**Global warming**, also referred to as **climate change**, is the observed century-scale rise in the average temperature of the Earth's climate system and its related effects.[1][2] Multiple lines of scientific evidence show that the climate system is warming.[3][4][5] Many of the observed changes since the 1950s are unprecedented in the instrumental temperature record which extends back to the mid 19th century, and in paleoclimate proxy records over thousands of years.[6]

In 2013, the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report concluded that "It is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century." [7] The largest human influence has been emission of greenhouse gases such as carbon dioxide, methane and nitrous oxide. Climate model projections summarized in the report indicated that during the 21st century the global surface temperature is likely to rise a further 0.3 to 1.7 °C (0.5 to 3.1 °F) for their lowest emissions scenario and 2.6 to 4.8 °C (4.7 to 8.6 °F) for the highest emissions scenario.[8] These findings have been recognized by the national science academies of the major industrialized nations[9][a] and are not disputed by any scientific body of national or international standing.[11]

Future climate change and associated impacts will differ from region to region around the globe.[12][13] Anticipated effects include warming global temperature, rising sea levels, changing precipitation, and expansion of deserts in the subtropics.[14] Warming is expected to be greater over land than over the oceans and greatest in the Arctic, with the continuing retreat of glaciers, permafrost and sea ice. Other likely changes include more frequent extreme weather events including heat waves, droughts, heavy rainfall with floods and heavy snowfall;[15] ocean acidification; and species extinctions due to shifting temperature regimes. Effects significant to humans include the threat to food security from decreasing crop yields and the abandonment of populated areas due to rising sea levels.[16][17] Because the climate system has a large "inertia" and greenhouse gases will stay in the atmosphere for a long time, many of these effects will not only exist for decades or centuries, but will persist for tens of thousands of years.[18]

Possible societal responses to global warming include mitigation by emissions reduction, adaptation to its effects, building systems resilient to its effects, and possible future climate engineering. Most countries are parties to the United Nations Framework Convention on Climate Change (UNFCCC),[19] whose ultimate objective is to prevent dangerous anthropogenic climate change.[20] Parties to the UNFCCC have agreed that deep cuts in emissions are required[21] and that global warming should be limited to well below 2.0 °C (3.6 °F) relative to pre-industrial levels,[b] with efforts made to limit warming to 1.5 °C (2.7 °F).[23]

Public reactions to global warming and concern about its effects are also increasing. A global 2015 Pew Research Center report showed a median of 54% consider it "a very serious problem". There are significant regional differences, with Americans and Chinese (whose economies are responsible for the greatest annual CO2 emissions) among the least concerned.

The global average (land and ocean) surface temperature shows a warming of 0.85 [0.65 to 1.06] °C in the period 1880 to 2012, based on multiple independently produced datasets.[26] Earth's average surface temperature rose by 0.74±0.18 °C over the period 1906–2005. The rate of warming almost doubled for the last half of that period (0.13±0.03 °C per decade, versus 0.07±0.02 °C per decade).[27] Although the increase of near-surface atmospheric temperature is the measure of global warming often reported in the popular press, most of the additional energy stored in the climate system since 1970 has gone into the oceans. The rest has melted ice and warmed the continents and atmosphere.[28][c]

The average temperature of the lower troposphere has increased between 0.12 and 0.135 °C (0.216 and 0.243 °F) per decade since 1979, according to satellite temperature measurements.[29][30] Climate proxies show the temperature to have been relatively stable over the one or two thousand years before 1850, with regionally varying fluctuations such as the Medieval Warm Period and the Little Ice Age.[31]

The warming that is evident in the instrumental temperature record is consistent with a wide range of observations, as documented by many independent scientific groups.[32] Examples include sea level rise,[33] widespread melting of snow and land ice,[34] increased heat content of the oceans,[32] increased humidity,[32] and the earlier timing of spring events,[35] e.g., the flowering of plants.[36] The probability that these changes could have occurred by chance is virtually zero.[32]

**Trends**

Temperature changes vary over the globe. Since 1979, land temperatures have increased about twice as fast as ocean temperatures (0.25 °C per decade against 0.13 °C per decade).[37] Ocean temperatures increase more slowly than land temperatures because of the larger effective heat capacity of the oceans and because the ocean loses more heat by evaporation.[38] Since the beginning of industrialisation the temperature difference between the hemispheres has increased due to melting of sea ice and snow in the North.[39] Average arctic temperatures have been increasing at almost twice the rate of the rest of the world in the past 100 years; however arctic temperatures are also highly variable.[40] Although more greenhouse gases are emitted in the Northern than Southern Hemisphere this does not contribute to the difference in warming because the major greenhouse gases persist long enough to mix between hemispheres.[41]

The thermal inertia of the oceans and slow responses of other indirect effects mean that climate can take centuries or longer to adjust to changes in forcing. One climate commitment study concluded that if greenhouse gases were stabilized at year 2000 levels, surface temperatures would still increase by about one-half degree Celsius,[42] and another found that if they were stabilized at 2005 levels surface warming could exceed a whole degree Celsius. Some of this surface warming will be driven by past natural forcings which are still seeking equilibrium in the climate system. One study using a highly simplified climate model indicates these past natural forcings may account for as much as 64% of the committed 2050 surface warming and their influence will fade with time compared to the human contribution.[43]

Global temperature is subject to short-term fluctuations that overlay long-term trends and can temporarily mask them. The relative stability in surface temperature from 2002 to 2009, which has been dubbed the global warming hiatus by the media and some scientists,[44] is consistent with such an episode.[45][46] 2015 updates to account for differing methods of measuring ocean surface temperature measurements show a positive trend over the recent decade.[47][48]

**Warmest years**

Sixteen of the 17 warmest years on record have occurred since 2000.[49] While record-breaking years attract considerable public interest, individual years are less significant than the overall trend. Some climatologists have criticized the attention that the popular press gives to "warmest year" statistics. In particular, ocean oscillations such as the El Niño Southern Oscillation (ENSO) can cause temperatures of a given year to be abnormally warm or cold for reasons unrelated to the overall trend of climate change. Gavin Schmidt stated "the long-term trends or the expected sequence of records are far more important than whether any single year is a record or not

On Earth, an atmosphere containing naturally occurring amounts of greenhouse gases causes air temperature near the surface to be about 33 °C (59 °F) warmer than it would be in their absence.[60][d] Without the Earth's atmosphere, the Earth's average temperature would be well below the freezing temperature of water.[61] The major greenhouse gases are water vapour, which causes about 36–70% of the greenhouse effect; carbon dioxide (CO2), which causes 9–26%; methane (CH4), which causes 4–9%; and ozone (O3), which causes 3–7%.[62][63][64] Clouds also affect the radiation balance through cloud forcings similar to greenhouse gases.

Human activity since the Industrial Revolution has increased the amount of greenhouse gases in the atmosphere, leading to increased radiative forcing from CO2, methane, tropospheric ozone, CFCs and nitrous oxide. According to work published in 2007, the concentrations of CO2 and methane had increased by 36% and 148% respectively since 1750.[65] These levels are much higher than at any time during the last 800,000 years, the period for which reliable data has been extracted from ice cores.[66][67][68][69] Less direct geological evidence indicates that CO2 values higher than this were last seen about 20 million years ago.[70]

Fossil fuel burning has produced about three-quarters of the increase in CO2 from human activity over the past 20 years. The rest of this increase is caused mostly by changes in land-use, particularly deforestation.[71] Another significant non-fuel source of anthropogenic CO2 emissions is the calcination of limestone for clinker production, a chemical process which releases CO2.[72] Estimates of global CO2 emissions in 2011 from fossil fuel combustion, including cement production and gas flaring, was 34.8 billion tonnes (9.5 ± 0.5 PgC), an increase of 54% above emissions in 1990. Coal burning was responsible for 43% of the total emissions, oil 34%, gas 18%, cement 4.9% and gas flaring 0.7%[73]

In May 2013, it was reported that readings for CO2 taken at the world's primary benchmark site in Mauna Loa surpassed 400 ppm. According to professor Brian Hoskins, this is likely the first time CO2 levels have been this high for about 4.5 million years.[74][75] Monthly global CO2 concentrations exceeded 400 ppm in March 2015, probably for the first time in several million years.[76] On 12 November 2015, NASA scientists reported that human-made carbon dioxide continues to increase above levels not seen in hundreds of thousands of years: currently, about half of the carbon dioxide released from the burning of fossil fuels is not absorbed by vegetation and the oceans and remains in the atmosphere.[77]

Over the last three decades of the twentieth century, gross domestic product per capita and population growth were the main drivers of increases in greenhouse gas emissions.[78] CO2 emissions are continuing to rise due to the burning of fossil fuels and land-use change.[79][80]:71 Emissions can be attributed to different regions. Attributions of emissions due to land-use change are subject to considerable uncertainty.[81][82]:289

Emissions scenarios, estimates of changes in future emission levels of greenhouse gases, have been projected that depend upon uncertain economic, sociological, technological, and natural developments.[83] In most scenarios, emissions continue to rise over the century, while in a few, emissions are reduced.[84][85] Fossil fuel reserves are abundant, and will not limit carbon emissions in the 21st century.[86] Emission scenarios, combined with modelling of the carbon cycle, have been used to produce estimates of how atmospheric concentrations of greenhouse gases might change in the future. Using the six IPCC SRES "marker" scenarios, models suggest that by the year 2100, the atmospheric concentration of CO2 could range between 541 and 970 ppm.[87] This is 90–250% above the concentration in the year 1750.

The popular media and the public often confuse global warming with ozone depletion, i.e., the destruction of stratospheric ozone (e.g., the ozone layer) by chlorofluorocarbons.[88][89] Although there are a few areas of linkage, the relationship between the two is not strong. Reduced stratospheric ozone has had a slight cooling influence on surface temperatures, while increased tropospheric ozone has had a somewhat larger warming effect(heat,world).