The Little Ice Age in the North Atlantic Region

Part IV: Norway

Peter Klevberg, Michael J. Oard*

Abstract

The first two parts of this series (Klevberg and Oard, 2011a, 2011b) introduced methods of studying past climate change, the historicity of the Medieval Warm Period and Little Ice Age, and the importance of the Little Ice Age in understanding climate change and constraining climatic models. The third part (Klevberg and Oard, 2012) provided more detailed reasons for concentrating on the North Atlantic region and summarized the rich climatic and glaciologic history of Iceland. Our study of the effects of the Little Ice Age in the North Atlantic region continues with this paper, which presents a summary of climate change indicators and the history of the Little Ice Age in Norway.

Overview of Norwegian Glaciers

Both Norway and Iceland benefit from the warming effects of North Atlantic Ocean currents (Figure 1). In contrast with Iceland, Norway has significant landmasses to the east with their continental climate. Mainland Europe's largest ice cap, Jostedalsbreen, is significantly smaller than Iceland's Vatnajökull, which edges Svalbard on a volume basis as the world's third largest ice cap. Important Norwegian glaciers are shown on Figure 2 and summarized in Table I.

Norway occupies the western half of the Scandinavian Peninsula, which

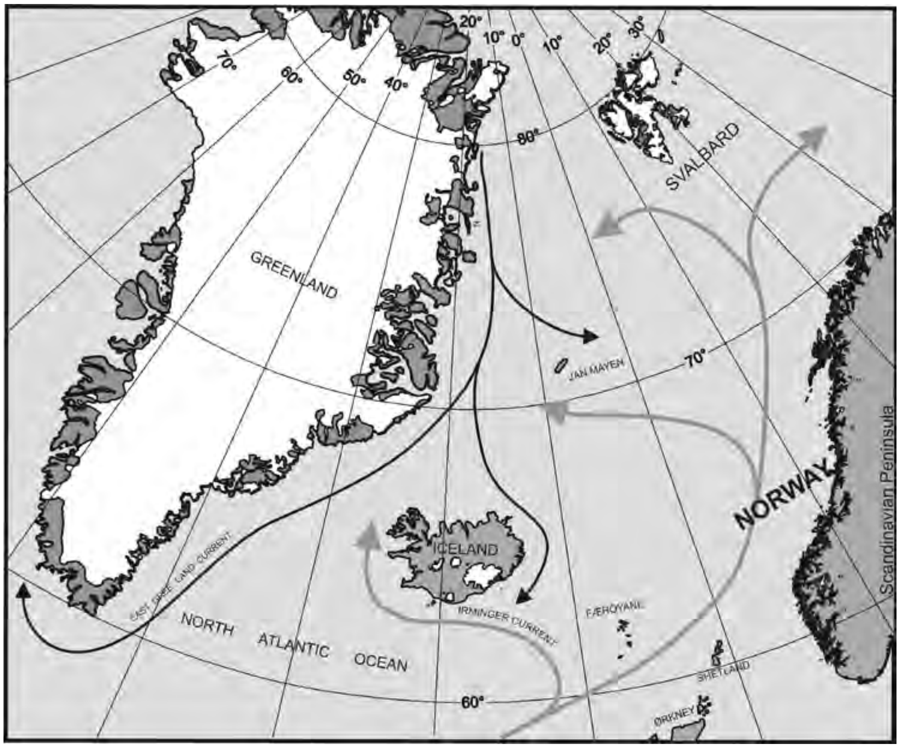

Figure 1. The North Atlantic Region. Cold ocean currents shown in black, warmer currents in gray.

---

* Peter Klevberg, B.S., P.E., Great Falls, Montana, grebvelk@yahoo.com
Michael J. Oard, M.S., Bozeman, Montana
Accepted for publication March 10, 2012

is large enough to provide significant climatic contrast. Glaciers near the coast are considered maritime, and respond differently to climatic variation than the inland glaciers (Bakke et al., 2008).

Evidences of Ancient Climate Changes

Evidence of markedly colder and warmer temperatures in the past than the present is plentiful in Norway (Bakke et al., 2005; Lillehammer, 1994). Fjords are overdeepened valleys flooded by the sea. Their form and location in high latitudes lend credence to the almost universal belief that they were shaped by moving ice. It is largely believed Norway was virtually buried by ice during the "Pleistocene," with outlet glaciers forming the fjords (Figure 3) and sculpting the interior (Follestad and Fredin, 2007; Lillehammer, 1994; many others–see virtually any book on Scandinavian geography), though evidence of lack of glaciation on many highlands (*vidder*) and *blokkhav* (alpine boulder fields) in high mountains is becoming more widely known. Yet even though much geologic work that led to development of fjords and mountains and other landforms was likely not glacial (Lidmar-Bergström et al., 2000), the extent of features that do appear glacial is extensive and much greater in magnitude than what has occurred in recorded history. Evidence in Norway of arctic wildlife and very different conditions from today is easy to come by (Lillehammer, 1994).

Figure 2. Principal Norwegian glaciers.

Some have speculated that Norwegian glaciers disappeared entirely during the "early Holocene climatic optimum" (Nesje et al., 2008; NORPAST, 2001), which is believed to have been more than 1°C warmer than at present (Bjune et al., 2005; Dahl and Nesje, 1994) and possibly 3°C warmer (Jensen and Vorren, 2008). Pine stumps are present on the high mountain plateau Hardangarvidda, far above the present treeline, and the treeline in Ranafjorden just southwest of Svartisen (Figure 2) was 185 m (610 feet) higher than today (Lillehammer, 1994) in what we interpret to be early postdiluvian time (perhaps immediately following the Great Ice Age). Comparable treeline differences have been found in studies in northern Norway (Bakke et al., 2005), and the Varanger Peninsula at the northern tip of Norway (Finnmark), which today is treeless, was forested (Lillehammer, 1994). Some researchers believe the equilibrium line altitude (ELA) in Finnmark was 100 to 200 m higher than now, meaning an average temperature +1.2°C relative to today (Karlen and Kuylenstierna, 1996). Major inferred climatic periods are summarized in Table II (traditional interpretation).

Climate change in recent centuries is also documented. In the region of Jostedalsbreen (Figure 2), trails documented in the twelfth century between farms crossed areas that to this day are covered by ice (Grove, 1988). This indicates that the climate had been

Table I. Summary of Norwegian Glaciers.

Figure Number	Glaciers/Locale*	Glacier Type(s)	Area (km2)*	Maximum Elevation (masl)	Elevation of Termini (masl)	E.L.A. (masl)
2	Blåmannisen	ice cap	87			
2	Folgefonna	ice cap	> 83		1050–1235	> 1659
2	Hardangarjøkulen	ice cap	73		1020–1360	> 1860
2	Jostedalsbreen	ice cap	486		350–1200	
2	Jotunheimen (Storbreen, Hellstugubreen, Gråsubreen; total)	cirque, valley	5.4			> 2090
			3.0			> 2200
			2.2			> 2290
			37.9		1390–1830	> 2290
2	Langfjordjøkulen	plateau	8.4			>1050
2	Lyngen, Storsteinsfjellbreen	cirque, valley	141	1833–1894	400–1000	
2	Okstinden	ice cap	15.1		730–1090	
1	Svalbard (total)	ice cap, cirque, valley, piedmont	36,500		typically near 0	200–800
2	Svartisen	ice cap	> 40		10–774	
2	Ålfotbreen	ice cap	7.6			>1382

*Indicated area typically includes multiple glaciers.

Data from Bakke et al., 2005; Kjøllmoen, 2007; and Liestøl, 1967.

relatively warm (or very dry) for a considerable period (Medieval Warm Period?). Even then, considerable variation was possible. Cold years are spoken of just after AD 1000, but only for a short time (Krag, 1995). The forest chopped down on the Rørosvidda during the Little Ice Age never grew back; it apparently had formed during a warmer period (Sogner, 1996). Proxy data from Folgefonna do not provide unequivocal evidence for the Medieval Warm Period (Bakke et al., 2005). Recent melting in Jotunheimen (Figure 2) has exposed artifacts indicating areas were bare 1,500 years ago that have been under ice since (Lepperød, 2010). If the dating is correct, then ice covered this area before the Little Ice Age and did not melt during the Medieval Warm Period, even though land use indicates the Medieval Warm Period was significantly more clement than at present (Helle, 1995)—evidence that the

Figure 3. Looking south down Sunnylvsfjorden from Klevberg, Sunnmøre, Norway. Photograph by Helge Klevberg.

Table II. Paleoclimatology of Norway.

Conventional Nomenclature*	Uncorrected ^{14}C date**	Corrected ^{14}C date**	Paleoclimatological Data & Interpretations
Paleolithic - immediately after deglaciation (Boreal)	10000–9000 B.C.	3060–3020 B.C.	Oldest ^{14}C-dated habitation site (Sarnes på Magerøya)
"Lower Atlantic time"	*9000–8000 B.C.*	*3020–2975 B.C.*	*Cold period, glacial advance*
	8000–7000 B.C.	2975–2915 B.C.	Climatic amelioration, forest advance
	7000–6000 B.C.	2915–2835 B.C.	At least 12.5°C avg. summer temperature (14°C+ in Østlandet based on *Cladium mariscus*)
"Wet Atlantic time" — Mesolithic	6000–3000 B.C.	2835–2315 B.C.	Treeline in Ranafjord area 185 m higher than today (Hardangarvidda similar)
Sub-Boreal time — Neolithic	3000–1000 B.C.	2315–980 B.C.	Somewhat lower precipitation and mild winters, average temperature 2–3°C warmer than present
Bronze Age	1000 B.C. - 0	980–0 B.C.	Markedly colder, forest disappeared from Varanger coastal areas
Sub-Atlantic time — Older Iron Age	0–400 A.D.	0–400 A.D.	Markedly warmer at time of Christ, with average temperature ca. 1°C warmer than present
Younger Iron Age to Viking Era	400–700 A.D.	400–700 A.D.	Return to colder climate
Viking Era to High Middle Ages	700–1200 A.D.	700 – 1200 A.D.	Generally warmer climate; land suitable for pasture was at least twice present area
High Middle Ages to Mid-Nineteenth Century	1200–1850 A.D.	1200–1850 A.D.	LITTLE ICE AGE
Modern Era	1850 A.D. – present	1850 A.D. – present	Global warming relative to Little Ice Age (climatic recovery)

Table generalized from a large number of sources.

*Conventional paleoclimatological terminology italicized, conventional anthropological/archaeological terminology not italicized.

**First Approximation Correction of ^{14}C Dates Using Brown (2006) Equation. Dates from Medieval times to present generally established independent of radiocarbon.

complexities of climatology, including variations in both temperature and precipitation, must be taken into account in attempting to explain glacial history in Norway, especially at these sites 2000 m above sea level.

The Little Ice Age Advances

In general, the coming of the Little Ice Age parallels that observed in Iceland, Switzerland, and elsewhere. Norway experienced a change toward a cooler and wetter climate beginning in the 1200s (Helle, 1995) and worsening after 1590 (Rian, 1995). The 1600s were a time of difficulty in Europe from a variety of sources, but "cold weather" featured high on the list (Rian, 1995, p. 222). Grove (1988, p. 78) states that government reports from 1702 reveal widespread evidence of "dramatic and swift" climatic deterioration after 1667. Late and early frosts and ice in fresh and saltwater bodies that today are virtually ice-free are recorded from the 1700s (Sogner, 1996). After somewhat milder but unstable years at the end of the eighteenth century, the early 1800s had cold winters and often cold summers (Dyrvik and Feldbæk, 1996; Seip, 1997).

Records of destruction of Norwegian farms by advancing glaciers, though limited, appear contemporary with (or up to a century later than) similar events in Iceland and Switzerland (Table III). Norwegian agriculture also suffered from the cooler climate and shorter growing seasons, even where glacial advance was not a threat (Grove, 1988).

Newer research has confirmed that deterioration in climate occurred

> beginning in the latter half of the 1200s. The summer temperature was lower, and the average temperature decreased. This was a weather pattern that came to dominate clear into the 1700s, with warmer periods between. (Bjørvik, 1996, p. 33)

Norwegian glaciers grew in all parts of the country, though more so in the south than the north, and with some differences in timing. Figure 4 compares glacial fluctuations for major Norwegian glaciers. The locations of these glaciers are indicated on Figure 2. In general, Norwegian glaciers reached their maximum extent in the mid to late 1700s (Grove, 1988). Historic fluctuations of important Norwegian glaciers are shown in Figure 4 and described individually below. The locations of these glaciers are shown in Figure 2.

Folgefonna

Folgefonna is Norway's third largest body of ice, after Jostedalsbreen and Svartisen (Kjøllmoen, 2007). It experienced three significant advances: (1) at approximately AD 1750, (2) in AD 1870, and (3) around 1930 (Bakke et al., 2005). As is typical, minor advances and retreats occurred between these major episodes. Folgefonna is a maritime glacier and is strongly influenced by winter precipitation.

Jostedalsbreen

Abandonment of some of the farms in the Jostedal area purportedly preceded the Black Death (Grove, 1988), which may indicate a glacial advance at that time. Bjørvik (1996, p. 34) states, "The 'Little Ice Age' fits the Jostedalsbreen region well from the middle of the 1200s." Grove (1988) cites Schøning's record from 1761, which states that cold years and bad harvests occurred from 1294 on. "The earliest reliable evidence of direct damage to farmland by advancing ice in Scandinavia comes from Jostedal in a brief account, dated 1684" (Grove, 1988, p. 69). Jostedal had been resettled in the 1500s (it had been abandoned as a result of the Black Death), contemporary with the demise of farms from the Mont Blanc glaciers in the Alps (Grove, 1988). Accounts from the early 1700s indicate significant glacial advance that overran relatively large areas that had been farmed for long periods, though the advances were typically interspersed with smaller recessions (Strøm, 2001). "In sum, evidence from the farm histories of Jostedalen dates the descent of the ice from the high tributary valleys to the 1680s and the subsequent encroachment onto permanent farm sites to the period

Table III. Farm or Settlement Overrun by Ice During Little Ice Age.

Farm or Settlement	Location	Glacier	Date Overrun
Fjall	Iceland	Breiðamerkurjökull	ca. 1700
Breiðá			1697–1700
Kári Sólmundarsson's tomb			pre 1712
Breiðamerkursandur farms			ca. 1350–1750
Trimbilsstaðir		Drangajökull	ca. 1600
Öldugil			ca. 1400–1710
Sviðningsstaðir			ca. 1700?
Þaralátursfjörður valley			ca. 1450–1650
Nedra Horn		Reykjafjarðarjökull	pre 1650
Fremra Horn			pre 1650
Various farms	Switzerland	Mont Blanc	late 1500s
Krumdalsætra	Norway	Tuftebreen	
Various farms		Jostedalsbreen	1680–1745
Tungøen			December 1743
Helleseter			
Various farms	Greenland	Greenland outlet glaciers	ca. 1350 ff.
Le Châtelard	France	Mer de Glace	pre 1600
Le Bois			

Sources: Evans and Twigg, 2002; Fagan, 2000; Grove, 1988.

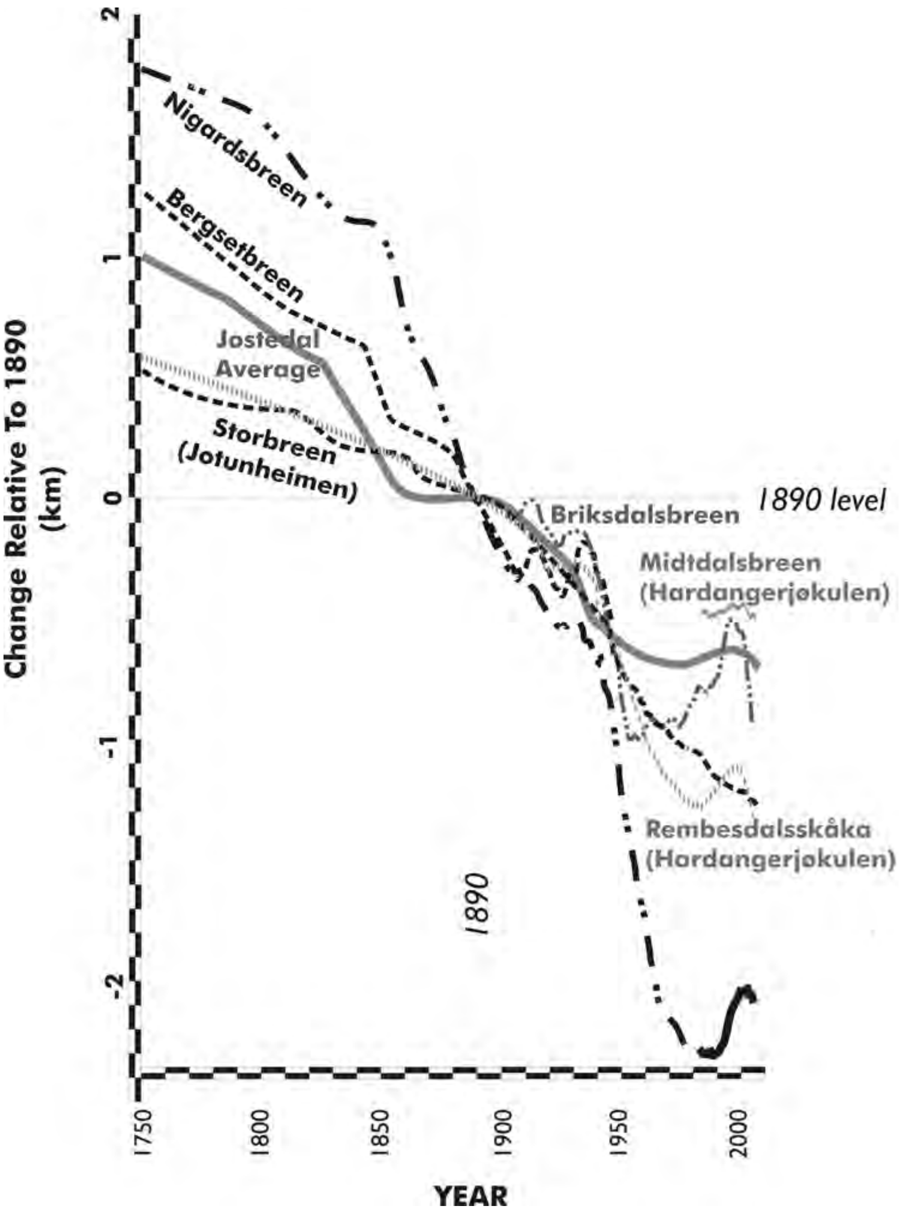

Figure 4. Variations in frontal position of several Norwegian glaciers. Values are standardized to 1890 frontal positions.

between the 1680s and 1745, a period of increased winter snowfall and short cold summers"(Grove, 1988, p. 73).

Hardangerjøkulen

The inferred drop in ELA for the Hardangerjøkul parallels that of the maritime Folgefonna and Jostedalsbreen (Bakke et al., 2005) or leads it in phase with the inland Jotunheimen (Nesje et al., 2008). The latter seems more probable for the more continental (i.e., inland) Hardangerjøkulen, though the complexities of different lag times for outlet glaciers and the relative importance of summer temperatures and winter precipitation between interior and coastal glaciers can make the comparison difficult (Dahl and Nesje, 1994). Inferences of climatic change based on these differences must be made with care.

Jotunheimen

Data for Jotunheimen, an inland ice cap, are much sparser than for Jostedalsbreen, which is the better documented. In general, they correspond to the growth and retreat of Jostedalsbreen, though the contrast between the maritime (Jostedalsbreen) and continental (Jotunheimen) is also documented (Bakke et al., 2008; Grove, 1988). The recent discoveries at Juvfonna reported by Lepperød (2010) suggest that ice accumulated in Jotunheimen long before the Little Ice Age, perhaps indicating cloudier conditions relative to the present, lower maximum summer temperatures than today, greater precipitation, or some similar combination of conditions.

Svartisen

Lacking good historical documentation, dating of Svartisen events depends largely on interpretation of data from radiocarbon testing and lichenometry (see the appendix in Klevberg and Oard, 2011a and Appendix B in Klevberg and Oard, 2011b). However, Petter Dass, Norway's famous hymnist and poet, noted that the Svartisen outlet glacier Engabreen reached the seashore about 1693 (Grove, 1988). The same maritime-continental contrast is observed in the north as has been noted farther south: "Whereas in the more maritime areas, although variations in temperature have been almost the same as in the interior, increased accumulation has played the decisive role" (Grove, 1988, p. 107).

Svalbard

Advances of glaciers on Spitsbergen, the largest island in the Svalbard Archipelago north of Norway, were the greatest "in at least 8,000 years"(Grove, 1988, p. 318). Not all of the Svalbard glaciers overtopped their terminal moraines, however. Presumably these moraines are relicts from the Great Ice Age, meaning advances were significantly less during the Little Ice Age.

Table IV. Equilibrium Line Altitude Comparisons for Iceland and Norway.

Little Ice Age Inferences				References	
Glacier/Region	Year	Temperature Difference	E.L.A. Difference	Base Year(s)*	Author
Solheimajökull	ca. 1800	-1.6 °C		1960–90	McKinzey et al., 2005
Eiríksjökull	ca. 1875	-1.5 °C	-250 m	ca. 1990s	Guðmundsson, 1998
Tröllaskagi	pre-1925		-200 m?	post 1925	Caseldine, 1987; Björnsson, 1980
Tröllaskagi-Hörgárdalur	1800s		-5 m	ca. 1920s?	Häberle, 1991
Tröllaskagi – observed		-2 °C	-50 m	1925–1960	Caseldine & Stötter, 1993
Tröllaskagi – theoretical			-300 m		
Iceland in general	1600–1920	-3 to -4 °C	ca. 200 m/°C	*clima optima*	Björnsson, 1980
			-400 m	1960–90	Grove, 2001
Western Norway	*clima optima*	+2 °C		1980–2005	Bjune et al., 2005
		-0.4 °C			Grove, 1988
Northern Norway			-150 m +		Grove, 1988, p. 414
		-1 °C			Grove, 1988
			- 100 to 250 m	1960–90	Bakke et al., 2005
Spitsbergen		-2 °C	-110 m		Grove, 1988
Western Norway	ca. 1750		-125 m	ca. 1990	Aa, 1996
					Grove, 1988

*estimated in some cases from context

Elsewhere

Small glaciers and ice caps grew or formed in many parts of the country distant from the larger glaciers. This was true in Sunnmøre; this part of the country was affected neither most nor least by the climatic change and may be more or less average. The preponderance of figures in this paper from Sunnmøre primarily reflect the fact the lead author's father is a *sunnmøring*; similar features could be found elsewhere in the country. Many of the small glaciers and ice caps observed during the Little Ice Age (Strøm, 2001) still exist, though they have often melted back severely (Figures 6, 7, and 8).

Interpreting the Glacial Record

Common ideas call for multiple glaciations in Norway, and examination of moraines and other features indicates this may have been the case. As was shown in Part I of this series (Kleverg and Oard, 2011a), it is especially important to note the limitations of proxy data because many of these are interdependent and rife with uniformitarian bias. Table II shows paleoclimatologic inferences for Norway; the dates become increasingly speculative and errant toward the top of the table (see appendix).

Dates of glacial events are often established using radiocarbon test results. Even for relatively recent materials, these dates are often believed to be greatly in error, much more than that reported by the testing laboratory, especially when efforts are made to date buried soils (Bakke et al., 2005; Karlén, 1981; Matthews, 1982; Matthews et al., 1996; Winkler et al., 2003). This has proven true for Little Ice Age deposits, and the error becomes worse with older samples (Brown, 2006).

Detailed reconstructions of Little Ice Age temperatures for western Norway have been based largely on historic proxy records (Nordli, 2001; Nordli et al., 2003). They are therefore particularly valuable. While evidence of cooler temperatures begins as early as the 1200s, glaciers did not advance enough to threaten habitations until at least the 1300s and probably much later in most places.

ELA estimates are calculated based on elevations of terminal moraines. ELA fluctuations are summarized in Table IV and indicate a drop in ELA between zero and 250 m, depending on the year maximum extent was reached and which base year is chosen for comparison. In general, results indicate a drop of 100 to 250 m (325 to 825 ft.), equivalent to tem-

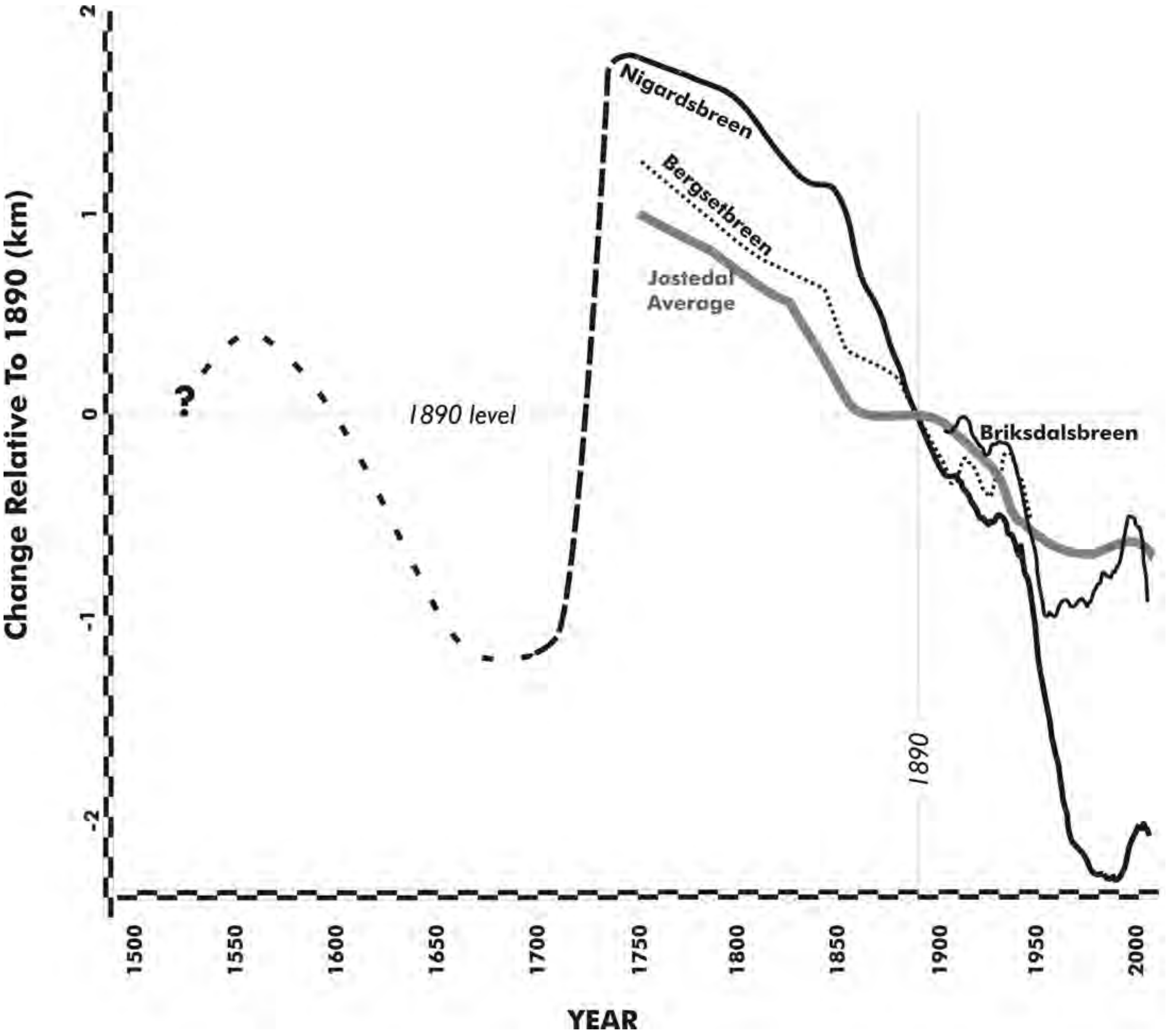

Figure 5. Fluctuations in end position of Jostedalsbreen outlet glaciers standardized to 1890 frontal positions.

perature anomalies between zero and -2.5°C (i.e. ±0F° minimum to -4.5F°).

Little Ice Age advances appear to have been approximately equal to previous maxima in the south of the country based on terminal moraines (Winkler et al., 2003), though evidence of previously more advanced termini is present both above sea level (Dahl and Nesje, 1994) and below sea level (Larsen et al., 2006) at some locations, such as Hjørundfjord and Sunnylvsfjord (Figures 2, 6, 7, 8, and 9). Difficulty in dating moraines contributes to confusion (Mathews et al., 1996). Topographic factors also complicate interpretation (Aa, 1996). Glaciers in the north of the country did not always reach their terminal moraines during this period (Grove, 2001), though they often erased earlier marginal moraines both in the north (Bakke et al., 2005) and the south (Dahl and Nesje, 1996).

Glacial maximum for the Little Ice Age in Norway occurred between 1700 and 1900, with most glaciers reaching their maximum extent around 1750, but some (especially in the north) reached maximum extent around 1900 or even later. Accounting for lag times and differences in response to temperature and precipitation, glacial extent data fit well with historical and proxy evidence for a gradual warming trend over the past 150 years or so. Interior (continental) glaciers have been observed to shrink while coastal (maritime) glaciers fluctu-

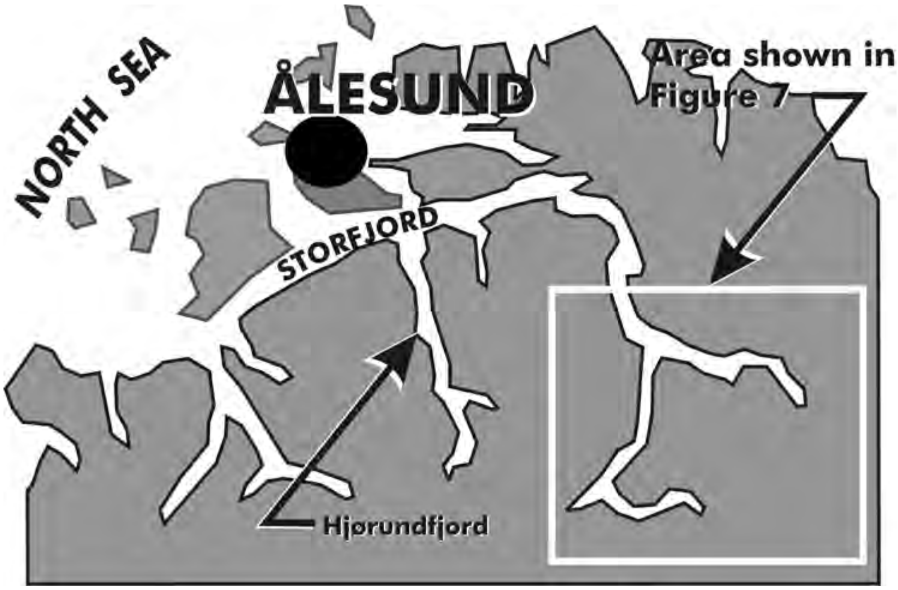

Figure 6. Map of Storfjord area, Sunnmøre, Norway.

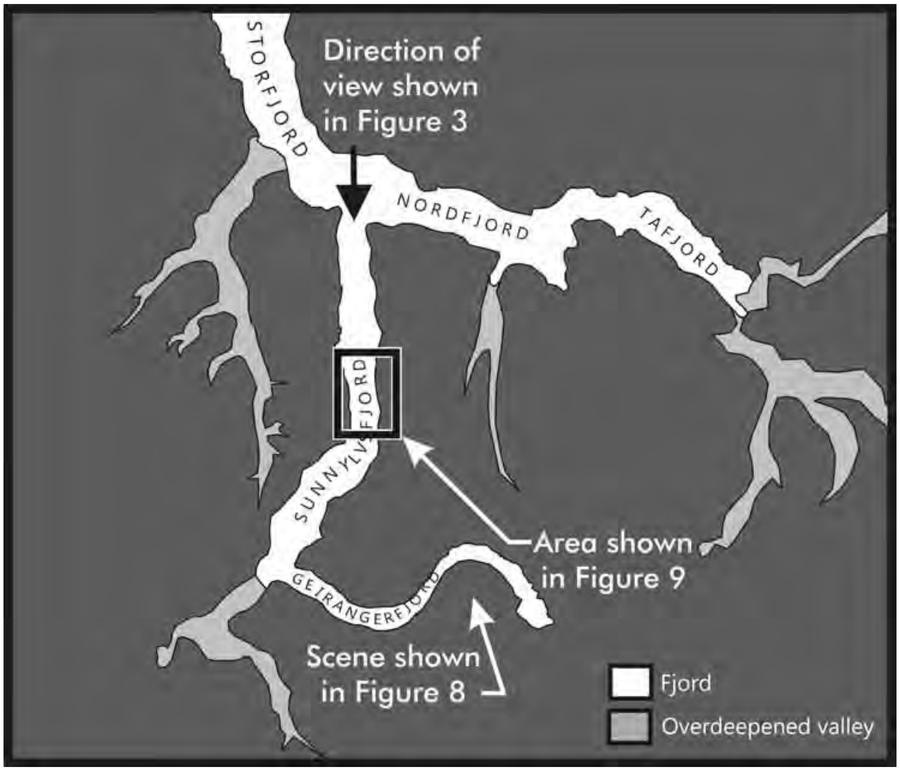

Figure 7. Map of inner Storfjord area.

ated or continued to grow in response to what were often simultaneous increases in temperature and coastal precipitation (Grove, 1988; Nesje and Dahl, 2003). The longest record comes from Jostedalsbreen, for which fluctuations in outlet glacier frontal position are indicated in Figure 5. In general, a date of ca. AD 1750 seems appropriate for the peak of the Little Ice Age in Norway.

The Little Ice Age Was Little

The observed effects of the Little Ice Age in Norway are minuscule compared to what is inferred to have happened in the unobserved (or at least undocumented) Great Ice Age. While existing glaciers advanced and small ice caps formed (Figure 8), these changes were orders of magnitude smaller than the valley widening and deepening inferred to have occurred thousands of years ago in the same areas (Figure 3). While it had profound impacts for people living proximate to the extant glaciers, and climate change (climatic deterioration) impacted thousands more, the Little Ice Age was nothing approaching the ancient icebound country with polar bears on the southwestern coast (Lillehammer, 1994).

Summary

That the Little Ice Age profoundly affected Norwegians living in proximity to glaciers is indisputable, and that its effects extended for centuries and to areas more distant from major glaciers is also documented (Figure 8). However, the name "Little Ice Age" appears appropriate, for not all marginal moraines and only a minority of terminal moraines were overtopped between 1450 and 1900. This indicates that in Norway the Little Ice Age, though noteworthy and measurable, was significantly smaller than the event or events that produced many of the topographic and geologic features we recognize as glacial. In the fjord country of western Norway, in particular, the differences are orders of magnitude in scale.

In general, the Little Ice Age appears to have peaked in Norway about the year 1750, similar to the record in Iceland (Klevberg and Oard, 2012). Grove (1988) noted the remarkable

Figure 8. The summer pasture areas (sætre) belonging to the Knivsflå and Horvadrag farms on the south side of Geirangerfjorden (Figure 5) were separated by this wall of dry-stacked rock in the late 1800s. While it may appear they simply quit building the fence, it actually ended at an ice field. The ice field is now gone. Photograph courtesy of Jens-Petter Grebstad.

correspondence between advances and retreats of similar glaciers in Iceland and Norway. Climate change during this period produced a drop in ELA in Norway of 100 to 250 m (325 to 825 ft.), indicating a depression in average temperature of as much as 2.5°C (4.5 F°) relative to AD 2000.

Landforms, sedimentary fabrics, and surface features that appear to be glacial in origin are found throughout the country, far beyond the limits of Little Ice Age glaciation, including far below present sea level. This appears to indicate a fundamental distinction between the inferred Great Ice Age and all subsequent glaciation; any subsequent glaciation may be expected to have resembled the Little Ice Age in both cause and character. Further significance of these observations to the climate change debate and ice age inferences will be addressed in future papers in this series.

Acknowledgments

Very little of this research would have been possible without the assistance of the lead author's parents and Norwegian relatives. We thank David Sunwall and Arve Misund for help in acquiring scientific papers and graphics. Jan and Inger Johanne Seland and the staff of Norges Geologiske Undersøkelse assisted the lead author in obtaining a report for the NORPAST project. We also thank Al Gore and the Nobel Peace Prize committee for generating widespread interest in our research. We gratefully acknowledge the assistance of the Creation Research Society. *Deum laudamus* (Isaiah 65:1).

Glossary

Black Death—the devastating spread of bubonic plague in Europe in medieval times. It reached Norway from England in 1349 and killed nearly two-thirds of the inhabitants.

cirque—a rounded basin eroded into a mountainside by a glacier.

continental glacier—This term is typically applied to glaciers or ice sheets covering large portions of continents, but Norwegian researchers regularly apply the term to inland glaciers af-

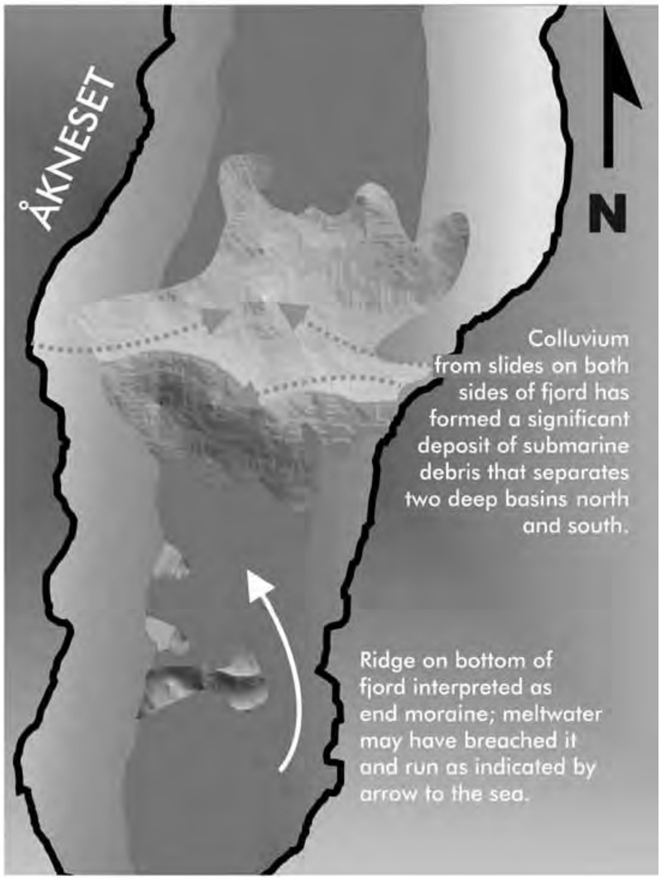

Figure 9. Moraine and landslides mapped beneath Sunnylvsfjorden, Sunnmøre. Deepest part of fjord in mapped area is nearly 500 meters (1,500 feet) deep and approximately 1,400 m (0.9 mi.) wide. Mountains flanking the fjord are about 850 m (2,800 ft.) above sea level, making the total glacial valley depth approximately 1,350 m (4,300 ft.).

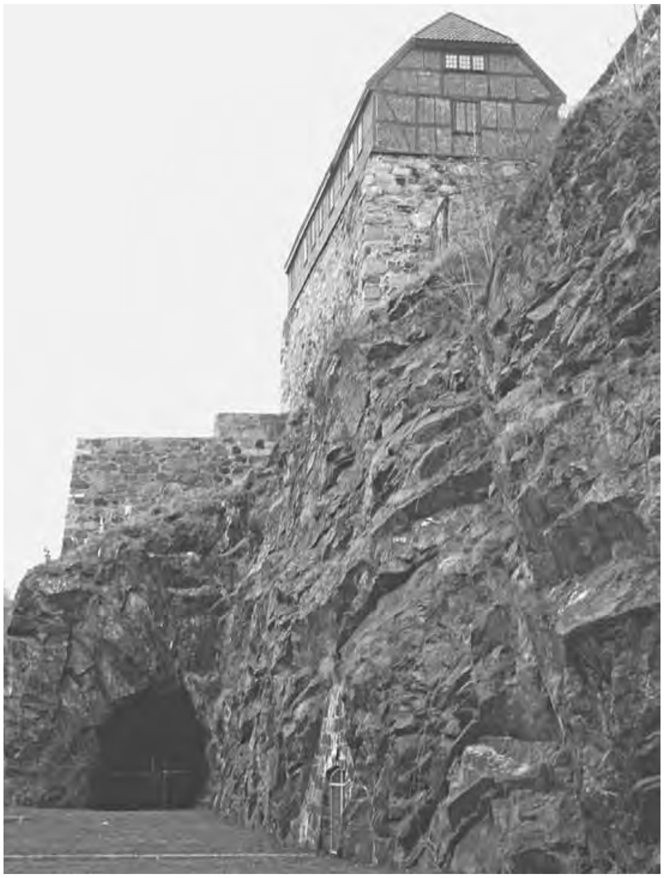

Figure 10. West side of Akershus Fortress, Oslo. The arched opening at lower left was an entrance for boats during medieval times. It is now two meters (a good six feet) above sea level.

fected by a continental rather than maritime climate.

equilibrium line altitude—the altitude at which the balance point occurs, with ice accumulating faster than it melts above the ELA and melting faster than it accumulates below the ELA.

fjord—a long, narrow arm of the sea; a deep valley, typically a drowned valley with a U-shaped section and shallower at the mouth where it meets the sea.

piedmont—at the foot of a mountain or mountain range

Appendix:

Isostasy, History, and the Great Ice Age in Norway

Early conclusions on "varves" and isostatic rebound formed the basis for opinions that affect the thinking of many to this day, despite the revelation that these rhythmites are generally not annual layers (Oard, 2009) and may often represent single depositional events (Berthault, 1986; Julien et al., 1994). Historical evidence of a much quicker and more recent isostatic adjustment is common (Figure 10—Akershus festning). Researchers routinely account for isostatic rebound in estimating treeline elevations and equilibrium limit altitudes (ELA's) in Norway and western Sweden (Bakke et al., 2005; Grove, 1988; Dahl and Nesje, 1996; and others–see many resources in paleoclimatology, e.g., the website of Norges Geologiske Undersøkelse). Dates, of course, are linked to typical uniformitarian assumptions and methods (Lillehammer, 1994).

Many places in Norway attest to the significance of *landheving*, the gradual elevation of the land over time. The same effect could be produced by eustasy, that is, change in sea level. This would require a significant drop in sea level, something not observed elsewhere. Instead, *landheving* has occurred in a roughly bullseye pattern (isostatic rebound), and with what is believed to be a modest *rise* in sea level (Grove, 1988; Lillehammer, 1994) widely attributed to global warming.

References

Aa, A.R. 1996. Topographic control of equilibrium-line altitude depression on reconstructed "Little Ice Age" glaciers, Grovabreen, western Norway. *The Holocene* 6:82–89.

Bakke, J., S.O. Dahl, Ø. Paasche, R. Løvlie, and A. Nesje. 2005. Glacier fluctuations, equilibrium-line altitudes and paleoclimate in Lyngen, northern Norway, during the Lateglacial and Holocene. *The Holocene* 15(4):518–540.

Bakke, J., Ø. Lie, S.O. Dahl, A. Nesje, and A.E. Bjune. 2008. Strength and spatial patterns of the Holocene wintertime westerlies in the NE Atlantic region. *Global and Planetary Change* 60:28–41.

Berthault, Guy. 1986. Experiments on lamination of sediments, resulting from a periodic graded-bedding subsequent to deposit. A contribution to the explanation of lamination of various sediments and sedimentary rocks. *Compte Rendus Academie des Sciences, Série II: Mecanique, Physique, Chimie, Sciences de la Terre et de l'Univers* 303:1569–1574.

Björnsson, H. 1980. Glaciers in Iceland. In Comité National Français de Géologie, *Geology of the European Countries: Denmark, Finland, Iceland, Norway, Sweden*, pp. 136–157. Graham and Trotman, London, UK.

Bjune, A.E., J. Bakke, A. Nesje, and H.J.B. Birks. 2005. Holocene mean July temperature and winter precipitation in western Norway inferred from palynological and glaciological lake-sediment proxies. *The Holocene* 15:177-189.

Bjørvik, H. 1996. *Folketap og sammendbrudd 1350–1520*. (Volume 4 of *Aschehougs norges historie*) [in Norwegian]. Aschehoug & Co. (W. Nygaard), Oslo, Norway.

Brown, R.H. 2006. Update on C-14 age calibration. *Creation Research Society Quarterly* 43:54.

Caseldine, C.J. 1987. Neoglacial glacier variations in northern Iceland: examples from the Eyjafjörður area. *Arctic and Alpine Research* 19:296–304.

Caseldine, C., and J. Stötter. 1993. "Little Ice Age" glaciation of Tröllaskagi Peninsula, northern Iceland: climatic implications for reconstructed equilibrium line altitudes (ELAs). *The Holocene* 3(4):357–366.

Dahl, O., and A. Nesje. 1994. Holocene glacier fluctuations at Hardangerjøkulen, central-southern Norway: a high-resolution composite chronology from lacustrine and terrestrial deposits. *The Holocene* 4:269–277.

Dahl, O., and A. Nesje. 1996. A new approach to calculating Holocene winter precipitation by combining glacier equilibrium-line altitudes and pine-tree limits: a case study from Hardangerjøkulen, central southern Norway. *The Holocene* 6:381-398.

Dyrvik, S., and O. Feldbæk. 1996. *Mellom brødre 1780–1830*. (Volume 7 of *Aschehougs norges historie*) [in Norwegian]. Aschehoug & Co. (W. Nygaard), Oslo, Norway.

Evans, D.J.A., and D.R. Twigg. 2002. The active temperate glacial landsystem: a model based on Breiðamerkurjökull and Fjallsjökull, Iceland. *Quarternary Science Reviews* 21:2143–2177.

Fagan, B. 2000. *The Little Ice Age: How Climate Made History 1300–1850*. Basic Books, New York, NY.

Follestad, B.A., and O. Fredin. 2007. Late Weichselian ice flow evolution in south-central Norway. *Norwegian Journal of Geology* 87:281–289.

Grove, J.M. 1988. *The Little Ice Age*. Metheun & Co., Ltd. New York, NY.

Grove, J.M. 2001. The initiation of the "Little Ice Age" in regions round the North Atlantic. In Ogilvie, A.E.J., and T. Jónsson (editors), *The Iceberg in the Mist: Northern Research in Pursuit of a "Little Ice Age,"* pp. 53–82. Kluwer Academic Publishers, Boston, MA.

Guðmundsson, H.J. 1998. Holocene glacier fluctuations of the Eiríksjökull ice cap, west central Iceland. *Jökull* 46:17–28.

Haberle, T. 1991. Holocene glacial history of the Hörgárdalur area, Tröllaskagi, northern Iceland. In Maizels, J.K., and C. Caseldine (editors), *Environmental Change in Iceland: Past and Present*, pp. 193–202. Kluwer Academic Publishers, Boston, MA.

Helle, K. 1995. *Under kirke og kongemakt 1130–1350*. (Volume 3 of *Aschehougs norges historie*) [in Norwegian]. Aschehoug & Co. (W. Nygaard), Oslo, Norway.

Jensen, C., and K.-D. Vorren. 2008. Holocene vegetation and climate dynamics of the boreal alpine ecotone of northwestern Fennoscandia. *Journal of Quaternary Science* 23:719–743.

Julien, P.Y., Y. Lan, and G. Berthault. 1994. Experiments on stratification of heterogeneous sand mixtures. *Creation Ex Nihilo Technical Journal* (now *Journal of Creation*) 8(1):37–50.

Karlén, W. 1981. A comment on John A. Matthews's article regarding ^{14}C dates of glacial variations. *Geografiska Annaler* 63:1–2.

Karlén, W., and J. Kuylenstierna. 1996. On solar forcing of Holocene climate: evidence from Scandinavia. *The Holocene*: 359-365.

Kjøllmoen, B. (editor). 2007. *Glaciological investigations in Norway in 2006*. Norsk Vassdrags og Energi Direktoratet, Oslo, Norway.

Klevberg, P., and M.J. Oard. 2011a. The Little Ice Age in the North Atlantic region—part I: introduction to paleoclimatology. *Creation Research Society Quarterly* 47:213–227.

Klevberg, P., and M.J. Oard. 2011b. The Little Ice Age in the North Atlantic region—part II: magnitude, extent, and importance of the Little Ice Age. *Creation Research Society Quarterly* 48:49–58.

Klevberg, P., and M.J. Oard. 2012. The Little Ice Age in the North Atlantic region—part III: Iceland. *Creation Research Society Quarterly* 48:224–238.

Krag, C. 1995. *Vikingtid og rikssamling 800–1130*. (Volume 2 of *Aschehougs norges historie*) [in Norwegian]. Aschehoug & Co. (W. Nygaard), Oslo, Norway.

Larsen, E., O. Longvå, and B.A. Follestad. 2006. Formation of DeGeer moraines and implications for deglaciation dynamics. *Journal of Quaternary Science* 6:263–277.

Lepperød, T. 2010. Ny kunnskap om villreinjakt for 1500 år siden [in Norwegian]. *Nettavisen* 26 September 2010. http://www.nettavisen.no/nyheter/article2984290.ece (accessed December 3, 2010).

Lidmar-Bergström, K., C.D. Ollier, and J.R. Sulebak. 2000. Landforms and uplift history of southern Norway. *Global and Planetary Change* 24:211–231.

Liestøl, O. 1967. Storbreen glacier in Jotunheimen, Norway. *Norsk Polarinstitututt Skrifter*. Nr. 141.

Lillehammer, A. 1994. *Fra jeger til bonde–inntil 800 e.Kr*. (Volume 1 of *Aschehougs norges historie*) [in Norwegian]. Aschehoug & Co. (W. Nygaard), Oslo, Norway.

Matthews, J.A. 1982. Soil dating and glacier variations: a reply to Wibjörn Karlén. *Geografiska Annaler* 64:1–2.

Matthews, J.A., A. Nesje, and S-O. Dahl. 1996. Reassessment of supposed early "Little Ice Age" and older Neoglacial moraines in the Sandane area of western Norway. *The Holocene* 6:106–110.

McKinzey, K.M., J.F. Orwin, and T. Bradwell. 2005. A revised chronology of key Vatnajökull (Iceland) outlet glaciers during the Little Ice Age. *Annals of Glaciology* 42:171–179.

Nesje, A. 2005. Briksdalsbreen in western Norway: AD 1900–2004 frontal fluctuations as a combined effect of variations in winter precipitation and summer temperature. *The Holocene* 15:1245–1252.

Nesje, A., and S.O. Dahl. 2003. The "Little Ice Age"–only temperature? *The Holocene* 13:139–145, 147.

Nesje, A., J. Bakke, S-O. Dahl, Ø. Lie, and J.A. Matthews. 2008. Norwegian mountain glaciers in the past, present and future. *Global and Planetary Change* 60:10–27.

Nordli, P.Ø. 2001. Reconstruction of nineteenth century summer temperatures in Norway by proxy data from farmers' diaries. In Ogilvie, A.E.J., and T. Jónsson, (editors), *The Iceberg in the Mist: Northern Research in Pursuit of a "Little Ice Age,"* pp. 201–218. Kluwer Academic Publishers, Boston, MA.

Nordli, P.Ø., Ø. Lie, A. Nesje, and S.O. Dahl. 2003. Spring-summer temperature reconstruction in Western Norway 1734–2003: a data-synthesis approach. *International Journal of Climatology* 23:1821–1841.

NORPAST. 2001. Third report, NORPAST–past climates of the Norwegian region. Norges Geologiske Undersøkelse (the geological survey of Norway, with the Norwegian research council, environment and development, research program on climate and ozone layer change, the national meteorological institute, and the universities in Bergen, Tromsø, and Ås).

Oard, M.J. 2009. Do varves contradict biblical history? In Oard, M.J., and J.K. Reed (editors), *Rock Solid Answers*, pp.125–148. Master Books, Green Forest, AR.

Rian, Ø. 1995. *Den nye begynnelsen 1520–1660*. (Volume 5 of *Aschehougs norges historie*) [in Norwegian]. Aschehoug & Co. (W. Nygaard), Oslo, Norway.

Seip, A-L. 1997. *Nasjonen bygges, 1830–1870*. (Volume 8 of *Aschehougs norges historie*) [in Norwegian]. Aschehoug & Co. (W. Nygaard), Oslo, Norway.

Sogner, S. 1996. *Krig og fred 1660–1780*. (Volume 6 of *Aschehougs norges historie*) [in Norwegian]. Aschehoug & Co. (W. Nygaard), Oslo, Norway.

Strøm, H. (1762) 2001. *Søndmørs beskrivelse* [in Dano-Norwegian]. Reprint, Vista / Stavanger Offset, Stavanger, Norway.

Winkler, S., J. Matthews, R.A. Shakesby, and P.Q. Dresser. 2003. Glacier variations in Breheimen, southern Norway: dating Little Ice Age moraine sequences at seven low-altitude glaciers. *Journal of Quaternary Science* 18:395–413.