151e Climate Change and Infectious Disease

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The release of greenhouse gases—principally carbon dioxide—into Earth's atmosphere since the late nineteenth century has contributed to a climate unfamiliar to our species, *Homo sapiens*. This new climate has already altered the epidemiology of some infectious diseases. Continued accumulation of greenhouse gases in the atmosphere will further alter the planet's climate. In some cases climate change may establish conditions favoring the emergence of infectious diseases, while in others it may render areas that are presently suitable for certain diseases unsuitable. This chapter presents the current state of knowledge regarding the known and prospective infectious-disease consequences of climate change.

OVERVIEW

The term *climate change* refers to long-term alterations in temperature, precipitation, wind, humidity, and other components of weather. Over the past 2.5 million years, the earth has warmed and cooled, cycling between glacial and interglacial periods during which average global temperatures moved up and down by 4–7°C. During the last glacial period, which ended roughly 12,000 years ago, global temperatures were, on average, 5°C cooler than in the mid-twentieth century (Fig. 151e-1).

The present climate period, known as the Holocene, is remarkable for its stability: temperatures have largely remained within a range of 2–3°C. This stability has enabled the successful population and cultivation of much of the earth's landmass by humanity. Current climate change differs from that in the past not only because its primary cause is human activities but also because its pace is faster. The 5°C of warming that occurred at the end of the last ice age took roughly 5000 years, whereas such a temperature increment may occur within the next 150 years unless the release of greenhouse gases is substantially reduced in coming decades. The current rate of warming on Earth is unprecedented in the last 50 million years. Climate science, although still a relatively new discipline, has provided an ever-clearer picture of how the changing chemistry of the atmosphere has influenced, and will continue to influence, the global climate.

GREENHOUSE GASES

Greenhouse gases (Table 151e-1 and Fig. 151e-2) are a group of gases in Earth's atmosphere that absorb infrared radiation and thus retain heat inside the atmosphere. In the absence of these gases, the earth's average temperature would be about 33°C colder. Carbon dioxide, released into the atmosphere primarily from fossil fuel combustion and deforestation, has had the greatest effect on climate since the Industrial Revolution. Of note, the Swedish scientist Svante Arrhenius first suggested in the late nineteenth century that the addition of carbon dioxide to the earth's atmosphere would increase the planet's surface temperature. Water vapor is the most abundant and a highly potent greenhouse gas but, given its short atmospheric life span and sensitivity to temperature, is not a major factor in recently observed climate change.

The atmosphere, some of the aerosols suspended in it, and clouds reflect a portion of incoming solar radiation back toward space. The remainder reaches Earth's surface, where it is absorbed and some is then emitted back at the atmosphere. The earth emits energy absorbed from the sun at longer wavelengths, primarily infrared, that greenhouse gases are able to absorb. The change in wavelength that occurs as solar radiation is absorbed and re-emitted from the earth's surface is fundamental to the greenhouse effect (Fig. 151e-3).

TEMPERATURE

Climate change has become nearly synonymous with global warming, as a clear signal from rising greenhouse gas concentrations has been an increase in the mean global surface temperature of ~0.85°C since 1880. However, this mean warming belies warming that is occurring much faster in certain regions. The Arctic has warmed twice as fast overall, and winters are warming faster than summers. Nighttime minimum temperatures are also rising faster than daytime high temperatures. Each of these nuances bears upon the incidence of infectious diseases in general and vector-borne disease specifically.

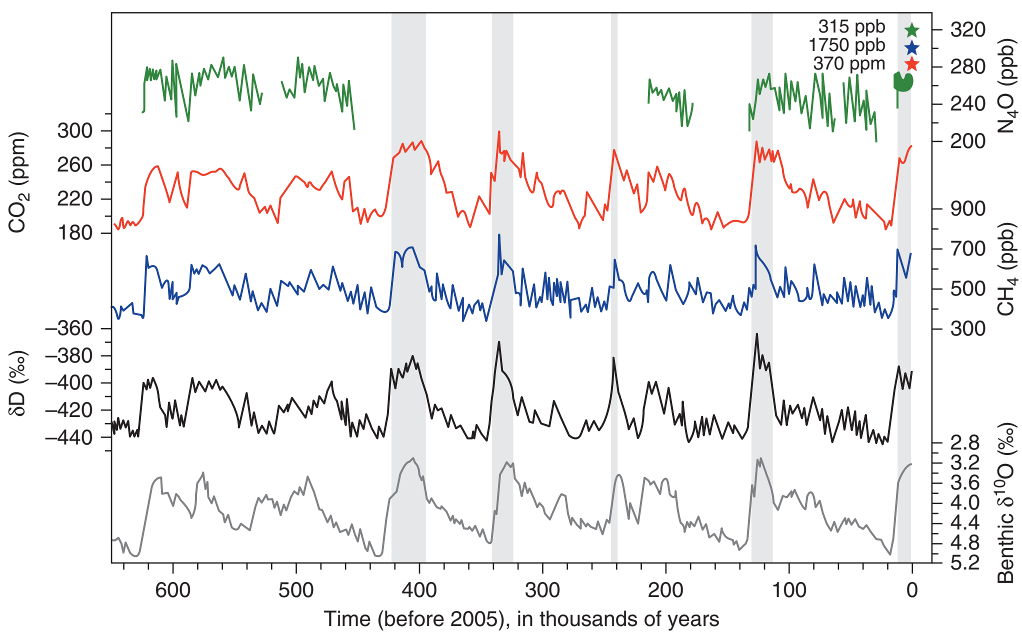

FIGURE 151e-1 Overview of the earth's temperature and primary greenhouse gases over the last 600,000 years. Variations of deuterium (δD; *black*) serve as a proxy for temperature. Atmospheric concentrations of greenhouse gases—CO_2 (*red*), CH_4 (*blue*), and nitrous oxide (N_2O; *green*)—were derived from air trapped within Antarctic ice cores and from recent atmospheric measurements. *Shaded areas* indicate interglacial periods. Benthic $\delta^{18}O$ marine records (*dark gray*) are a proxy for global ice-volume fluctuations and can be compared to the ice core data. Downward trends in the benthic $\delta^{18}O$ curve reflect increasing ice volumes on land. The *stars* and *labels* indicate atmospheric concentrations as of the year 2000. CO_2 levels surpassed 400 ppm as of 2013 and are rising at a rate of 2–2.5 ppm per year. *(From Intergovernmental Panel on Climate Change Fourth Assessment Report. Working Group I, Chapter 6, Figure 6.3. Cambridge University Press, 2007.)*