

## Climate Change and Humans

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The history of humankind is inextricably tied to climate. Climate strongly influences human life. Human activities also affect climate, although the extent of our impacts is only now becoming apparent.

Climate change is part of the natural world. Cyclical changes in the Earth's orbital geometry, caused by the gravitational pull of the Sun and other planets, determine the amount of solar radiation that reaches and warms the Earth. They are instigators of climate change. Continental movement, atmospheric circulation patterns, shifting ocean currents, and volcanic eruptions are others.

Climate involves the interaction of air, water, land, polar ice, and all organic life. Greenhouse gases, including water vapor, carbon dioxide, nitrous oxide, ozone, and methane, absorb solar radiation; warm the Earth; and sustain life. Without greenhouse gases, the Earth would be 50-60 degrees Fahrenheit colder, and an impossible place for humans to live.

Climate is characterized by periods of stability, gradual change, and rapid climate change events (called RCCEs or "rickys"). RCCEs happen in a matter of centuries, decades, or even years, and often create havoc for human culture. *Climatic instability rather than stability marks our time on Earth.*

During its 4.5 billion year history, the Earth has experienced extreme variations in global climate, ranging from deep freeze to hot swampy conditions. Humankind has been around only long enough--about 5 million years--to experience a small fraction of these global climate changes, mostly within our ancestral African homeland. We are a tiny blip on Earth's geological timescale.

Humans evolved in Africa. Archaeological and genetic evidence show that human populations migrated out of Africa and slowly colonized Europe and Asia, beginning about 1.5 million years ago during the last great Ice Age, called the Pleistocene. The last wave of Pleistocene migrants, *the modern human ancestors of us all (Homo sapiens)*, spread rapidly out of Africa no later than 50,000 years ago; out-competed older human groups (called Neanderthals); and eventually populated nearly every continent on Earth. In evolutionary perspective, we are a Pleistocene-adapted species.

Human colonization happened during both cold *glacial* and warm *interglacial intervals* of the Ice Age. During the last glacial interval some 20,000 years ago, Ice Age people living at northern latitudes in Siberia hunted across the Bering Strait, then dry land because seawater was locked up in immense continental glaciers, and eventually reached Alaska and North America. Like all glacial intervals, this last glacial period started slowly but abruptly ended in less than 4,000 years, *initiating the warmer Holocene interglacial interval, which we are now in.*

Another glacial interval could begin in 5,000 years or more if the changes predicted in the Earth's orbital geometry are correct. But this is needless worry for future generations because modern greenhouse gas emissions and pollution have likely tipped Earth's climate in the opposite direction.

The Holocene interglacial, which began 10,000 years ago, is our long summer of climate stability. Average temperatures rose 9 degrees Fahrenheit from glacial conditions. Melting glaciers caused sea levels to rise about 400 feet. The amount of atmospheric carbon dioxide increased by one-third because, among other things, extensive continental ice sheets no longer existed to deflect solar radiation. The important role of polar ice caps in maintaining global climate cannot be overstated.

Warm and relatively stable Holocene interglacial conditions have allowed our complex civilization to develop over about 400 generations. Still, the Holocene has been punctuated by warming and cooling cycles and RCEs, which have been sources of either human opportunity or enormous misery in the distant and recent past.

Holocene societies met the challenges of natural climate change in different ways. The archaeological record shows that highly integrated or rigid societies, such as the Maya of Central America and the Viking colonies on Greenland, were more susceptible to climate catastrophe than more diverse and flexible ones. For example, the ancient Harrappans of India successfully adapted to weak monsoons and persistent aridity by developing elaborate rainwater harvesting and collecting systems.

*Humans have affected the atmosphere and climate in a significant way only within the last several hundred years (our terrestrial impacts are another story).* This is evidenced by steep spikes in carbon dioxide and other greenhouse gas levels in polar ice and deep-sea cores. Ice cores and ocean sediments provide invaluable records of global climate and temperature over the last 750,000 years.

Pleistocene and Holocene carbon dioxide levels ranged from about 200 to 280 parts per million (ppm). Within the past 200 years, this level has increased to 387 ppm. The spike begins in the Industrial Age (ca. 1850) and rises sharply to present times. The amount of carbon dioxide in the atmosphere now is about 30% above pre-industrial levels. This abrupt increase is outside the Pleistocene-Holocene natural range of variability and is attributed to deforestation and modern society's intense reliance on fossil fuels.

Escalating greenhouse gas levels raise Earth's temperature. During the last century, the average global temperature increased by 1.3 degree Fahrenheit. It is predicted to rise another 3.2 to 7.2 degrees in this century. These temperature increases seem modest but resonate on land and in oceans as prolonged

drought, water shortages, catastrophic wildfire, coastal flooding, ocean acidification, and fierce weather events. Drought forced the ancestral Puebloan people of the American Southwest to abandon their ancient homeland for more favorable environments. With the Earth's current population of 6.8 billion people, the prospect of mass population movements to more hospitable places is daunting. Even now, rising sea levels are causing total human abandonment of low-lying islands in the South Pacific.

Humans adapted to climate change in the past by relying on technology, social flexibility and innovation. Today, the climate change picture is different due to the pervasive influence of modern greenhouse gases and a crowded planet. An accurate understanding of past climate and human history is an essential first step toward addressing climate change. *U.S. Forest Service commitment to climate strategy, environmental sustainability, and management action are the next steps.*

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\* The climate and archaeological literatures are immense. This brief synopsis of humans and climate change is inspired by and based on these largely non-technical books and reports, as well as others not cited here.

