

# Climate Change 3: History and Current State<sup>☆</sup>

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## Introduction

The term *climate* is originated from the greek word *klima* meaning inclination. In the antic Greece, difference in weather conditions was associated with a difference inclination of solar rays to the surface of the Earth. At present, the term *climate* commonly means typical weather conditions for a given area. More formally, climate is determined as a statistical ensemble of weather for sufficiently long, usually a few (frequently, three) decades.

The Earth was formed as a planet about 4.6 billion years before present.

The basic compartments of the Earth's climate system are *atmosphere*, oceans, land, *cryosphere*, and *biosphere (biota)*. For the atmosphere, only typical time scales of response to external forcing are up to a few months; for the ocean, the corresponding time scale is  $10^0$ – $10^3$  years, depending on the layer involved. For the land compartment, appropriate time scales are between a few days up to several decades. For the terrestrial biosphere, a typical time scale is about  $10^0$ – $10^1$  years. Very large time scale  $10^3$ – $10^4$  years is associated with the terrestrial ice sheets.

External forcing also operates at different time scales. For instance, orbital forcing exhibits the strongest changes at periods about 20 kyr (20 kiloyears; 1 kyr =  $10^3$  years) – precessional forcing, 40 kyr – obliquity forcing), and 100 kyr – eccentricity forcing; these are the so called Milankovitch periods. According to the currently accepted astrophysical theory, solar irradiance has increased by about 2% over the last 200 Myr (200 million years; 1 Myr =  $10^6$  years). Earth volcanism, very intensive in the past, gradually diminishes over the last about 6000 years, while explosive eruptions still occur during the last few centuries.

As meteorological instrumental measurements cover only the last few centuries, to quantify past climates indirect (proxy) data are used. Among those data, terrestrial and marine sediments cover very old paleoepochs up to 1 Myr years before present (BP). Epochs that are more recent may be reconstructed based on the flora pollen and oceanic corals. The latter based mostly on the fossil *foraminifera* samples. Ice boreholes serve as a very important source of our knowledge about the last several hundred kyrs, especially the deep drilling holes at the Antarctic sites Vostok and Dome C providing information for the last 420 kyr and 720 kyr, respectively. For the last few thousand years, important climatic information comes from tree annual rings.

The longest instrumental temperature record exists for Central England (monthly means are available since 1659). Instrumental meteorological measurements become routine in the middle of the 19th century.

## Pre-Quaternary Climates

The pre-Cambrian climates (older than 570 Myr BP, here and thereafter see [Table 1](#)) are poorly covered by the proxy data and are the most uncertain. While solar irradiance was about 1/3 less in this period than at present, there is an evidence of the existence of liquid water on the Earth's surface. Such a low solar input into the climate system could be compensated by high concentrations of the greenhouse gases, basically CO<sub>2</sub> and CH<sub>4</sub>. It is likely that part of the pre-Cambrian period was extremely cold, as glacial deposits were found even at the sites located in the tropical latitudes.

For the *Paleozoic era* (570–236 Myr BP), more reliable data on the oceanic temperatures exist only for the late period (*the Permian*). However, there is evidence of large climate variations during the Paleozoic. In particular, the supercontinent Gondwana (located in the high southern latitudes) was supposed to be covered by ice in the late Paleozoic era (so-called the *Permian glaciation*).

The *Mesozoic era* (236–67 Myr BP) was extremely warm, on about 10–15 °C warmer than present, with only small temperature difference (about 15 °C) between equatorial and polar belts (currently, the value for this difference is about 46 °C). There is no

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