CLIMATE CHANGES AND THEIR INFLUENCE ON HUMAN HISTORY

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Summary

This article provides a brief survey of selected episodes in the history of the changing climate and their relations to the course of human history. In the light of the most recent investigations, the development of agriculture and ancient civilizations might be an issue of relatively stable climate during the last 10 000 years. The ancient cultures existed mostly in low geographic latitudes, that is, in warm climatic regions. In our age, the most densely populated states can be found largely in subtropical or tropical zones, in other words, in warm climatic areas, supposing that the warm climate is connected with sufficient rainfall. During World War II, an unexpected turn took place in the climate of east and north Europe: the warming trend was replaced by rapid cooling which contributed to the failure of the German offensive against the Soviet Union. In order to understand the plausible future of global climate, a new aspect is presented, namely the variations of atmospheric carbon dioxide and global temperature during the Phanerozoic. The carbon cycle in the Earth-atmosphere system suggests deprival of CO_2 from the atmosphere, mostly in the last 40 million–70 million years, and it seems evident that a great deal of the carbon has been accumulated in the lithosphere in the form of carbonates like limestone, marble, dolomite, and various sediments.

1. Introduction

The principles of modern climatology were developed by the end of the nineteenth and the beginning of the twentieth century, respectively, when instrumental observations from several decades and different regions of the world had been collected. Thus, it became possible to compare the atmospheric conditions of remote regions and characterize different classes of climate by determining the statistical features of climatological series, like averages of many years, frequencies of weather events, seasonal variations, extreme values, etc. The opinion was voiced that climate may be considered more or less constant and only weather is variable within the scope of climate. In other words, climate changes are slow and/or insignificant, while weather may vary greatly from day to day, or even from hour to hour.

In the 1960s, it became evident that the growth rate of food production in the world is less than the growth rate of the world population, so the per capita food supply is decreasing in a threatening manner. It is noteworthy that the world population doubled in 37–38 years after World War II, the shortest time ever seen. The question has been raised: how many humans could be sustained by Earth? More exactly, what is the highest potential foodproduct that can be provided with perfect utilization of Earth's resources? However, harvest depends strongly on weather and climate. If climate begins to turn worse in some regions, it may result in worldwide famine. The southward expansion of the Sahara and the repeating drought in the Sahel area emphasized the threat of unfavorable climate change. Therefore, World Conferences on Provisioning were organized, first in 1963 in Washington, D.C., later, in 1974 in Rome. It was necessary to mobilize the FAO and WMO, two specialized organizations of the United Nations, to elaborate a strategy establishing a general approach and identify the most urgent tasks.

In accordance with a former UN resolution of December 20, 1961 (1721/XVI), the WMO started to organize the World Weather Watch (WWW), a system based on three pillars: (a) the Global Observation System, including surface- and space-based atmospheric observations (meteorological satellites); (b) the Global Telecommunication System, and (c) the Global Data Processing System, including three Meteorological World Centers and about 23 Regional Centers.

Due to the rapid development of our technical ability, human activity is able to cause climate changes, at least in some respect, to be discussed by scientists. By the end of the 1960s, WWW was practically completed and, in the 1970s, WMO, after thorough preparation, began to notice the Global Atmospheric Research Program (GARP). The goal of GARP was to reveal the physical factors and constituents that contribute to the formation of weather and climate. In the light of the comprehensive investigations carried out in the GARP subprograms and the First Global GARP Experiment (FGGE), in the 1980s WMO started the World Climate Program. In the 1990s, a new scientific project began, the International Decade for Reduction of Natural Disasters, with the help of WMO.

Even this brief survey shows that climate research keeps abreast of the demands of technical and economical development. It is clear that the knowledge of past climate is indispensable for the investigation of future prospects. Human history teaches us that there are catastrophes in nature, inevitable to mankind, as well as natural disasters whose damage may be reduced or diverted. History proves that human aptitude is limited, that humans can accommodate to the changes of environment in some degree, that we are able to live with extreme weather phenomena, though reluctantly enduring the damages in both material losses and human lives. On the other hand, nature knows more ways to defend life than humans do, and climatic events that are bad for some species can be good for others.

2. Climate Changes in Prehistorical Times and Before Recent Age

According to the most recent glaciological, paleoclimatological, and oceanographical investigations, in prehistorical times, during a period of 100 000 or perhaps 250 000 years, unusual extreme temperature variations took place in a great part of the Northern Hemisphere. Similar, but much smaller, variations were identified in Antarctica by analyzing the ice cores collected from station Vostok. In 1990–1992, a glaciological expedition was organized, the Dansgaard expedition, to investigate the ice cores from central Greenland (lat 73°N, long 38°W). The length of the ice cores was more than 3000 m and their deepest layers were about 250 000 years old. The analysis of the ^{18}O isotope ratio taken from the ice cores provided an unexpected picture, namely that the last 10 000-year period had a surprisingly stable climate compared to the previous 100 000 years or even the previous 250 000 years. Between 110,000 and 10,000 BP, at least 20 rapid changes occurred in temperature, some of them within a couple of decades. These extreme temperature changes disappeared in the last 10 000 years. The mean temperature in central Greenland was about 15 K lower in the period 110,000–10,000 BP than its present value. The drastic changes during this period were verified by a number of various paleoclimatological investigations like pollen analyses, oceanographical sediments, etc.

The rapid changes may be explained, in the opinion of some researchers, as follows: a deep ocean current starting from the Denmark Strait between Iceland and Greenland fluctuates between two metastable conditions. This deep ocean current has been named the Broecker conveyor after its discoverer Wallace Broecker, an American oceanographer. This current starts from the North Atlantic, passes through the South Atlantic, the Indian Ocean, and up to the Pacific Ocean, while the countercurrents take place near the ocean surface in the form of well-known sea currents. As long as the Gulf Stream transfers water with greater salinity from subtropical to high latitudes, due to cooling and surplus salinity, this water rushes down in Denmark Strait like a huge waterfall into a depth of 3000–4000 m. This waterfall yields five million $m^3 s^{-1}$ of water and initiates the deep ocean current mentioned above. In comparison, the Amazon yields 120 thousand $m^3 s^{-1}$ at its mouth.

Icebergs, broken off the continents and consisting of distilled water, appeared sometimes in great abundance over the subarctic parts of the Atlantic ocean, which lead to a diminishing salinity in that region; the waterfall stops, as well as the deep ocean current. According to theoretical calculations, without the Gulf Stream, about a 14 K lower mean annual temperature would be expected in Scandinavia. At the same time, similar drastic temperature changes can occur in Greenland, Canada, and in large parts of the North Atlantic. Since the deep ocean current is linked with the Gulf Stream, a cessation of the former will be followed by awakening or stopping of the latter. It is likely that in this case other sea currents would change, too.

If temperature was falling in the subarctic area, the atmosphere could hold less water vapor there, less snow will fall, and consequently less snow accumulation will occur. Therefore, fewer icebergs would plunge into the ocean, water salinity in the relevant regions of the Atlantic Ocean would begin to increase, and the cycle of the whole mechanism would start again. This is a plausible explanation of the rapid temperature variations in the period of 250,000–10,000 BP. However, it is not clear why this cycle has stopped in the last 10 000 years.

It seems to be not accidental that the appearance of agriculture and human civilization in the last 10 000 years occurred simultaneously with a more balanced climate, which replaced drastic temperature variations.

The beginning of human history was characterized by the development of greater ancient cultures. It is to be noted that the most significant civilizations like Chinese, Hindu, Mesopotamian, Egyptian, Israeli, Phoenician, Chartagian, Hellenic, and Roman flourished almost exclusively between lat 40° N and the equator. This is the area of subtropical and tropical climate with annual mean temperature between 15 °C and 26 °C—much warmer than that in west and central Europe. The presence of rivers with abundant water or a climate favorable for growing cereals might be the reason for the settlement of people, founding cities, developing written cultures and sciences (see *Effects of Global Warming on Human Cultural Diversity*).

Archeological and historical data indicate how humans responded to climatic phenomena in the centuries and millennia before the modern age. Human reactions to climate changes are most sensitive in those regions where temperature and water are crucial for life support, like the subpolar and semiarid climatic zones. For example, in the subpolar region of North America, caribou-hunter tribes settled between 2500 and 2000 BC. These tribes knew very well the route of spring and autumn wandering of caribou herds, and, making thorough use of the animals, developed the so-called "first independent culture." However, between 2000 and 1300 BC, due to cool summers, indicating a cooling climatic episode, the caribou herds vanished from this area and so did the hunter tribes. In the years 1300–700 BC, the summers turned warmer again, thus the "second independent culture," similar to the former one, could reappear (see *Global Warming and Human Migration*).

At the beginning of the third millennium BC, herdsmen lived in some parts of the Sahara, but by the end of that millennium, the savanna had gradually turned into desert, and herdsmen wandered away. The huge diluvial water (or lake) deep beneath the present surface is believed to have witnessed a wetter ancient climate.

In ancient times, agriculture and growing cereals appeared first in West Asia. In ancient Persia, for the purpose of milling, special windmills were used, with vertical rotating axes, able to work with draught animals in calm weather. The operation of windmills with vertical axes was newly invented in modern times by J.G.S. Darrieus (1920), however, his invention was first applied in the 1970s in Canada.

The network of irrigation canals built by the Assyrian queen Semiramis about 800 BC utilized the water of the rivers Tigris and Euphrates for irrigating the area, which had been barren before.

From the ninth through the twelfth centuries AD, the area of the North Atlantic warmed up and sailing became rather safe. Icebergs endangered the ships less frequently. Therefore, Vikings could get to Iceland and Greenland and were able to sail along the shore of Labrador up to Newfoundland. The so-called "Thule culture" appeared in the northwest of Greenland, (nowadays, Thule is an Eskimo settlement and an American base, respectively, in at lat 77.5°N and lat 76°N, long 70°W). In the succeeding centuries, gradual cooling started, sailing became more dangerous, and Viking colonies vanished.

Contemporary drawings show that during the Middle Ages spring and summer temperature turned warmer many times, for example in the eleventh through thirteenth centuries ("medieval optimum"), when vine growing extended to South England and Belgium. The cool period starting in the fifteenth century and ending in the nineteenth century is known as the "little ice age." Table 1 summarizes the climatic changes and events related with climate from 3000 years BC to the nineteenth century, without a claim of completeness.

Time	**Location**	**Event**
3000–2200 BC	Sahara	Wetter climate, nomad herdsmen live in Sahara
2200–2000 BC	Sahara	Gradual desiccation
2500–2000 BC	Subpolar region of North America	Mild summers, caribou-hunting tribes form "first independent culture"
2000–1300 BC	Subpolar region of North America	Cool summers, caribou-hunting tribes disappear
1300–700 BC	Subpolar region of North America	Mild summers, "second independent culture" is formed
~1000 BC	Persia	Windmills with vertical axis (in calm weather work with draught animals)
900–800 BC	Mesopotamia	Irrigation canals between Tigris and Euphrates
1000–1300 AD	North Atlantic	Vikings are sailing over Atlantic ocean to Greenland and Labrador. Thule culture in northwest Greenland. Mild climatic period.
1200–1400 AD	South England, Belgium	"Medieval optimum." Vine growing in that area
~1450–1850	West Europe, extended area in the world	"Little ice age"

Table 1. Chronology of climatic events since ancient age

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Biographical Sketch

George Koppany was born on 31 March 1932 in Bajmok, former Yugoslavia. He attended primary school in Bajmok, started secondary school in Szabadka (Subotica) and finished it in Bonyhad (Hungary, Tolna county). He studied meteorology in ELTE University of Budapest and graduated there with eminent certificate in 1956. He worked at the Hungarian Meteorological Service from 1956 to 1985 as a meteorologist in the field of long-range weather forecasting. From February 1966 to February 1967 he spent 6 months each in the Soviet Union and the USA, respectively, as a UN fellow. He also took part in several international meetings and conferences in the Soviet Union, Italy, Germany, Austria, Czechoslovakia, Bulgaria, the United Kingdom, and Argentina. The author was invited to the J.A. University of Szeged in l984, where he was appointed professor and head of the Department of Climatology in 1986. He retired in 1998.

He has published 17 books, booklets, and lecture notes, was joint author on 8 books, published 100 scientific publications, 108 public educational articles, and published 24 book reviews.

He is a member of the Hungarian Meteorological Society since 1957, member of the Meteorological Scientific Council at the Hungarian Academy of Science and member of the Public Educational Society since 1974 In 1996 he was a member of the New York Academy of Sciences.