Det svenska jordbrukets historia,* vols. 1–5. Stockholm: Natur & Kultur, 1998–2003.
Myrdal, J., and M. Morell (ed.). *The Agrarian History of Sweden: 4000 BC to AD 2000*. Nordic Academic Press: Lund, 2011.
Myrdal, J., 'Farming and feudalism, 1000–1700'. *The Agrarian History of Sweden: 4000 BC to AD 2000*, edited by J. Myrdal, and M. Morell, 72–117. Nordic Academic Press: Lund, 2011.

Neumann, J., and S. Lindgrén. 'Great historical events that were significantly affected by the weather: 4, The great famines in Finland and Estonia, 1695–97.' *Bulletin of the American Meteorological Society* 60 (1979): 775–787.

Nordli, P.Ø. *Spring and summer temperatures in Trøndelag 1701–2003.* Norvegian Meteorological Institute, met.no report, 5. (2004). Oslo.

Nordli, Ø., E. Lundstad, A. E. J. Ogilvie. 'A late-winter to early-spring temperature reconstruction for southeastern Norway from 1758 to 2006'. *Annals of Glaciology* 46 (2007): 404–408.

Nordli, Ø. *Norwegian farmers' diaries used for quality control and calibration of early instrumental observations and for temperature reconstructions.* PhD thesis, Bergen: University of Bergen, 2008.

Norrgård, S., and S. Helama. 'Historical trends in spring ice breakup for the Aura River in Southwest Finland, AD 1749–2018'. *The Holocene* 29 (2019): 953–963.

Ogilvie, A.E.J. *Climate and Society in Iceland from the Medieval Period to the Late Eighteenth Century.* PhD thesis, University of East Anglia, 1982.

Ogilvie, A.E.J. 'The past climate and sea-ice record from Iceland. Part 1: Data to A. D. 1780'. *Climatic Change* 6 (1984): 131–152.

Ogilvie, A.E.J. 'The climate of Iceland, 1701–1784'. *Jökull* 36 (1986): 57–73.

Ogilvie, A.E.J. 'Climatic changes in Iceland A. D. c. 865 to 1598'. *Acta Archaeologica* 61 (1991): 233–251.

Ogilvie, A.E.J. 'Documentary evidence for changes in the climate of Iceland, A.D. 1500 to 1800'. In *Climate Since A.D.* 1500, edited by R.S. Bradley, and P.D. Jones, 92–117. Routledge, London and New York, 1992.

Ogilvie, A.E.J. 'The climate of Scandinavia in medieval times'. In *Medieval Scandinavia: An Encyclopedia*. Garland Encyclopedias of the Middle Ages, edited by P. Pulsiano, and K. Wolf, with P. Acker and D.K. Fry, 94–96. Garland Publishing, New York and London, 1992.

Ogilvie, A.E.J. 'Sea-ice conditions off the coasts of Iceland A.D. 1601–1850 with special reference to part of the Maunder Minimum period (1675–1715)'. *AmS-Varia* 25 (1996): 9–12.

Ogilvie, A.E.J., and I. Jónsdóttir. 'Sea ice, climate, and Icelandic fisheries in historical times'. *Arctic* 53 (2000): 383–394.

Ogilvie, A.E.J. 'Climate and farming in northern Iceland, ca. 1700–1850'. In *Aspects of Arctic and Sub-Arctic History*, edited by I. Sigurdsson, and J. Skaptason, 289–299. University of Iceland Press, Reykjavik, 2001.

Ogilvie, A.E.J., and T. Jónsson. '"Little Ice Age" research: A perspective from Iceland'. *Climatic Change*, 48 (2001): 9–52.

Ogilvie, A.E.J. 'Local knowledge and travellers' tales: a selection of climatic observations in Iceland.' In *Iceland – Modern Processes and Past Environments*, edited by C. Caseldine, A. Russell, J. Harðardóttir, and Ó. Knudsen, 257–287. Amsterdam, Elsevier Science, 2005.

Ogilvie, A.E.J. 'Historical climatology, climatic change, and implications for climate science in the 21st century'. *Climatic Change* 100 (2010): 33–47.

Ogilvie, A.E.J. 'Famines, mortality, livestock deaths and scholarship: Environmental stress in Iceland ca. 1500–1700'. In *The Dance of Death in Late Medieval and Renaissance Europe: Environmental Stress, Mortality and Social Response*, edited by A. Kiss, and K. Prybil, 9–24. London: Routledge, 2019.

Olsen, G. 'Klima og historie'. *Fortid og Nutid* 13 (1939): 1–26.

Palm, L. A. *Gud bevare utsädet! Produktionen på en västsvensk ensädesgård: Djäknebol i Hallands skogsbygd 1760–1865*. Stockholm: Kungl. Skogs- och lantbruksakademin, 1997.

Pedersen, E. S. 2015. 'Klimaets plass i norsk historie: En forskningshistorisk oversikt'. *AmS-Varia*, 58; 61–76.

Pettersson, O. *Klimatförändringar i historisk och förhistorisk tid: en studie i geofysik*. Stockholm: Almqvist & Wiksell, 1913.

Pfister, C. *Das Klima der Schweiz von 1525 bis 1860 und seine Bedeutung in der Geschichte von Bevölkerung und Landwirtschaft*. Bern: Verlag Paul Haupt, 1984.

Pfister, C. 'Fluctuations climatiques et prix céréaliers en Europe du XVIe au XXe siècle'. *Annales. Histoire, Sciences Sociales* 43 (1988): 25–53.

Pfister, C., S. White, and F. Mauelshagen. 'General Introduction: Weather, Climate, and Human History'. In *The Palgrave Handbook of Climate History*, edited by White, S., Pfister, C., & Mauelshagen, F., 1–17. London: Palgrave Macmillan, 2018.

Pfister, C., C. Camenisch, and P. Dobrovolný. 'Analysis and Interpretation: Temperature and Precipitation Indices'. In *The Palgrave Handbook of Climate History*, edited by S. White, C. Pfister, and F. Mauelshagen, 115–129. London: Palgrave Macmillan, 2018.

Rasila, V., E. Jutikkala, and A. Mäkelä-Alitalo (eds.). *Suomen maatalouden historia. Osa 1: Perinteisen maatalouden aika*: *esihistoriasta 1870-luvulle*. Helsinki: Suomalaisen Kirjallisuuden Seura, 2003

Raudkivi, P. 'Maa meie ema, ilm meie isa. Märkmeid looduse rollist Liivimaa 14. sajandi ajaloos'. *Acta Historica Tallinnensia* 15 (2010): 3–23.

Raudkivi, P. 'Ilm teeb ajalugu. Aspekte talurahva ühiskondlikust haavatavusest Eesti- ja Liivimaal 19. sajandi algul' *Acta Historica Tallinnensia* 22 (2016): 18–40.

Raudkivi, P. 'Die Erde unter einer Aschewolke. Der Vulkanismus als historischer Faktor'. *Forschungen zur baltischen Geschichte* 11 (2016), 181–196.

Retsö, D. 'A contribution to the history of European winters: some climatological proxy data from early sixteenth century Swedish documentary sources.' *Climatic Change* 52 (2002): 137–173.

Retsö, D. 'Documentary evidence of historical floods and extreme rainfall events in Sweden 1400–1800'. *Hydrology and Earth System Sciences* 19 (2015): 1307–1323.

Retsö, D., and J. Söderberg. 'Winter severity in medieval Sweden: the documentary evidence'. In *The Dance of Death in Late Medieval and Renaissance Europe: Environmental Stress, Mortality and Social Response*, edited by A. Kiss, and K. Pribyl. London: Routledge, 2019: 25–45.

Retsö, D., and L. Leijonhufvud. Documentary evidence of droughts in Sweden between the Middle Ages and c 1800. *Climate of the Past*, 17 (2021) in press.

Rosenlund, M. *Väder som förändrade världen*. Helsinki: Schildts & Söderströms, 2018.

Røstad, A. 'Verumskifte fyre nedgangstida i Noreg'. *Syn og segn* 30 (1924): 209–214.

Røstad, A. 'Var det auking i luftstrøyminga?' *Syn og segn* 30 (1924): 401–415.

Salvesen, H. *Jord i Jemtland: Bosetningshistoriske og økonomiske studier i grenseland ca 1200–1650*. Östersund: Det nordiske ødegårdsprosjekt, 1979.

Salvesen, H. 'The climate as a factor of historical causation'. In *European climate reconstructed from documentary data: methods and results*, edited by Frenzel, B., Pfister, C. and Gläser, B., 219–233. *Paläoklimaforschung*, 7. Gustav Fischer Verlag. 1992. Stuttgart.

Sandnes, J., and Salvesen, H. *Ødegårdstid i Norge: et nordiske ødegårdsprosjekts norske undersøkelser*. Universitetsforlaget: Oslo, 1978.

Soens, T. 'Resilient societies, vulnerable people: coping with North Sea floods before 1800.' *Past & Present* 241 (2018): 143–177.

Soikkanen, H. '"Miekalla, nälällä a rutolla" – kriisit historiassa'. In Kun halla nälän tuskan toi. Miten suomalaiset kokivat 1860-luvun nälkävuodet, edited by A. Häkkinen, V. Ikonen, K. Pitkänen, and H. Soikkanen. Porvoo: WSOY, 1991: 11–35.

Solantie, R. *Hallojen loppuminen keväällä ja alkaminen syksyllä*. Helsinki: Finnish Meteorological Institute. 1987.

Solantie, R. *The climate of Finland in relation to its hydrology, ecology and culture*. Finnish Meteorological Institute contributions No. 2. 1990. Helsinki.

Solantie, R. 'Klimatperioder och Finlands kolonisering'. *Historisk Tidskrift för Finland* 77 (1992): 86–96.

Solantie, R. 'Maataloutta pakkaspirun maassa'. *Historiallinen Aikakauskirja* 104 (2006): 185–190.

Solantie, R. *Ilmasto ja sen määräämät luonnonolot Suomen asutuksen ja maatalouden historiassa*. Jyväskylä: University of Jyväskylä, 2012.

Speerschneider, C.J.H. *Om Isforholdene i danske Farvande i ældre og nyere Tid. Aarene 690–1860*. Copenhagen: Danish Meteorological Institute, 1915.

Steensberg, A., 'Archæological dating of the climatic change about A.D. 1300'. *Nature* 168 (1951): 672–674.

Tarand, A. 'Ice Cover in the Baltic Region and the Air Temperature of the Little Ice Age'. In *Proceedings of the International Symposium on the Little Ice Age Climate*, edited by Mikami, T., 94–100. Tokyo, 1992. Editorial Committee of LIAC Proceedings, Department of Geography, Tokyo Metropolitan University.

Tarand, A., and P.Ø. Nordli, 'The Tallinn temperature series reconstructed back half a millennium by use of proxy data'. *Climatic Change* 48 (2001): 189–199.

Tarand, A., J. Jaagus, and A. Kallis. Eesti kliima minevikus ja tänapäeval. Tartu: Universtiy of Tartu Press, 2013.

Thórarinsson, S. *The Thousand Years Struggle Against Ice and Fire*. Reykjavík: Museum of Natural History, 1956.

Thoroddsen, Þ. 'Islands Klima i Oldtiden'. *Geografisk Tidsskrift* 22 (1914): 204–216.

Thoroddsen, Þ. *Árferði á Íslandi í þúsund ár*. Copenhagen: S.L. Møller. 1916.

Tornberg, M. 'Ilmaston- ja sadonvaihtelut Lounais-Suomessa 1550-luvulta 1860-luvulle'. *Turun Historiallinen Arkisto* 44 (1989): 58–87.

Tornberg, M. 'Ilmastohistoria – nyt'. In *Muuttuva maailmamme: ympäristöongelmia eilen ja tänään*, edited by E. Kuparinen, 47–82. Turku: Univeristy of Turku, 1992.

Utterström, G. 'Some population problems in pre-industrial Sweden'. *Scandinavian Economic History Review* 2 (1954): 103–165.

Utterström, G. 'Climatic fluctuations and population problems in early modern history'. *Scandinavian Economic History Review* 3 (1955): 3–47.

Utterström, G. 'Population and agriculture in Sweden, circa 1700–1830'. *Scandinavian Economic History Review* 9 (1961): 176–194.

van Bavel, B.J., D.R., Curtis, M.J. Hannaford, M. Moatsos, J. Roosen, and T. Soens, 'Climate and society in long-term perspective: Opportunities and pitfalls in the use of historical datasets'. *Wiley Interdisciplinary Reviews: Climate Change* 10 (2019): e611. doi:10.1002/wcc.611

van Bavel, B., D. Curtis, J. Dijkman, M. Hannaford, M. de Keyzer, E. van Onacker, and T. Soens, *Disasters and History. The Vulnerability and Resilience of Past Societies*. Cambridge: Cambridge University Press, 2020.

Vestbö-Franzén, Aadel, *Råg och rön: Om mat, människor och landskapsförändringar i norra Småland,* ca 1550–1700. Jönköping: Jönköpings läns museum, 2005.

Þórhallur Vilmundarson. Evaluation of historical sources on sea ice near Iceland. In *Hafísinn*, edited by Thorbjörn Karlsson, 313–332. Reykjavík: Almenna Bókafélagið, 1972.

Voipio, V. 'Katovuosi 1601 vaikutuksineen Varsinais-Suomessa'. *Historiallinen Arkisto* 24 (1914): 1–37.

Voutilainen, M. *Nälän vuodet: nälänhätien historia*. Atena: Jyväskylä, 2017.

Werenskiold, W. 'Klimavekslinger som historisk faktor'. *Samtiden* 35 (1924): 147–158.