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Weather and climate: changing human exposures

In discussing "climate change and health" we must distinguish between the health impacts of several meteorological exposures: weather, climate variability and climate change.

Weather is the continuously changing condition of the atmosphere, usually considered on a time scale that extends from minutes to weeks. Climate is the average state of the lower atmosphere, and the associated characteristics of the underlying land or water, in a particular region, usually spanning at least several years. Climate variability is the variation around the average climate, including seasonal variations and large-scale regional cycles in atmospheric and ocean circulations such as the El Niño/ Southern Oscillation (ENSO) or the North Atlantic Oscillation.

Climate change occurs over decades or longer time-scales. Until now, changes in the global climate have occurred naturally, across centuries or millennia, because of continental drift, various astronomical cycles, variations in solar energy output and volcanic activity. Over the past few decades it has become increasingly apparent that human actions are changing atmospheric composition, thereby causing global climate change.[1]

The Climate System

Earth's climate is determined by complex interactions between the Sun, oceans, atmosphere, cryosphere, land surface and biosphere. The Sun is the principal driving force for weather and climate. The uneven heating of Earth's surface (being greater nearer the equator) causes great convection flows in both the atmosphere and oceans, and is thus a major cause of winds and ocean currents.

Five concentric layers of atmosphere surround this planet. The lowest layer (troposphere) extends from ground level to around 10-12 km altitude on average. The weather that affects Earth's surface develops within the troposphere. The next major layer (stratosphere) extends to about 50 km above the surface. The ozone within the stratosphere absorbs most of the sun's higher-energy ultraviolet rays. Above the stratosphere are three more layers: mesosphere, thermosphere and exosphere.

Overall, these five layers of the atmosphere approximately halve the amount of incoming solar radiation that reaches Earth's surface. In particular, certain "greenhouse" gases, present at trace concentrations in the troposphere (and including water vapour, carbon dioxide, nitrous oxide, methane, halocarbons, and ozone), absorb about 17% of the solar energy passing through it. Of the solar energy that reaches Earth's surface, much is absorbed and reradiated as long-wave (infrared) radiation. Some of this outgoing infrared radiation is absorbed by greenhouse gases in the lower atmosphere, which causes further warming of Earth's surface. This raises Earth's temperature by 33°C to its present surface average of 15°C. This supplementary warming process is called "the greenhouse effect" (Figure 2.1).

Figure 2.1. The greenhouse effect (reference 2)

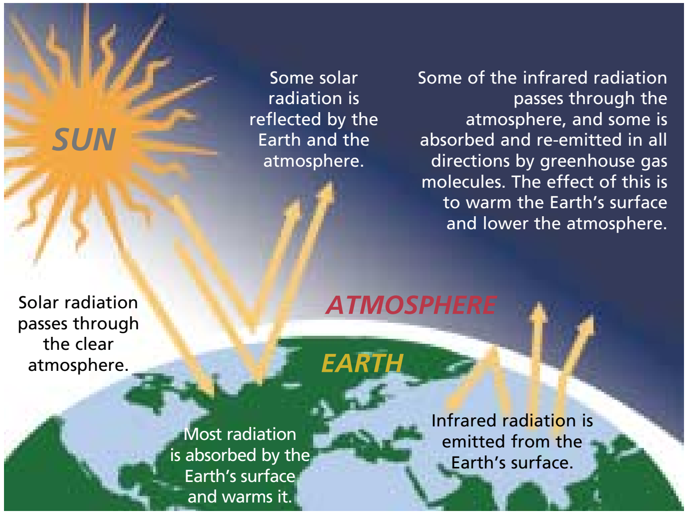
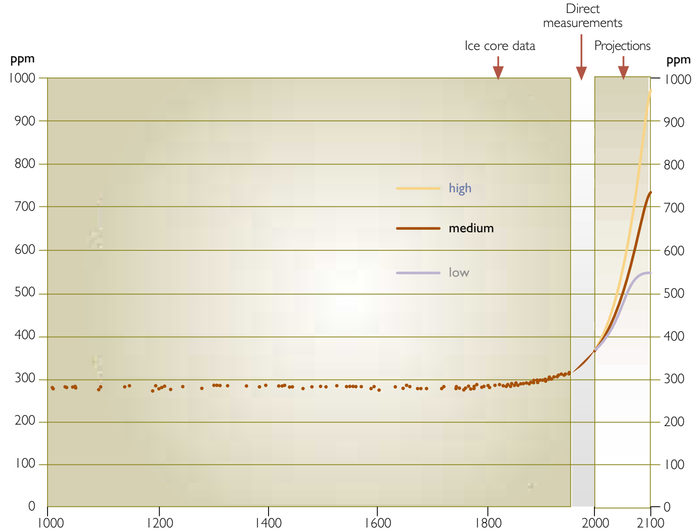


Figure 2.2. Atmospheric concentration of CO_2 from year 1000 to year 2000



Source: Watson et al, 2001.[3] (The data are from polar ice cores and from direct atmospheric measurements over the past few decades. Projections of CO_2 concentrations for the period 2000 to 2100 are based on the IPCC's six illustrative SRES scenarios and IS92a.)

Table 2.1: Examples of greenhouse gases that are affected by human activities

	CO_2 (Carbon Dioxide)	CH_4 (Methane)	N_2O (Nitrous Oxide)	CFC-11 (chloroflu-oro-carbon-11	HFC-23 Hydrofluoro-carbon-23)	CF_4 (Perfluorom-ethane)
Pre-industrial concentration	~280 ppm	~700 ppb	~270 ppb	Zero	Zero	40 ppt
Concentration in 1998	365 ppm	1745 ppb	314 ppb	268 ppt	14 ppt	80 ppt
Rate of Concentration change [b]	1.5 ppm/yr [a]	7.0 ppb/yr [a]	0.8 ppb/yr	-1.4 ppt/yr	0.55 ppt/yr	1 ppt/yr
Atmospheric lifetime	5-200 yr [c]	12 yr [d]	114 yr [d]	45 yr	260 yr	>50,000 yr

Source: reference 1

a Rate has fluctuated between 0.9 ppm/yr and 2.8 ppm/yr for CO_2 and between 0 and 13 ppb/yr for CH_4 over the period 1990 to 1999.
b Rate is calculated over the period 1990 to 1999.
c No single lifetime can be defined for CO_2 because of the different rates of uptake by different removal processes.
d This lifetime has been defined as an "adjustment time" that takes into account the indirect effect of the gas on its own residence time.
ppm: parts per million. **ppb:** parts per billion. **ppt:** parts per trillion.

Greenhouse Gases

Human-induced increases in the atmospheric concentration of GHGs are amplifying the greenhouse effect. In recent times, the great increase in fossil fuel burning, agricultural activity and several other economic activities has greatly augmented greenhouse gas emissions. The atmosphere concentration of carbon dioxide has increased by one-third since the inception of the industrial revolution (Figure 2.2).

Table 2.1 provides examples of several greenhouse gases and summarizes their 1790 and 1998 concentrations, their rate of change over the period 1990 to 1999 and their atmospheric lifetime. The atmospheric lifetime is highly relevant to policy makers because the emission of gases with long lifetimes entails a quasi-irreversible commitment to sustained climate change over decades or centuries.

Studying the Health Impacts of Climate

Studying the impact of weather events and climate variability on human health requires appropriate specification of the meteorological "exposure". Weather and climate can each be summarized over various spatial and temporal scales. The appropriate scale of analysis, and the choice of any lag period between exposure and effect, will depend on the anticipated nature of the relationship. Much of the research requires long-term data sets with information about weather/climate and health outcome on the same spatial and temporal scales. For example, it has proven difficult to assess how climate variability and change has influenced the recent spread of malaria in African highlands because the appropriate health, weather and other relevant data (e.g. land use change) have not been collected in the same locations and on the same scales.

In all such research, there is a need to accommodate the several types of uncertainty that are inherent in these studies. Predictions about how complex systems such as regional climate systems and climate-dependent ecosystems will respond when pushed beyond critical limits are necessarily uncertain. Likewise, there are uncertainties about the future characteristics, behaviours and coping capacity of human populations.