

## CLIMATE CHANGES SINCE THE LAST ICE AGE

**16,000 BC:** Variations in the Earth's orbit (orbital forcing) bring the last of some 102 Ice Ages to a peak with continental glaciers covering much of the polar and sub-polar land areas of the world. In North America, all of New England and Eastern Canada, all of the Great Lakes area, most of Ohio, Indiana, Minnesota, and North Dakota lie under thousands of feet of ice. The average surface temperature of the Earth is estimated at roughly 11° F cooler than at present. The sea level of the world ocean lies more than 300 feet lower than at present.

**16,000 BC to 10,800 BC:** These same variations in the Earth's orbit now bring about global warming. The ice sheets melt, sea levels rise. This warming causes roughly nine million cubic miles of ice to melt in approximately 9,000 years. By 7,500 BC, the last of the Northern European ice sheet leaves Scandinavia. By 5,500 BC, the last of the North American ice sheets leave eastern Canada.

This warming was neither steady nor everywhere the same. There were periods (the Dryas Stadials) when both continental and mountain glaciers advanced, and periods when they retreated. These climatic changes varied widely from place to place, with some areas being affected while others were not. The warming trend was global and obvious, but very uneven as to when and where.

**10,800 BC to 9,500 BC:** This period brought a sudden reversal in the warming trend and an extremely abrupt return to glacial advances. This cold period is called the **Younger Dryas**. Global temperatures abruptly dropped some 27°F and stayed cold for about 1,300 years. The end of the Younger Dryas came even more abruptly, with global warming of some 10°F to 18°F in less than ten years. This warming marks the end of the last ice age and the start of the modern Holocene Era.

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**9,500 BC to Present:** Gradual but erratic global warming resumes, with numerous cold periods and warm periods of varying lengths, intensities, and geographic distributions. Some of the more notable warm and cold periods of the Northern Hemisphere are noted below. The Southern Hemisphere had its own pattern of warm and cold periods, many of which were entirely different. The global historical climate picture is extremely complex and not at all well known.

**7,000 BC to 3,000 BC (The Holocene Climatic Optimum):** By 3,500 BC, world surface temperatures were 5° to 6° warmer than at present. The Arctic Ocean is ice-free during the summer months, and mountain glaciers have completely disappeared from the Norwegian mountains and the Alps in Europe, and from the Rocky Mountains of the United States and Canada. The world ocean is some ten feet higher than at present. Much of the present Sahara Desert has a moister savanna-like climate, with hippos, giraffes, crocodiles and other savanna species of wildlife. Boreal forests extended hundreds of mile farther north, and what are now the deserts of Central Asia were heavily forested.

**100 BC to 300 AD (The Roman Warm Period):** This was a period of relative warmth following the Bronze Age Cool Period. Temperatures in the Mediterranean World were very similar to those prevailing there today—perhaps a bit warmer here and a bit cooler there.

**300 AD to 900 AD (The Dark Ages Cold Period):** During this era, a series of tremendously powerful storms pounded northwestern Europe, resulting in the flooding of hundreds of miles of low-lying coastal areas and the loss of almost a million lives. The years 535-536 AD were marked by a “cold, hazy Sun”, low temperatures, summer snow, and crop failures. In 829AD, the Nile River froze over at Cairo.

**900 AD to 1350 AD (Middle Ages Warm Period):** This period showed a rapid, but uneven, warming of northern hemisphere climates. The North Atlantic becomes pretty much ice-free during the summer months and

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allows wide-spread Norse exploration as far as North America. Norse colonies in Greenland export local products to Scandinavia. Wine grapes thrived in parts of Britain where they cannot be raised today. Temperatures were from 2° to 10° warmer than at present. The period lasted only a brief 450 years. By 1,350 AD, it had pretty much vanished.

**1350 AD to 1880 AD (The Little Ice Age):** This is a period of rapid but uneven cooling of northern hemisphere climates. Alpine and Norwegian glaciers advance to their farthest extent in post-glacial times. Northern forests disappear, to be replaced with tundra. Severe winters characterize much of northern Europe and North America (much to the dismay of the early American settlers). Canals and rivers ice over, snowfalls are heavy, and summers short and cool. World surface temperatures were about 1° to 3° cooler than present.

In the US, the year 1816 is widely known as the “year with no summer”. Snow falls in New England in June. Widespread crop failures and deaths due to hypothermia are common. This cold period was contemporary with a substantial reduction in sunspot activity, and presumably a similar reduction in solar radiation.

**1880 AD to 1940 AD:** Increased solar activity corresponds with a warming trend that moves us out of the Little Ice Age,. Mountain glaciers recede and summer ice in the Arctic Ocean begins to melt again.

**1940 AD to 1977 AD:** Short cooling trend (causes unknown, but probably increased cloud cover caused by industrial pollution). Temperatures are cooler than at present. Mountain glaciers stop receding, and some start to advance. Tabloids warn of widespread catastrophes due to “New Ice Age”.

**1977 AD to 1999 AD:** Warming trend (causes unknown, but widely attributed to increases in atmospheric carbon dioxide). Tabloids warn of widespread catastrophes due to “global warming”.

**1999 AD to Present:** Slight cooling trend (causes unknown).