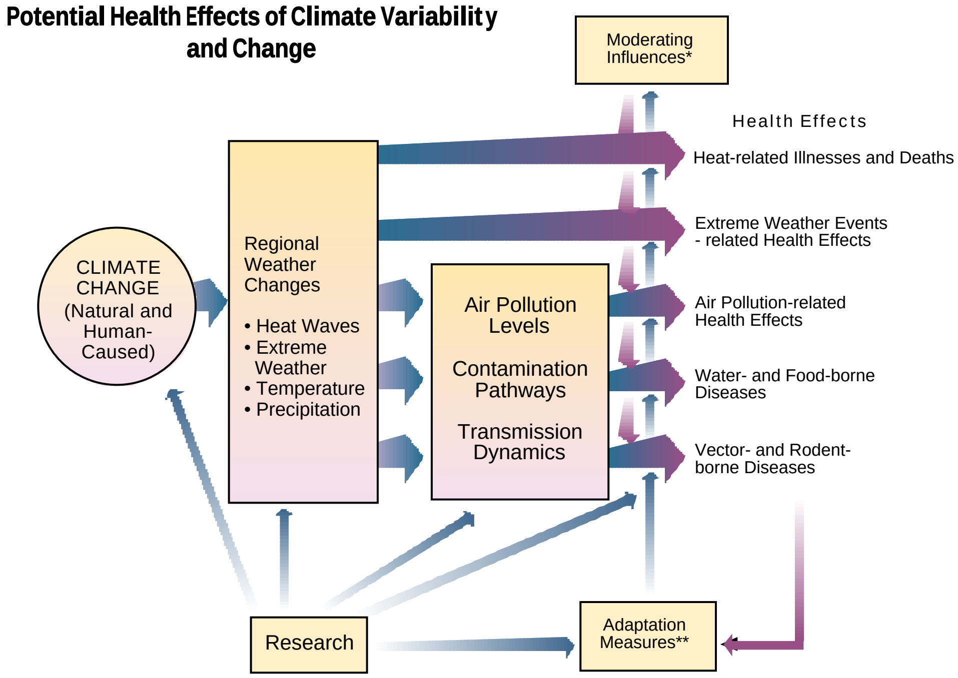

Figure 1: Schematic diagram of the potential health effects of climate variability and change. (Source, Patz et al., 2000)

*** Moderating influences include non-climate factors that affect climate-related health outcomes, such as: population growth and demographic change; standards of living; access to health care; improvements in health care; and public health infrastructure.**

**** Adaptation measures include actions to reduce risks of adverse health outcomes, such as: vaccination programs; disease surveillance; monitoring; use of protective technologies (e.g., air conditioning, pesticides, water filtration/treatment); use of climate forecasts; and development of weather warning systems; emergency management and disaster preparedness programs; and public education.**

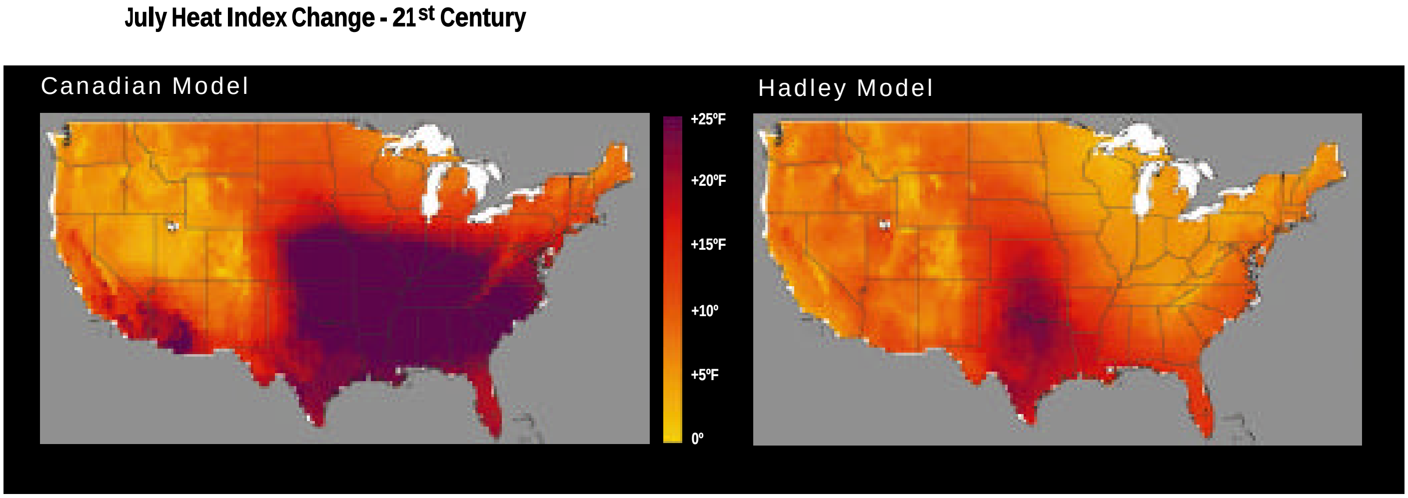

Figure 2: Both models project substantial increases in the July heat index (which combines heat and humidity) over the 21st century. These maps show the projected increase in average daily July heat index relative to the present. The largest increases are in the southeastern states, where the Canadian model projects increases of more than 25˚F. For example, a July day in Atlanta that now reaches a heat index of 105˚F would reach a heat index of 115˚F in the Hadley model, and 130˚F in the Canadian model. Map by B. Felzer, UCAR, based on data from Canadian and Hadley modeling centers.

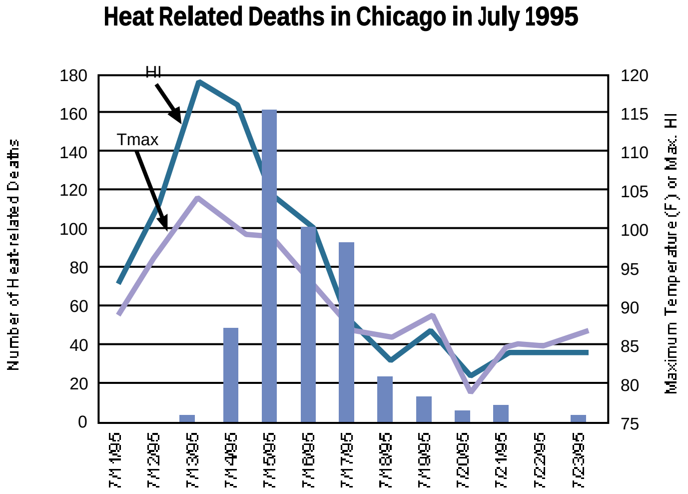

Figure 3: This graph tracks the maximum temperature (Tmax), heat index (HI), and heat-related deaths in Chicago each day from July 11 to 23, 1995. The gray line shows maximum daily temperature, the blue line shows the heat index, and the bars indicate the number of deaths each day. Source: NOAA/NCDC.

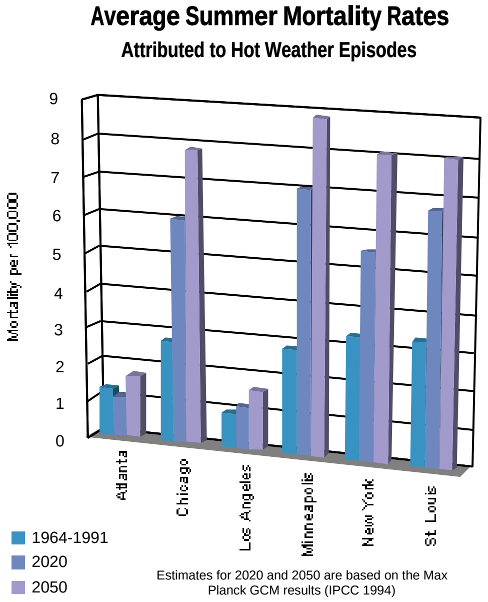

Figure 4: Deaths due to summer heat are projected to increase in US cities, according to a study using time-dependent results (for greenhouse gas increase only) from several climate models (Kalkstein and Greene, 1997). Mortality rates (number of deaths per 100,000 population) are shown from the Max Planck Institute model, the results from which lie roughly in the middle of the models examined (the other climate scenarios used were from Geophysical Fluid Dynamics Laboratory (GFDL) and the Hadley Centre). Because heat-related illness and death appear to be related to temperatures much hotter than those to which the population is accustomed, cities that experience extreme heat only infrequently appear to be at greatest risk. For example, Philadelphia, New York, Chicago, and St. Louis have experienced heat waves that resulted in a large number of heat-related deaths, while heat related deaths in Atlanta and Los Angeles are much lower. In this study, statistical relationships between heat waves and increased death rates are constructed for each city based on historical experience. Deaths under a city's future climate are then projected by applying that city's projected incidence of extreme heat waves to the statistical relationship that was estimated for the city whose present climate is most similar to the projected climate for the city in question. This approach attempts to represent how people will acclimate to the new average climate that they experience.

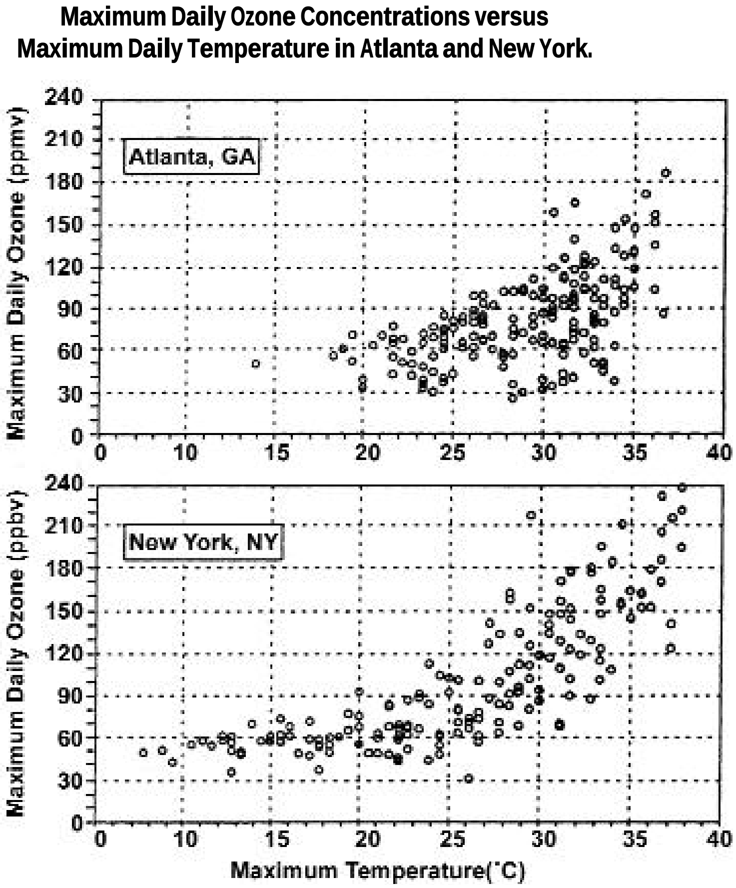

Figure 5: These graphs illustrate the observed association between ground-level ozone concentrations and temperature in Atlanta and New York City (May to October 1988-1990). The projected higher temperature across the US in the 21st century will likely increase the occurrence of high ozone concentrations, especially because extremely hot days frequently have stagnant air circulation patterns, although this will also depend on emissions of ozone precursors and meteorological factors. Ground-level ozone can exacerbate respiratory diseases and cause short-term reductions in lung function. (Maximum Daily Ozone Chart provided by USEPA.)

Seasonality of Shellfish Poisoning in Florida 1981-1994

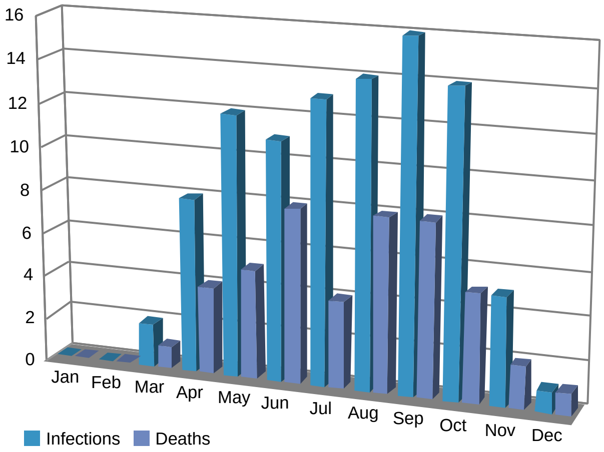

Figure 6: Monthly distribution of oyster-associated *Vibrio vulnificus* illness (or shellfish poisoning) and deaths occurring in Florida from 1981-1994. Over the 14-year period, higher numbers of cases occur during summer. Monitoring in Florida shows a statistically significant association between concentrations of this pathogen in estuaries and temperature and salinity, the latter being affected by rainfall and runoff. Adapted from: Lipp and Rose, 1997.

Locations of Combined Wastewater Systems

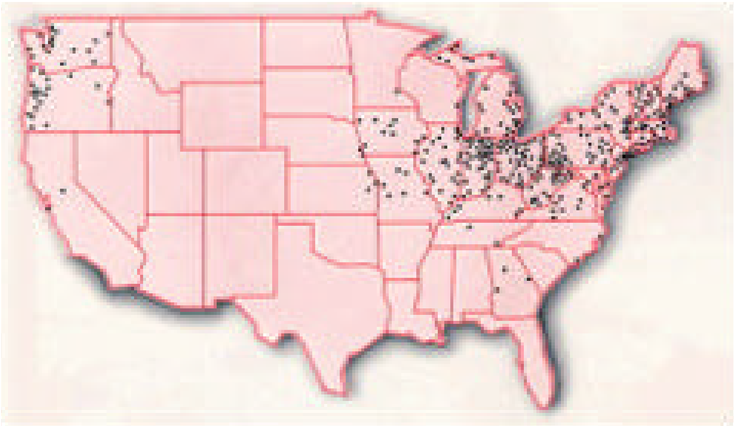

Figure 7: Wastewater systems that combine storm water drainage and sewage and industrial discharges are still in use in about 950 communities in the US, mostly in the Northeast and Great Lakes regions. These combined sewer systems deliver both storm drainage and wastewater to sewage treatment facilities. However, during rain or snowmelt, the volume of incoming water can exceed the capacity of the treatment system. Under those conditions, combined sewer systems are designed to overflow and discharge untreated wastewater into surface water bodies, and are termed as a combined sewer overflow (CSO) event. EPA, in 1994, developed a *CSO Control Policy* that sets forth a national framework for prevention of combined sewer overflows through the federal Clean Water Act's water discharge permit program. It has been suggested that if they continue to discharge untreated wastewater during storm events, combined sewer systems may pose a greater health risk should the frequency or intensity of storms increase. Source: USEPA, http://www.epa.gov/owmitnet/cso.htm.

Reported Cases of Dengue 1980-1999

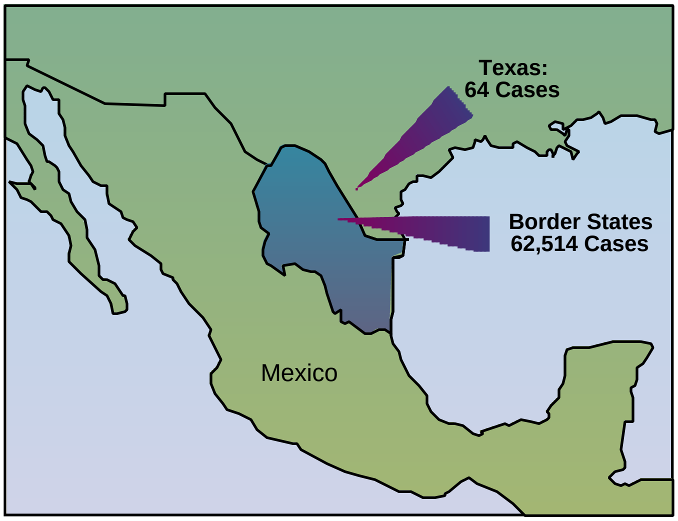

Figure 8: Dengue along the US-Mexico border. Dengue, a mosquito-borne viral disease, was once common in Texas (where there were an estimated 500,000 cases in 1922), and the mosquito that transmits it remains abundant. The striking contrast in the incidence of dengue in Texas versus three Mexican states that border Texas (64 cases vs. 62,514) in the period from 1980-1999 provides a graphic illustration of the importance of factors other than temperature, such as use of air conditioning and window screens, in the transmission of vector-borne diseases. National Institute of Health, Mexico; Texas Department of Health; US Public Health Service. Unpublished data.