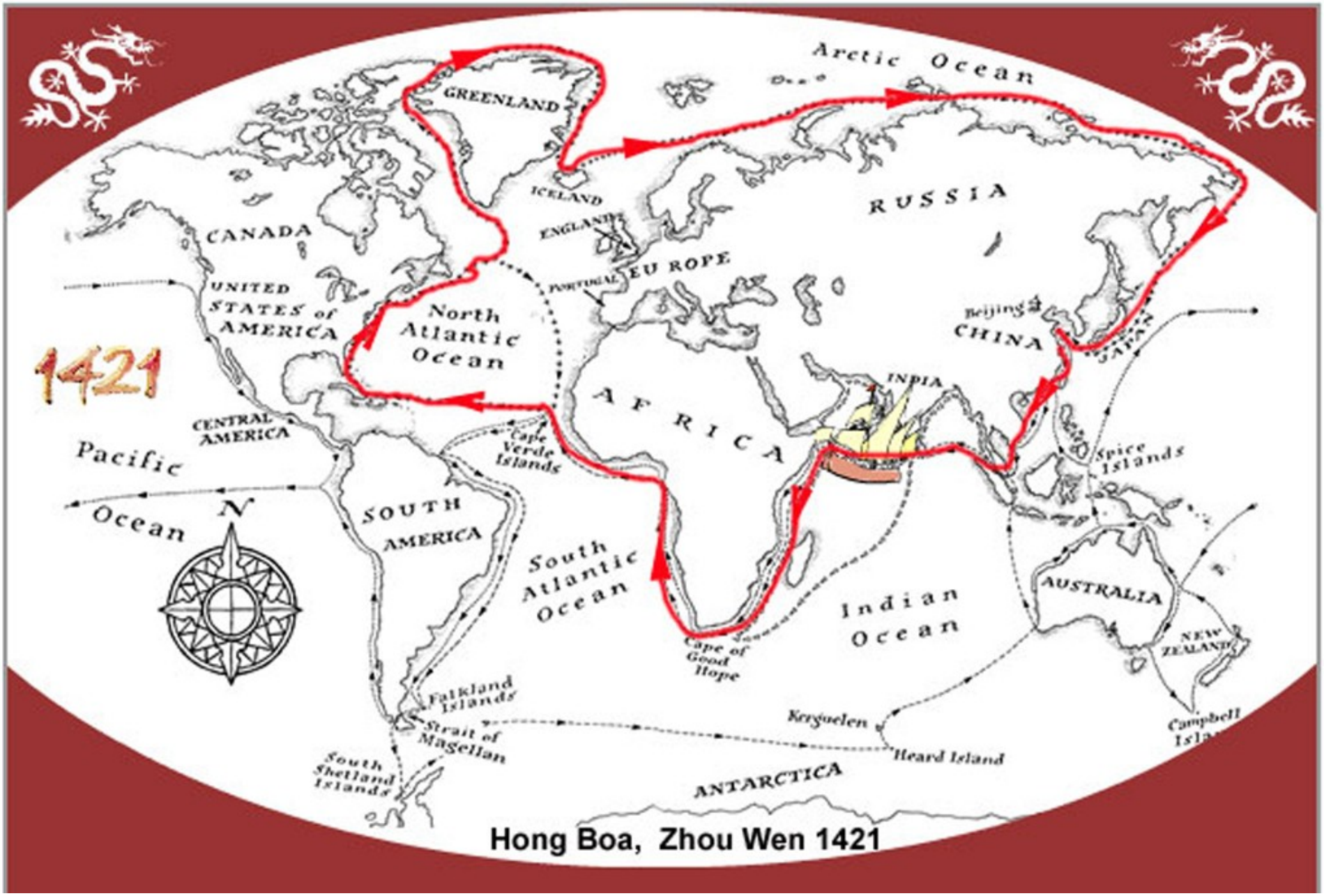
Arctic Ocean
GREENLAND
ICELAND
ENGLAND
RUSSIA
CANADA
EU ROPE
PORTUGAL
UNITED STATES of AMERICA
North Atlantic Ocean
Beijing
CHINA
1421
INDIA
AFRICA
CENTRAL AMERICA
Cape Verde Islands
Spice Islands
Pacific Ocean
N
SOUTH AMERICA
South Atlantic Ocean
Indian Ocean
AUSTRALIA
NEW ZEALAND
Cape of Good Hope
Falkland Islands
Strait of Magellan
Kerguelen
Heard Island
Campbell Isla
South Shetland Islands
ANTARCTICA
Hong Boa, Zhou Wen 1421

The following detailed chronology of late Holocene climatic and historic events is based primarily on Le Roy Ladurie (1971), Grove (1988), Savage (1995), Nesje and Dahl (2000), and other sources as noted.

Medieval climatic optimum

- 760-810: Multi-year droughts initiated first collapse phase of classical Mayan civilization in the Yucatán Peninsula of Mexico (Peterson and Haug 2005).
- 793: Viking raid at Lindisfarne, England. This was the beginning of major Viking expansions outward from Scandinavia.
- 800-1000s: Aletsch and Grindelwald glaciers (Switzerland) were much smaller than today.
- 835: Viking invasions of England, Scotland, Wales, Ireland, and France began in earnest. By the mid-9th century most of these areas were permanently occupied by Vikings.
- 860: Second collapse phase of Mayan civilization caused by mulit-year drought (Peterson and Haug 2005).
- 870: Vikings have taken all of England, except for the Wessex region. England became an Anglo-Danish dominion by end of 9th century.
- 874: Settlement of Iceland began; Viking immigration from Norway, England, Ireland, Faeroes, *etc.* Glaciers of Iceland much smaller than today.
- 880-1140: Radiocarbon dates on trees that grew in Canada far north of modern timberline.
- 910: Final collapse phase of Mayan civilization caused by mulit-year drought (Peterson and Haug 2005).
- 911: Viking dukedom granted by France in the area of Normandy (= *Norse land*), with its center at Rouen. Normandy became one of the strongest of Viking dukedoms.
- 924: Aethelstan became king of Wessex and began a drive to force the Vikings out of southern England. During the mid-10th century, the Anglo-Saxon kindgom became dominant in southern England.
- 930: Iceland nation established as independent commonwealth; population estimate of 25,000 to 40,000 inhabitants (Magnusson 1987).
- 985: Settlement of Greenland began.
- 1000: Short-lived Norse attempt to settle in Newfoundland was thwarted by native resistance.
- 1000s: Low radiocarbon levels in tree rings indicate high solar output and presumably warmer temperatures.
- 1000s: Decline in Tiwanaku culture in Bolvian-Peruvian altiplano linked to prolonged drought conditions (Peterson and Haug 2005).
- 1000s: Tyndall Glacier (Mt. Kenya, Africa) begins to advance (Mahaney 1990).
- 1000-1200: Rapid population growth in Estonia based on cereal grains—barley, rye, wheat. Northernmost region for crop tillage as the primary means of subsistence. Population by early 13th century at least 150,000 people (Tannberg et al. 2000).
- 1000-1300: Frequent severe droughts in the Great Plains of the central United States (Miao et al. 2007).
- 1020-1200: Minimal sea-ice cover around Iceland.

- 1066: Norman invasion of England led by William the Conqueror. The Anglo-Saxon kindgom was defeated, and William became king of England. The Norman (Viking) empire included all of England, Normandy, and much of western France.
- 1080-1180: Favorable interval of mild winters and dry summers in western Europe: England, France, Germany.
- 1100: Human population of Iceland reached an estimated peak of 70,000 inhabitants (Magnusson 1987).
- 1100-1300: Warm and dry interval in west-central Asia based on lake sediment, north of the Tien Shan Mountains in northwestern China (Long et al. 2011).
- 1104: Hekla volcano erupted in Iceland following several centuries of quiescence. Rich farming region of Thjórsárdalur was completely destroyed and abandoned (Bárdarson 1991). Hekla has since become one of the most active volcanoes in the world.

Hekla, an active volcano in south-central Iceland. Following a long quiet period, this volcano erupted in 1104 and has since been one of the world's most active volcanoes. The barren scoria fields in the foreground attest to the local effects of this volcano. Photo date 8/94; © by J.S. Aber.

- 1126: Greenland obtains Catholic bishop; Norse population of 2,000 to 4,000 in two well developed settlements in southwestern coastal region.

Medieval glaciation

- Late 1100s: Sharp fall in Camp Century ice-core ^{18}O content signals lower temperature in North Atlantic region.
- 1200: Foraminifera in deep Atlantic sediments show culmination of warming trend of preceding few centuries.
- 1200: Beginning of increased sea ice in coastal waters of Iceland.
- 1200s: Glaciers began to advance in Iceland.
- 1215-1350: Glaciers began to advance in several parts of Europe.
- 1215: *Oberriederin* (irrigation canal) overrun by advance of Aletsch glacier; radiocarbon dates on buried larch; canal head still covered by modern Aletsch glacier.
- 1227: Thick sea ice on the Baltic allowed a German army to march from the mainland of Estonia to the islands of Muhu and Saaremaa and to capture those islands (Tannberg et al. 2000).
- 1261: Greenland accepted sovereignty of the King of Norway; Iceland also voted allegiance to the king in 1262.
- 1275: Initial expansion of perennial snow and ice cover on Baffin Island that killed and buried vegetation, which is just now beginning to emerge (Morton 2012).
- 1275-1300: Prolonged drought caused disappearance of cliff-dwelling Anasazi culture in southwestern U.S. (Peterson and Haug 2005).

- 1280: Radiocarbon date on wood (*Pinus cembro*) of forest buried by advance of Grindelwald glacier; forest does not again grow on site today.
- 1300s: Decline of vineyards in Germany; vineyards completely disappeared in England.
- 1300-1350: Fishing replaced cereal crops as main food resource in Iceland.
- 1315: Crop failure and starvation in northern Estonia (Tannberg et al. 2000).
- Mid-1300s: Old sea route from Iceland directly west to Greenland impassable due to southward expansion of sea ice; serious decline began in Greenland settlements.
- 1340-50: Western (northern) settlement in Greenland abandoned and derelict.
- 1350: Beginning of disasterous wind-blown sand drifting along northwestern coast of Denmark. Episodes of wind erosion and sand-dune migration occurred several times during the following centuries (Clemmensen and Andersen 1998).
- 1380-1460: Minimal sea-ice cover around Iceland.
- 1397: Union of Kalmar; Greenland and Iceland became colonies of Danish Kingdom.
- 1400-1700: 3‰ decline in ^{18}O values for Inuit and Norse teeth in western Greenland implies significant climatic cooling.

Norse skeletal remains from graves at Hvalsey church, Greenland. ^{18}O values from tooth enamel indicate sharply colder temperature during the Little Ice Age (Fricke *et al.* 1995). Photo by Preben Jensen; reproduced by permission.

- 1400-1750: Cold and wet interval in west-central Asia based on lake sediment, north of the Tien Shan Mountains in northwestern China (Long et al. 2011).
- 1408-10: Last reliable account of Norsemen still living in Greenland; all had perished by end of 15th century.
- 1450: Further expansion of perennial snow and ice cover on Baffin Island that killed and buried vegetation, which is just now beginning to emerge (Morton 2012).
- 1460: Increased sea ice in coastal waters of Iceland.
- 1460-1560: End of Medieval glaciation was followed by a century of relatively mild climate.
- 1510: German merchants visited Greenland and found Innuits living among ruins of Norse settlements.
- 1530-75: Chamonix/Mont Blanc glaciers (France) advanced, but caused no damages.

Little Ice Age

- 1570: Medieval gold mines of Hohe Tauern blocked by glacier ice; Icelandic glaciers much larger than today.
- 1585: First account of **cave glacier** from Jura region; a natural cave filled with ice formations that persisted until 1910.

- 1588: Grindelwald glacier broke through its end moraine.
- 1594-98: Glaciers of Italian Alps advanced markedly.
- 1595: Gietroz glacier (Switzerland) advanced, dammed Dranse River, and caused flooding of Bagnes with 70 deaths.
- 1600: Eruption of Huaynaputina volcano (Peru) caused the most severe short-term cooling event of the past 600 years in the northern hemisphere.
- 1600: Vernagt glacier (eastern Alps) advanced and blocked Rofenthal causing lake to form; failure of ice dam led to destructive flooding.
- 1600: Dramatic increase in sea ice in coastal waters of Iceland which lasted until early 20th century.
- 1600-10: Advances by Chamonix glaciers accompanied by massive floods entirely destroyed three villages--Bonnenuit, Le Chatelard and La Bonneville--and severely damaged a fourth, La Rosiere. Oldest village (Le Chatelard) dated from 1200s.
- 1600-1700: Western coast of Greenland began to submerge due to crustal depression adjacent to thicker ice sheet; submergence continued.
- 1640-50: General glacier advances throughout Alps. Fossil trees (*P. cembro*) from high moraines in Mont Blanc vicinity radiocarbon dated to 1630-80 interval.
- 1644: Chamonix glaciers advanced across Chamonix valley and threatened to transform valley into lake. Swiss glaciers expanded to their maximum Little Ice Age positions: 1644-53.
- 1650s: Some signs of moderation; Chamonix glaciers retreated slightly from their terminal moraines.
- 1650-1700: Rapid rise in Black Sea chemocline corresponds to end of the peak bloom period of *Emiliana huxleyi* (coccolithophore) brought about by colder temperature, winter storms, and mixing surface and nutrient-rich deep water (Arnold et al. 2012).
- 1670-80s: No signs of significant waning. Maximum historical advances achieved by glaciers in eastern Alps; Vernagt glacier again caused flooding. Noticeable decline of human population by this time in areas close to glaciers, whereas population elsewhere in Europe had risen.
- 1690s: Moderate withdrawal of many glaciers in Alps took place; Chamonix glaciers retreated about 500 m. Norwegian glaciers experienced opposite trend, however, with marked advances.
- Late 1600s: Recurrent famine in Scotland; 100,000 Scots had emigrated to northern Ireland by 1691 (Oppenheimer and Boyle 1990).
- 1693: Hekla (Iceland) experienced enormous eruption, in which 22,000 km² of land was covered by tephra fall; 55 farms were ruined or badly damaged in neighboring districts (Bárdarson 1991).
- 1695-97: Great Famine of Estonia. Climate was unfavorable for crops in 1694; summer of 1695 was cold and rainy, followed by an early autumn frost that destroyed the summer crops. Cold conditions continued during 1696, and rain fell throughout the summer. Peasants, orphans and the elderly began to die *en masse* of starvation. Melting of snow in spring 1697 revealed many corpses. Meanwhile, rich landlords and merchants exported grain to Finland and Sweden, where crops also had failed. 70,000 to 75,000 people died during the famine in Estonia, which did not end until 1698 (Tannberg et al. 2000).

- 1695-1709: Outlet glaciers of Drangajökull and Vatnajökull (Iceland) advanced dramatically, approaching or destroying farms. One farm at Fjallsjökull dated from AD 900 (Bárdarson 1991).

Fjallsjökull, an outlet glacier of Vatnajökull ice cap on the southeastern coast of Iceland. Advance of this glacier in the 1695-1710 period destroyed a farm that dated from Viking settlement. Photo date 8/94; © by J.S. Aber.

- 1700-20: Glaciers maintained overall positions in Europe; some minor advances and retreats took place.
- 1700-21: Great Northern War: crippled by the famine of late 1690s, Sweden was vulnerable to attack by Russia, Poland, and Denmark. Weakend by war, famine and plague, Swedish power over the Baltic region was broken.
- 1710: Nigardsbreen (Norway) was advancing at rate which averaged 100 m per year over next 25 years.
- 1720: Engabreen (Norway) buried a farm; other glaciers threatened farms in Norway.
- 1720-30s: Alpine glaciers maintained positions, much larger than today, but did not experience major advances.
- 1732: Vatnajökull crushed ruins of Icelandic farm that had been abandoned during earlier advance.
- 1735: Nigardsbreen destroyed pasture land and threatened a farm, which was completely destroyed by ice in 1743.

Nigardsbreen, an outlet glacier of Jostedalsbreen, is visible at the valley head in the distance. In the early 1700s, this glacier expanded dramatically and destroyed a farm. The combination of glacier advances, melt-water floods, and other disasters led to much human suffering in the vicinity. Photo date 6/87; © by J.S. Aber.

- 1740s: Glaciers advanced in all Alpine regions, including Chamonix glaciers, Grindelwald and Vernagt glaciers.
- 1741: Drangajökull destroyed another farm in Iceland.
- 1748-50: Norwegian glaciers achieved their historical maximum Little Ice Age positions.

Tuftebreen is a small outlet glacier of Jostedalsbreen. It is just visible at top of the mountain side in this view. During the Little Ice Age this glacier advanced and reached a maximum position about A.D. 1750. The maximum limit is marked by the stony lateral moraine on the valley floor. The glacier destroyed some pasture, but the local farm survived. Photo date 6/87; © by J.S. Aber.

- 1760-90: Long-term "normality" of glacier expansion accepted; no real sign of significant glacier retreats.
- 1775: Worst episode of sand-dune drifting in northwestern Denmark. Many farms, villages, and churches were destroyed during the late 1700s.

St. Laurentii Church was partly buried by drifting sand dunes in 1775; the entrance could be held open only by digging away sand during following years. In 1795, the church was abandoned, and the walls were torn down in 1810 (Langberg 1971). Only the tower survives; it was utilized as a lighthouse for some years. Photo date 6/79; © J.S. Aber.

- 1780: New York Harbor froze over for the first recorded time allowing people to walk from Manhattan Island to Staten Island (Morton 2012).
- 1783-84: Huge fissure eruptions of Laki volcano in Iceland; greatest historical volcanic eruptions anywhere in world; possibly largest in all Holocene (Bárdarson 1991). Volcanic gas (SO_2) killed vegetation, plus a severe winter resulted in mass starvation of livestock. The "haze famine" killed about one-quarter of Iceland's human population.

Laki volcano erupted in Iceland in 1783-84. A tremendous volume of lava poured from fissures and spread across the landscape as *aa flows*. These flows are now covered by moss, as seen here. The Laki eruption was one of the largest anywhere, and the resulting famine was the greatest natural disaster in the history of Iceland. Photo date 8/94; © by J.S. Aber.

- 1806-08: Crop failures and famine in Estonia (Tannberg et al. 2000).
- 1810-1819: Coldest decade of the last 1250 years in the French Alps, according to tree-ring data (Corona et al. 2011). Mean summer temperature was 3 °C lower than the warmest decades (810s and 1990s).

1816: Coldest single year on record in many places in Europe and North America, following the 1815 eruption of Mount Tambora in Indonesia.

- 1816-25: New glacier offensive throughout Europe; all Alpine glaciers showed advances reaching positions slightly short of 17th century Alpine maximum limits.
- 1830-40s: Moderate retreat shown by many glaciers.

- 1840s: Introduction of potatoes in Estonia put an end to recurring famines (Tannberg et al. 2000).
- 1850-55: Fairly general glacier advances throughout Alps; some panic in population, but no serious damages resulted.
- 1855: Signs of moderate retreats by Chamonix glaciers.

End of the Little Ice Age

- 1860-80s: Evidence of pronounced glacier withdrawal all over continental Europe; many Alpine glaciers retreated >1 km by end of 19th century. Icelandic glaciers remained in advanced positions, however.
- 1870: Athabasca glacier of the Columbia Icefield (Alberta, Canada) advanced to near its Little Ice Age maximum completely blocking Sunwapta valley. Other glaciers in western Canada experienced major expansions.
- Late 1800s: Little Ice maximum in western Canada, which is contrary to general glacier retreat in most other part of the world—see **Fig. 19-17**.

View from crest of Little Ice Age recessional moraine looking upvalley toward Hilda Glacier, Alberta, Canada. The glacier has wasted to a very small size during this century. Photo date 8/85; © by J.S. Aber.

View downvalley, showing Little Ice Age moraines built by Hilda Glacier. The outermost lateral moraine (left foreground) marks the maximum Little Ice Age ice margin, 1870-90s. Some of the moraines retain a core of stagnant ice that is insulated by the cover of sediment. Photo date 8/85; © by J.S. Aber.

- 1890: Eyjabakkajökull, an outlet glacier of Vatnajökull (Iceland), surged to its maximum historical limit.
- 1890: Approximate end of Little Ice Age climate in Svalbard based on lake sediments (Jiang et al. 2011).
- 1900: Sléttjökull, an outlet glacier of Mýrdalsjökull (Iceland), stood at its Little Ice Age maximum. Other Icelandic glaciers at or near their maxima.

View from margin of Sléttjökull looking northward over the recently deglaciated landscape. At the beginning of the 20th century, the margin of Sléttjökull was located at the end moraine (yellow dots) in the middle distance, about 2 km from the present ice margin. Photo date 8/94; © by J.S. Aber.

- Early 1900s: Rapid retreat by glaciers on Mt. Kenya, Africa.

- 1917: Iceland became an independent sovereign state; gained full independence from Denmark in 1944.
- 1920: Marked decrease in sea ice in coastal waters of Iceland. Summer temperature rises markedly in the French Alps (Corona et al. 2011).
- 1920-30s: Glaciers declined rapidly everywhere, except Antarctica; **end of Little Ice Ages**.


During the 1930s, Nigardsbreen (Norway) retreated rapidly and uncovered a rock basin in which this proglacial lake is ponded. A lateral moraine from an earlier retreat phase is visible above the lake in the right foreground. Photo date 6/87; © by J.S. Aber.

Wine harvests of western Europe

Phenology is the study of seasonal dates of plant growth phenomena, such as flowering or ripening in fruit trees or grape vines. The date at which grapes ripen is mainly a function of summer temperature; warm, sunny weather results in an early wine harvest, and *vice versa*. Good historical records of the annual wine harvest have been compiled from towns in western Europe (France and Switzerland) by historians interested in the impact of climate on human activities (Le Roy Ladurie 1971).

The following chronology indicates a close correspondence between wine harvest dates and glacier advances during the Little Ice Age. Early wine harvests generally coincided with glacier retreats; late harvests were times of glacier advances. However, glacier responses usually lagged a few years behind the climatic changes indicated by wine harvest dates. Chronology of wine harvest dates and climatic conditions in western Europe is based on Le Roy Ladurie (1971).

- 1510-1559: Decidedly warm overall, average harvest date 26 Sept.
- 1560-1600: Definitely cooler, average harvest date 30 Sept. 1590s was coldest decade of 16th century.
- 1601-1616: Warm or average conditions, average harvest 25 Sept.
- 1617-1650: Outstanding cold episodes with low temperatures and late wine harvests.
- 1651-1686: Early wine harvest dates with drought episodes.
- 1687-1703: Late wine harvests, exceptionally cold spring/summer temperatures (thermometer readings). 1690s was coldest decade of 17th century, crop failures common.
- 1711-1717: Cold spring/summer weather, late wine harvests.
- 1718-1737: Warm spring/summer weather, early wine harvests.
- 1739-1752: Cold spring/summer weather, late wine harvests.

- 1757-1763: Warm spring/summer weather, early wine harvests.
- 1765-1777: Especially cold, wet spring/summer weather, low barometric pressure, late wine harvests.
- 1778-1784: Warm spell throughout Europe, highest thermometer readings recorded prior to 20th century.
- 1801-1811: Hot summers, early wine harvests.
- 1812-1817: Cold, wet spring/summer weather. 1816 coldest year on record, latest wine harvests ever known (early November), cereal crops failed.
- 1850-1856: Cold springs and cool summers, late wine harvests.
- post-1856: Warm, clear spring/summer weather, high air pressure, early wine harvests, end of Little Ice Ages in western Europe.

Reference:

Late Holocene climatic change

- Aarseth, I., Holtedahl, H., Kjeldsen, O., Liestøl, O., Østrem, G. and Sollid, J.L. 1980. Glaciation and deglaciation in central Norway. *Norsk Polarinstitutt, Field Guide to Excursion,* 31 August-3 September, 1980.
- Arnold, G.L., Lyons, T.W., Gordon, G.W. and Anbar, A.D. 2012. Extreme change in sulfide concentrations in the Black Sea during the Little Ice Age reconstructed using molybdenum isotopes. *Geology* 40/7, p. 595-598.
- Bárdarson, H.R. 1991. *Ice and fire,* 4th Ed. Reykjavík, 244 p.
- Baroni, C. and Orombelli, G. 1994. Abandoned penquin rookeries as Holocene paleoclimatic indicators in Antarctica. *Geology* 22:23-26.
- Bernhardt, C.E., Horton, B.P. and Stanley, J.-D. 2012. Nile Delta vegetation response to Holocene climate variability. *Geology* 40/7, p. 615-618.
- Broecker, W.S. and Denton, G.H. 1989. The role of ocean-atmosphere reorganization in glacial cycles. *Geochimica et Cosmochimica* 53: 2465-2501.
- Brush, G.S. 1991. Stratigraphic history helps us understand today's Chesapeake Bay. *Geotimes* 36:21-23.
- Campbell, I.D. *et al.* (1998). Late Holocene ~1500 yr climatic periodicities and their implications. *Geology* 26:471-473.
- Clemmensen, L.B. and Andersen, C. 1998. Late Holocene deflation of beach deposits, Skagen Odde, Denmark. *Geological Society Denmark, Bulletin* 44:187-188.
- Cook, E., Bird, T., Peterson, M., Barbetti, M., Buckley, B., D'Arrigo, R., Francey, R. and Tans, P. 1991. Climatic change in Tasmania inferred from a 1089-year tree-ring chronlogy of Huon Pine. *Science* 253:1266-1268.

- Corona, C., Edouard, J.-L., Guibal, F., Guiot, J., Bernard, S., Thomas, A. and Denelle, N. 2011. Long-term summer (AD751-2008) temperature fluctuation in the French Alps based on tree-ring data. *Boreas* 40, p. 351-366.
- Fricke, H.C., O'Neil, J.R. and Lynnerup, N. 1995. Oxygen isotope compositon of human tooth enamel from medieval Greenland: Linking climate and society. *Geology* 23:869-872.
- Froede, C.R. Jr. 2002. Rhizolith evidence in support of a late Holocene sea-level highstand at least 0.5 m higher than present at Key Biscayne, Florida. *Geology* 30(3), p. 203-206.
- Grove, J.M. 1988. *The Little Ice Age.* Methuen, London, 498 p.
- Jiang, S., Liu, X., Sun, J., Yuan, L., Sun, L. and Wang, Y. 2011. Record of late Holocene and recent climate change, Ny-Ålesund, Svalbard. *Boreas* 40, p. 468-480.
- Krogh, K.J. 1967. *Viking Greenland.* National Museum of Denmark, Copenhagen, 187 p.
- Langberg. H. (ed.) 1971. *Hvem byggede hvad,* vol. 3, Jylland. Politikens Forlag, Copenhagen, 400 p.
- Le Roy Ladurie, E. 1971. *Times of feast, times of famine: A history of climate since the year 1000.* Doubleday, Garden City, New York, 426 p.
- Le Roy Ladurie, E. 2004. *Histoire humaine et comparée du climat: Caniculer et glaciers XIII^{e}-XVIII^{e} siècles.* Librairie Arthème Fayard, Paris, 740 p.
- Long, M., Jinglu, W., Hong, Y., Haiao, Z. and Abuduwaili, J. 2011. The Medieval Warm Period and the Little Ice Age from a sediment record of Lake Ebinur, northwest China. *Boreas* 40, p. 518-524.
- Luckman, B.H., Holdsworth, G. and Osborn, G.D. 1993. Neoglacial glacier fluctuations in the Canadian Rockies. *Quaternary Research* 39:144-153.
- Magnusson, M. 1987. *Iceland saga.* The Bodley Head, London, 246 p.
- Mahaney, W.C. 1990. *Ice on the Equator: Quaternary geology of Mount Kenya.* W. Caxton Ltd., Sister Bay, Wisconsin, 386 p.
- Miao, X., Mason, J.A., Swinehart, J.B., Loope, D.B., Hanson, P.R., Goble, R.J. and Liu, X. 2007. A 10,000 year record of dune activity, dust storms, and severe drought in the central Great Plains. *Geology* 35, p. 119-122.
- Morton, M.C. 2012. Volcanoes sparked - and prolonged - the Little Ice Age. *Earth* 57, p. 21.
- Nansen, F. 1911. *In northern mists.* Stokes, New York, 2-volume set.
- Nesje, A. and Dahl, S.O. 2000. *Glaciers and environmental change.* Arnold, London, 203 p.
- Nesje, A. and Kvamme, M. 1991. Holocene glacier and climate variations in western Norway: Evidence for early Holocene glacier demise and multiple Neoglacial events. *Geology* 19: 610-612.
- Nunn, P.D. 2000. Environmental catastrophe in the Pacific Islands around A.D. 1300. *Geoarchaeology* 15/7, p. 715-740.
- Nunn, P.D. 2003. Nature-society interactions in the Pacific Islands. *Geografiska Annaler* 85B, p. 219-229.

- Nunn, P.D. and Britton, J.M.R. 2001. Human-environment relationships in the Pacific Islands around A.D. 1300. *Environment and History* 7, p. 3-22.
- Oppenheimer, M. and Boyle, R.H. 1990. *Dead heat.* Basic Books, New York, 268 p.
- Peterson, L.C. and Haug, G.H. 2005. Climate and the collapse of Maya civilization. *American Scientist* 93, p. 322-329.
- Polyak, V.J., Cokendolpher, J.C., Norton, R.A. and Asmerom, Y. 2001. Wetter and cooler late Holocene climate in the southwestern United States from mites preserved in stalagmites. *Geology* 29(7), p. 643-646.
- Robinson, A.B., Robinson, N.E. and Soon, W. 2007. Environmental effects of increased atmospheric carbon dioxide. *Journal of American Physicians and Surgeons* 12, p. 79-90.
- Savage, A. 1995. *The Anglo-Saxon chronicles.* Crescent Books, New York, 288 p.
- Svendsen, J.I. and Mangerud, J. 1997. Holocene glacial and climatic variations on Spitsbergen, Svalbard. *The Holocene* 7/1:45-57.
- Swinehart, J.B. 1990. Wind-blown deposits. *In* Bleed, A.B. and Flowerday, C. (eds.), *An atlas of the Sand Hills,* p. 43-56. Conservation and Survey Division, Inst. Agriculture and Natural Resources, University of Nebraska, Resource Atlas 5a.
- Swinehart, J.B. and Diffendal, R.F. Jr. 1990. Geology of the pre-dune strata. *In* Bleed, A.B. and Flowerday, C. (eds.), *An atlas of the Sand Hills,* p. 29-42. Conservation and Survey Division, Inst. Agriculture and Natural Resources, University of Nebraska, Resource Atlas 5a.
- Tannberg, T., Mäesalu, A., Lukas, T., Laur, M. and Pajur, A. 2000. *History of Estonia*. Avita, Tallinn, 335 p.
- Thompson, L.G., Mosley-Thompson, E., Dansgaard, W. and Gootes, P.M. 1986. The Little Ice Age as recorded in the stratigraphy of the tropical Quelccaya Ice Cap. *Science* 234:361-364.
- Viau, A.E., Gajewski, K., Fines, P., Atkinson, D.E. and Sawada, M.C. 2002. Widespread evidence of 1500 yr climatic variability in North America during the past 14,000 yr. *Geology* 30:455-458.