National Climate Change

Temperature

- U.S. temperatures are rising.
- They are projected to rise much more in this century.
- Just how much more depends primarily on the amount of heat-trapping emissions.

Precipitation

- Precipitation has generally been increasing, but not in all areas.
- Dry areas are generally expected to become drier while wet areas become wetter.
- More precipitation has been occurring in heavy downpours.
- Precipitation is projected to continue recent trends, becoming less frequent (longer periods between events) but more intense.

Storms

- Atlantic hurricanes have increased in intensity. There has been no overall change in the frequency of land-falling hurricanes.
- The most intense storms are likely to become even stronger, with greater wind speed and rain fall rates.
- Storm tracks have been shifting northward in the U.S., and are projected to continue to do so.
- Cold-season storms are projected to become stronger in the most northerly locations.

Extreme weather

- Heatwaves and heavy downpours are becoming more frequent and more intense and this is projected to continue.

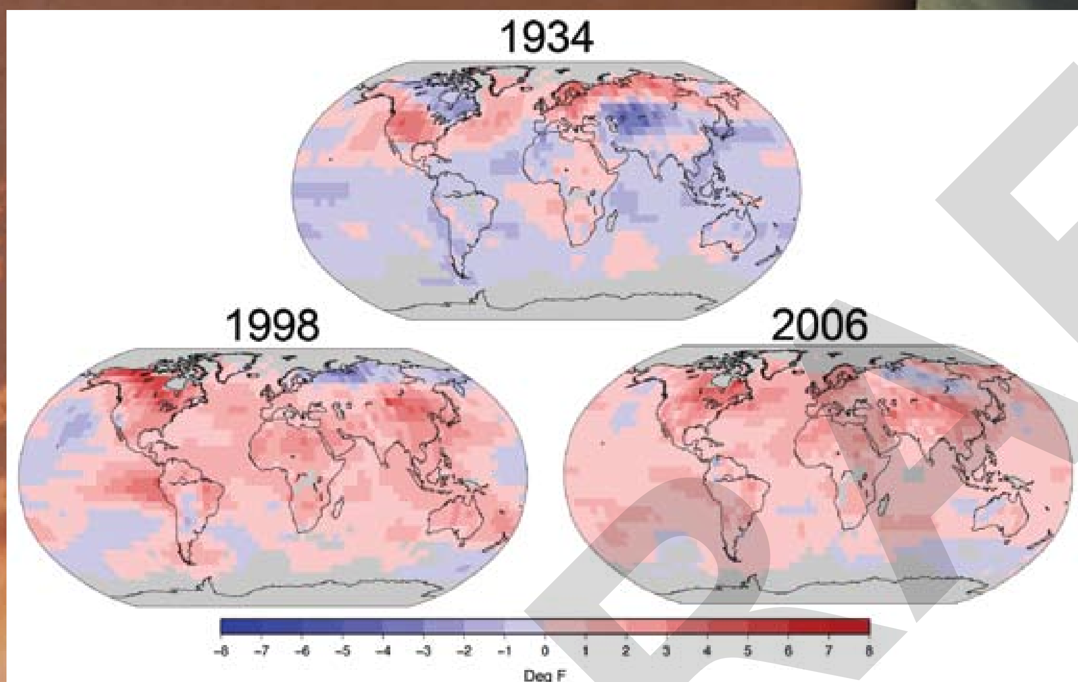
Emissions

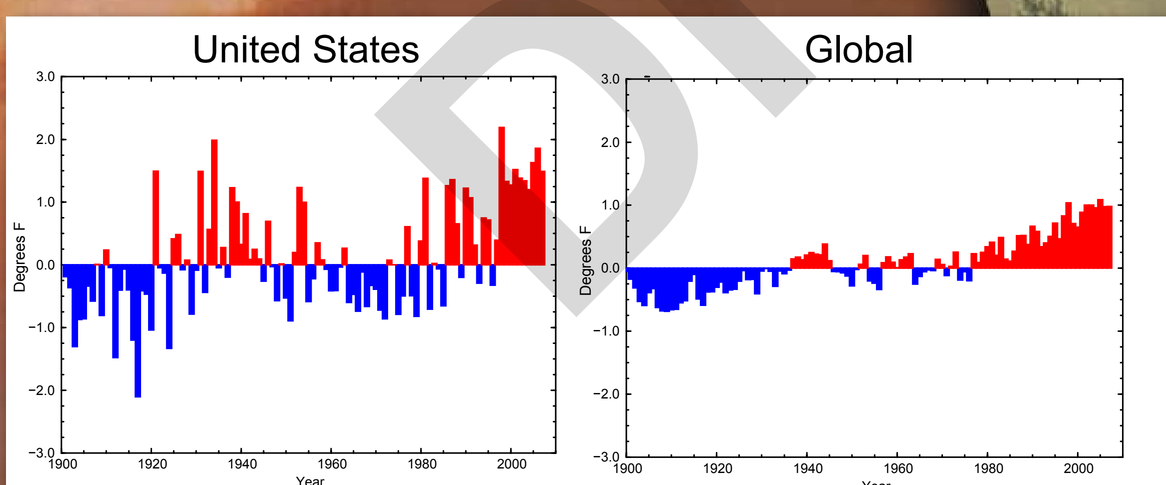
- U.S. emissions of heat-trapping gases are rising and come primary from burning fossil fuels.
- Uptake of carbon by trees in the United States absorbs about one-third of our emissions. Another one-third is absorbed by the oceans and vegetation in other regions.
- The remaining one-third accumulates in the atmosphere, adding to the greenhouse effect, leading to further global climate change.

Key Sources: CCSP 2.2 Carbon Cycle | CCSP 3.2 Climate Projections | CCSP 3.3 Extremes | CCSP 3.4 Abrupt Climate Change | CCSP 4.1 Sea Level Rise

Like the rest of the world, the United States has been warming significantly over the past 50 years in response to the build up of heat-trapping gases. When looking at national climate, however, it is important to recognize that climate varies much more at the scale of a country than at the scale of the globe. While various parts of the world have had particularly hot or cold periods in earlier parts in the historical record, these periods have *not* been global in scale, whereas the warming of recent decades has been truly global – hence the term *global* warming.

For example, the 1930s were very warm in much of the United States, but they were *not* unusually warm globally. On the other hand, the warmth of recent decades has been global in extent. The maps show annual average temperatures across the globe for the three years that were the hottest three on record in the United States: 1998, 1934 and 2006.





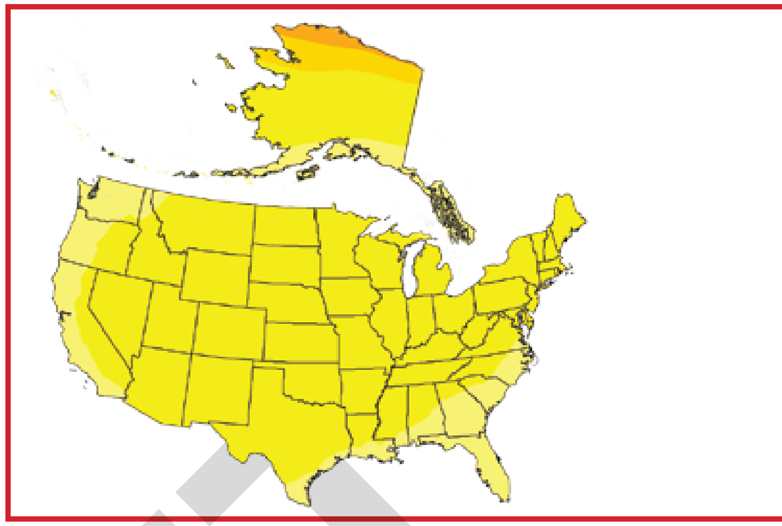
Annual average temperatures compared to mean baseline.

U.S. Temperatures

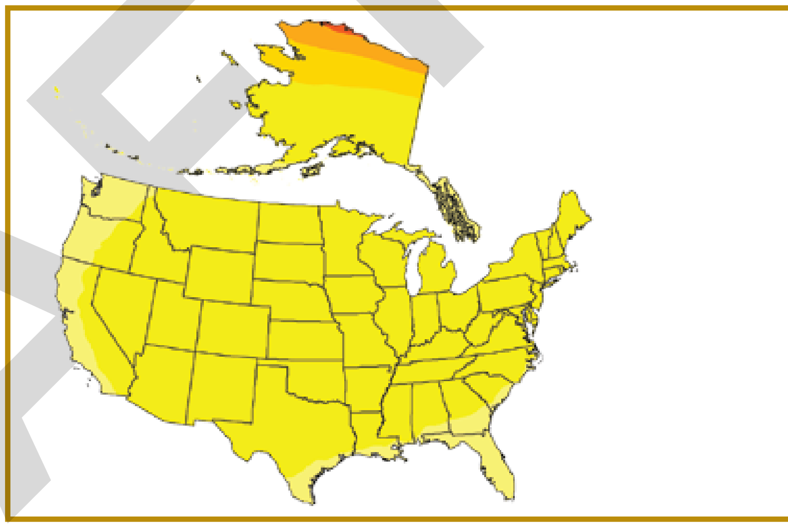
2020

Projected Change in Annual Average Temperature

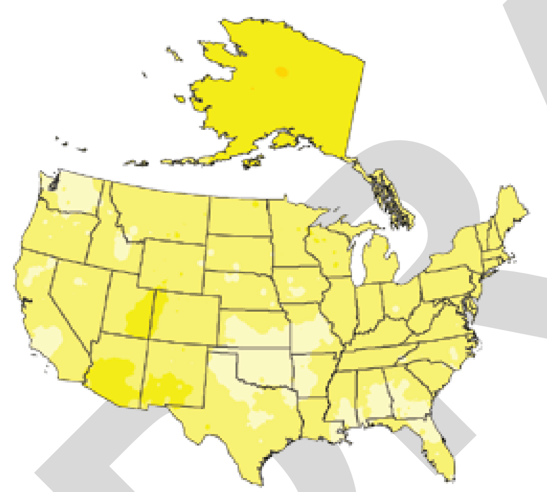
High Emissions*

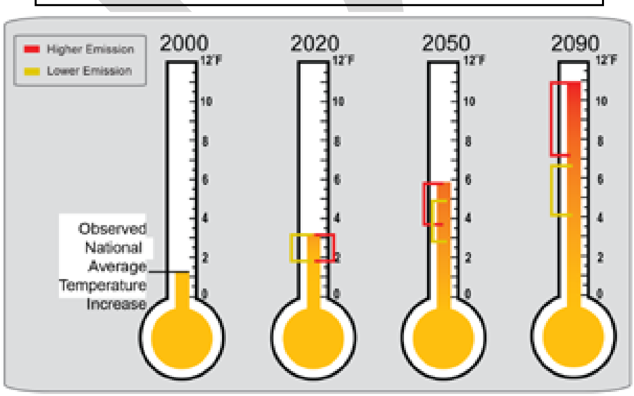


Low Emissions*



Observed Change in Annual Average Temperature 1970-2000

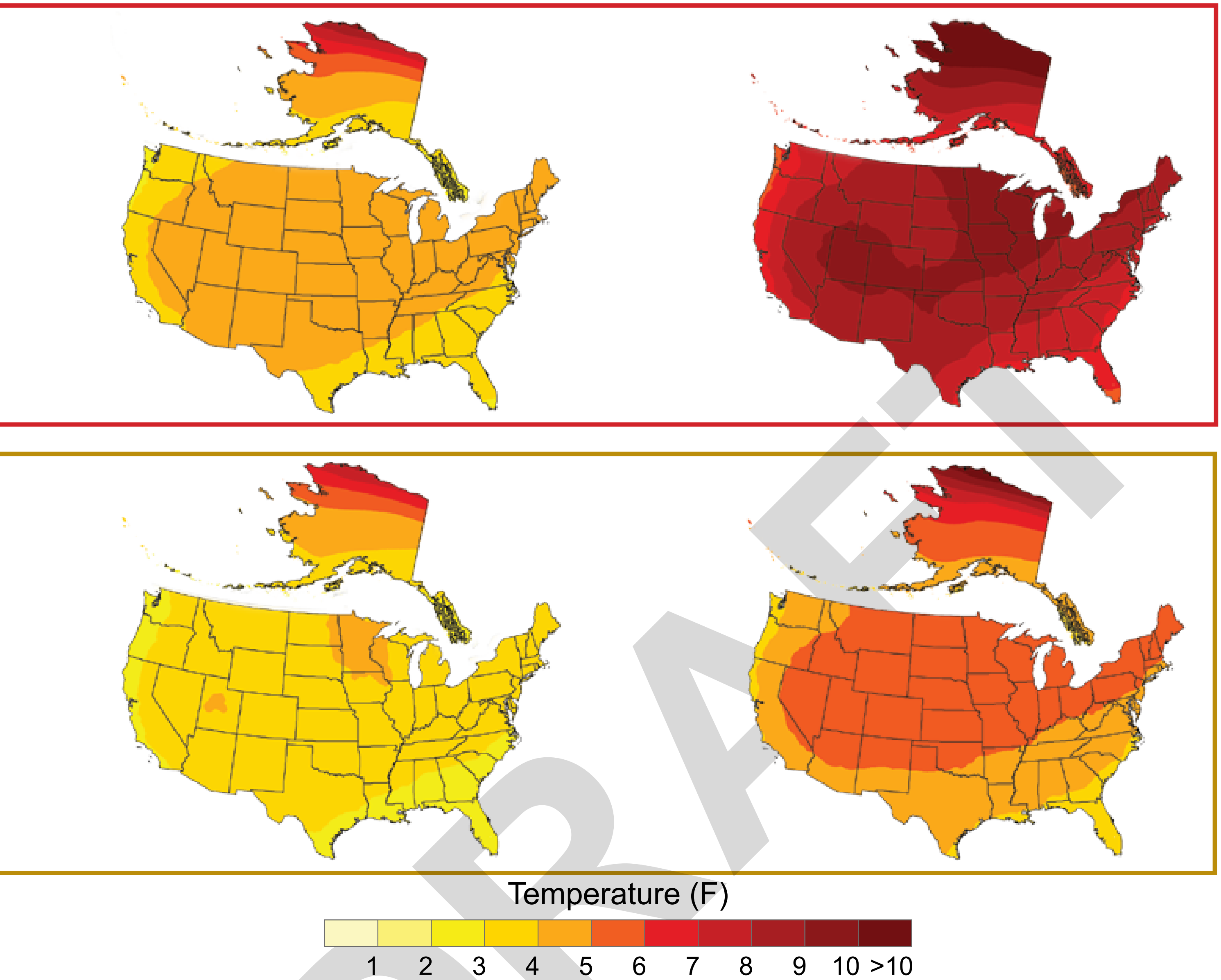


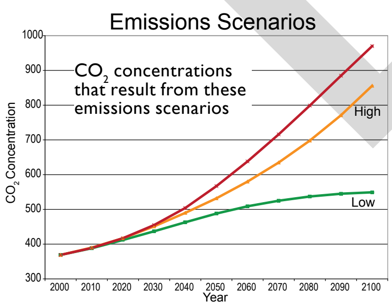


Temperatures in the U.S. have risen over the past 50 years and are projected to rise even more in this century. The first map shows observed warming since the 1960s and the remaining six maps show projected annual average warming over the course of this century under a low emissions and a high emissions scenario.

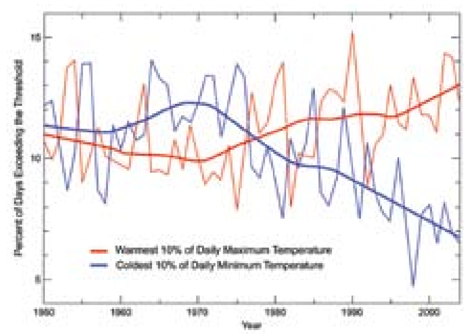
Temperature increases in the next couple of decades will be primarily determined by past emissions of heat-trapping gases. This explains why there is little difference between the maps showing the two scenarios for 2020. Increases after the next couple of decades will be primarily determined by future emissions, as seen on the maps for the middle and end of this century.

2050 **2090**





* The maps on this page are based on sixteen models' projections of future temperature using two scenarios of carbon dioxide emissions from the Intergovernmental Panel on Climate Change (IPCC), Special Report on Emission Scenarios (SRES)[I]. The "low" scenario here is IPCC SRES B1, while the "high" is A2. In other places in this report, the higher scenario A1FI (red line in graphic at left) is used as the "high" scenario.



As average temperature has increased, cold extremes have decreased and hot extremes have increased, as shown on the chart above.

U.S. Precipitation

Precipitation over the United States as a whole has generally increased, though there have been important regional differences. Wetter areas, such as the Northeast, have generally become wetter while drier areas, such as the Southwest, have generally become drier. This fits the pattern projected to occur due to warming. There have also been seasonal differences, with some seasons showing large increases or decreases in various regions.

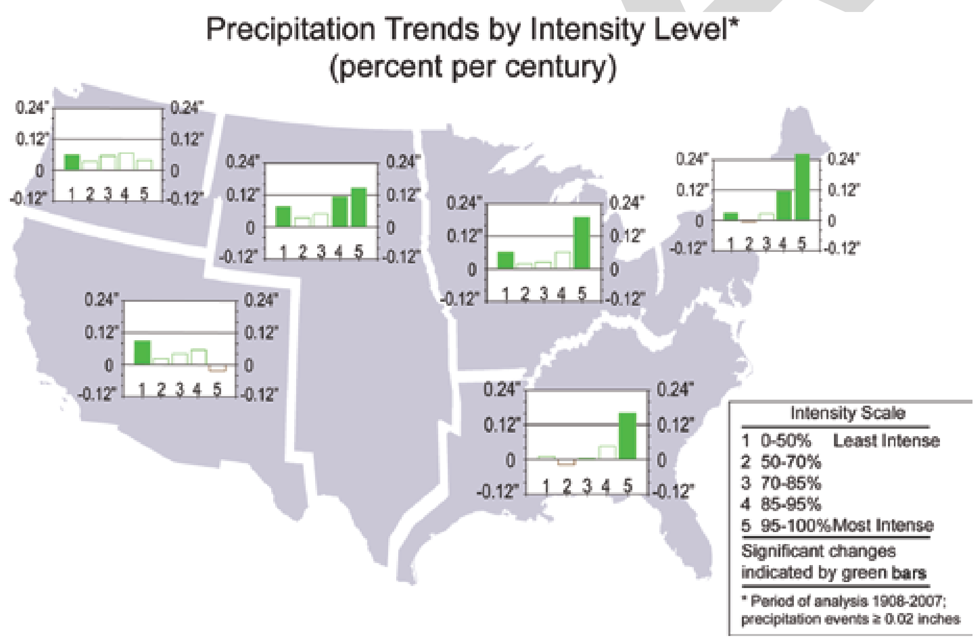
One of the clearest precipitation trends in the U.S. is the increasing frequency and intensity of heavy downpours. The amount of precipitation falling in the heaviest 1 percent of rain events increased nearly 20 percent over the past century. Total average precipitation over the nation as a whole increased by about 7 percent, with individual locations ranging from much more to much less than this average.[2]

Model projections of future precipitation generally suggest continuations of observed patterns, with northern areas becoming wetter and southern areas, particular in the West, becoming drier.

Precipitation changes due to human-induced warming are more difficult to predict than changes in temperature. It is virtually certain that in some seasons, some areas will experience an increase in precipitation, other areas experience a decrease, and others will see little discernible change. The difficulty arises in predicting the extent of those areas and the amount of change.

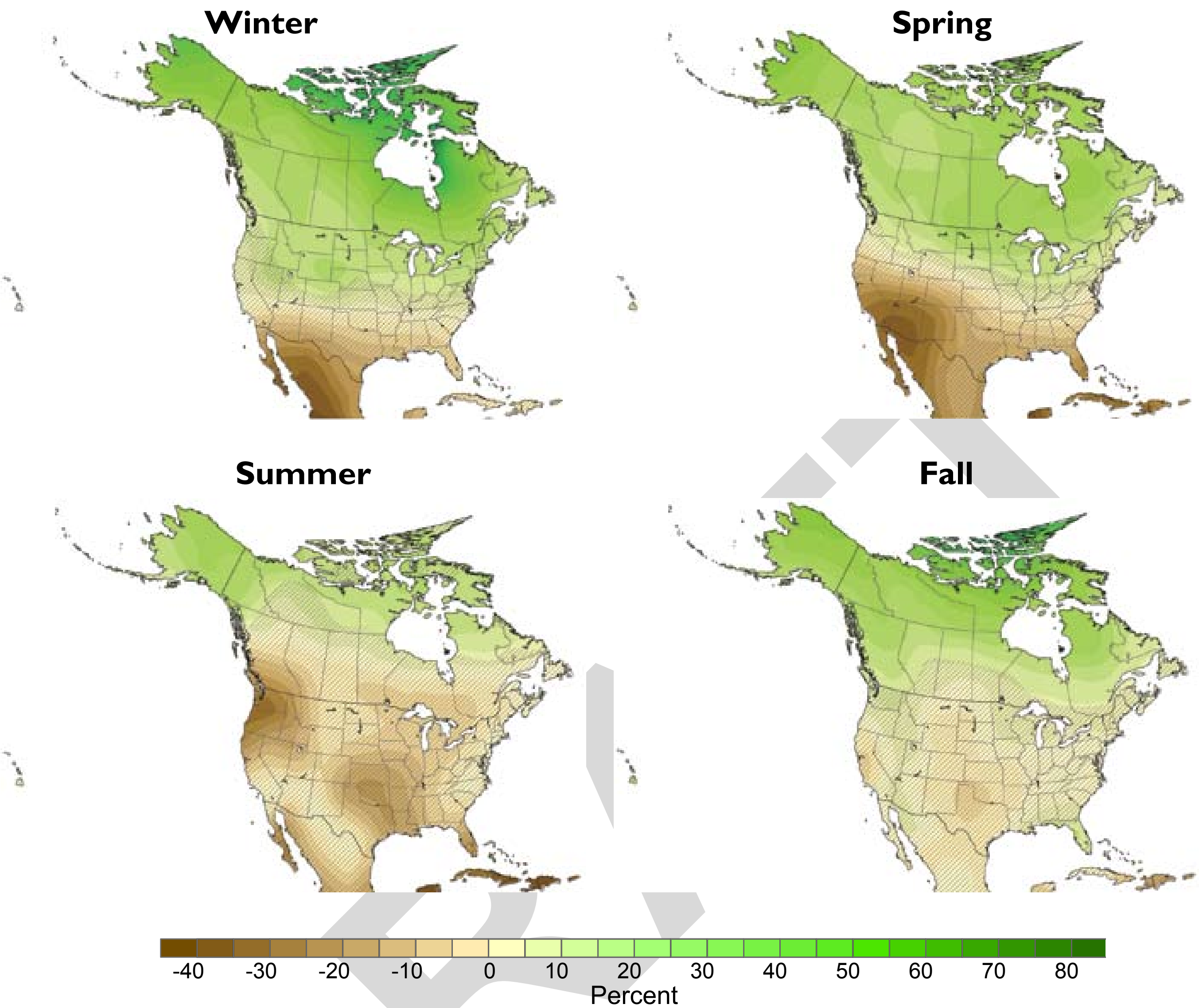
The maps to the right show the best estimates of percentage changes in seasonal average precipitation by the end of this century in a high emissions scenario based on 15 climate models. The hatched areas are less certain than unhatched. Confidence in predicted changes are higher in winter and spring than in summer and fall.

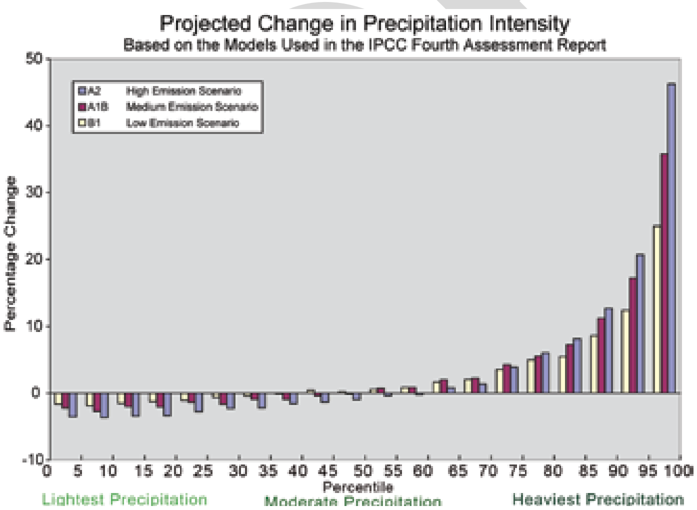
In winter and spring, northern areas are expected to receive significantly more precipitation than they do now, because warmer air holds more moisture. This effect is particularly noticeable in northern regions that will go from very cold and dry conditions to warmer but snowier conditions. Alaska is already experiencing this and the Great Plains, upper Midwest, and Northeast are likely to experience this in the next few decades. Significant reductions in precipitation are predicted in southern areas in winter and spring. This is particularly pronounced in the Southwest, where it will have serious ramifications for water resources.



The bar graphs show trends in precipitation intensity by region. Each bar represents precipitation of a particular intensity with the far left bar being lighter rainfall and the far right bar the heaviest.

Projected Change in North American Precipitation





The maps above show model projections of precipitation changes by the end of this century in percent by seasons. Hatched area are less certain than unhatched areas.

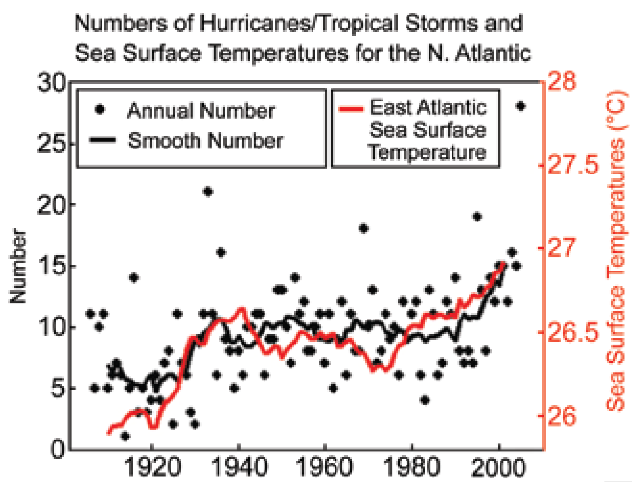
The figure to the left shows projected changes in the intensity of precipitation displayed in 5 percent increments from the lightest drizzles to the heaviest downpours. As shown here, the lightest precipitation is projected to decrease, while the heaviest will increase, continuing the observed trend. The higher emission scenarios yield larger changes.

Storms

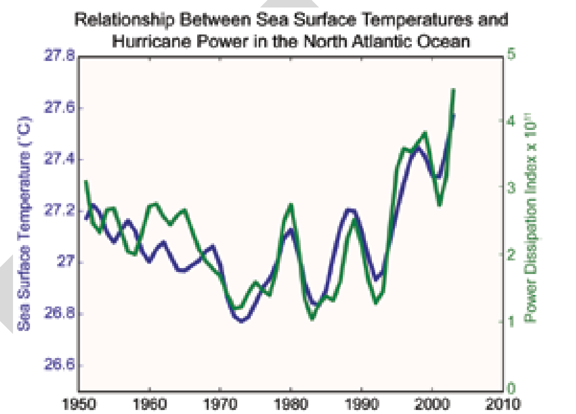
Changes in extreme weather and climate events are among the most serious challenges to our nation in coping with a changing climate. Many extremes and their associated impacts are now changing. The U.S. has been experiencing more unusually hot days and nights. Heavy downpours have become more frequent and intense. Droughts are becoming more severe in some regions. These trends are projected to continue[4].

The power and frequency of Atlantic hurricanes have increased substantially in recent decades as shown on the graphs below. In the future, the most intense hurricanes are likely to become even stronger, with greater wind speeds, rain fall rates, and storm surge levels[5].

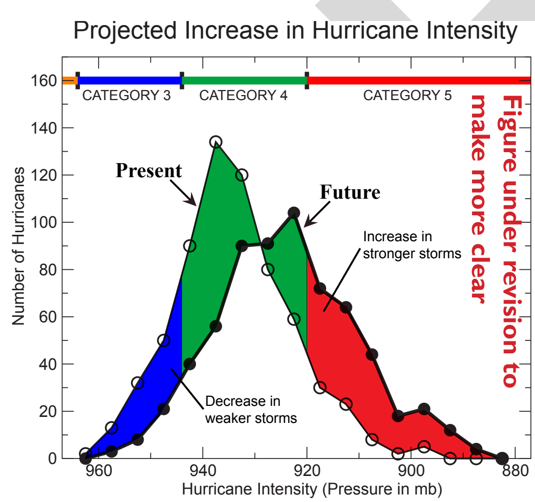
Outside the tropics, storm tracks are shifting northward and are projected to continue to do so. Strong cold season storms are likely to become stronger and more frequent, with greater wind speeds and more extreme wave heights.



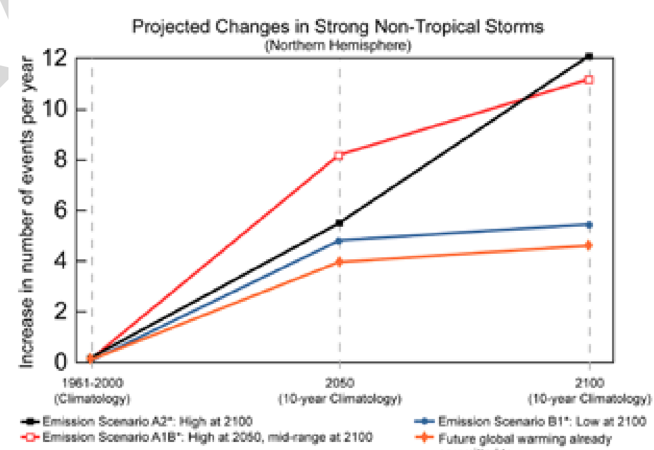
Annual numbers of hurricanes/tropical storms in the North Atlantic (black dots) and 9-year running mean (black line) are correlated with sea surface temperature (9-year smoothed temperature, red line).



Sea surface temperature (blue) and the Power Dissipation Index for North Atlantic hurricanes. Hurricane rainfall and wind speeds are likely to increase in response to human-caused warming. Analyses of model simulations suggest that for each 1.8°F increase in tropical sea surface temperatures, core rainfall rates will increase by 6-18 percent.

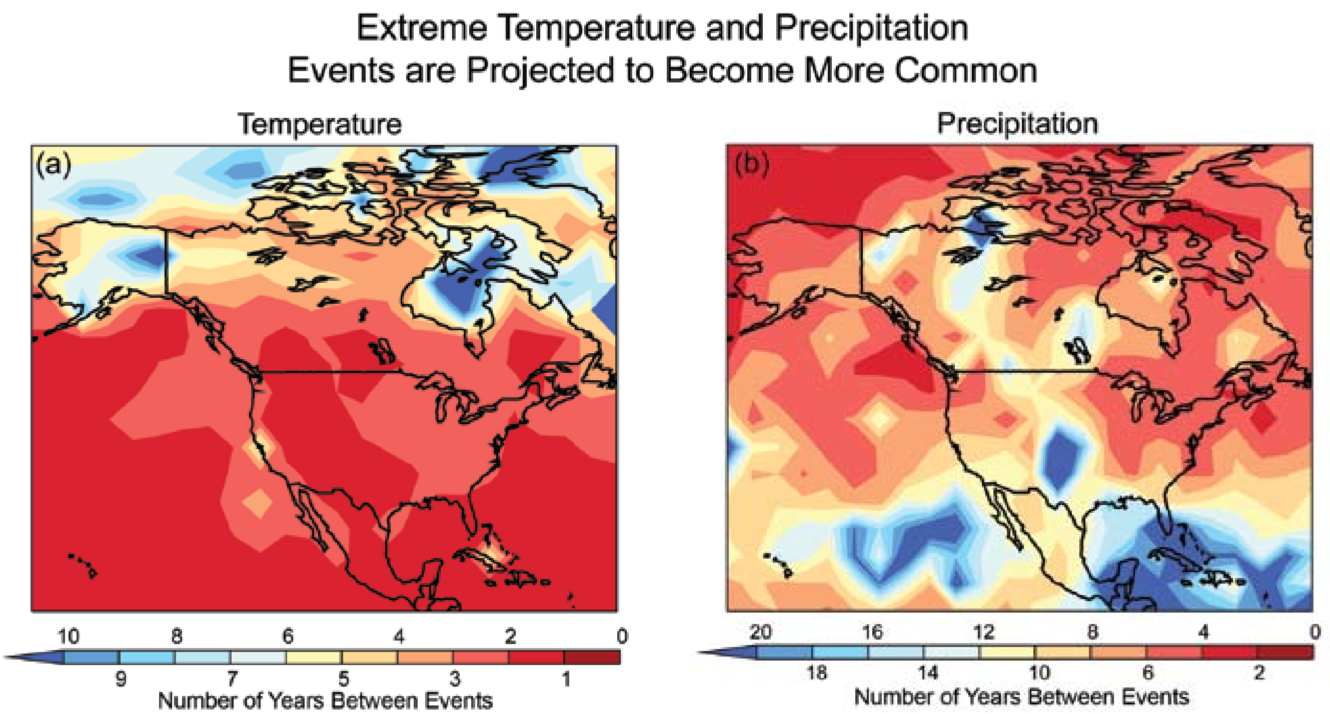


Strong hurricanes are projected to increase and weak hurricanes are projected to decrease.



The projected change in intense low pressure systems (strong storms) during the cold seasons for the Northern Hemisphere for various emission scenarios. There are likely to be more frequent deep low-pressure systems (strong storms) outside the tropics, with stronger winds and more extreme wave heights.

Extreme weather



a) Simulations for 2090-2099 indicate how currently rare extremes (a 1-in-20-year event) are projected to become more commonplace. A day so hot that it is currently experienced once every 20 years would occur every other year or more by the end of the century.

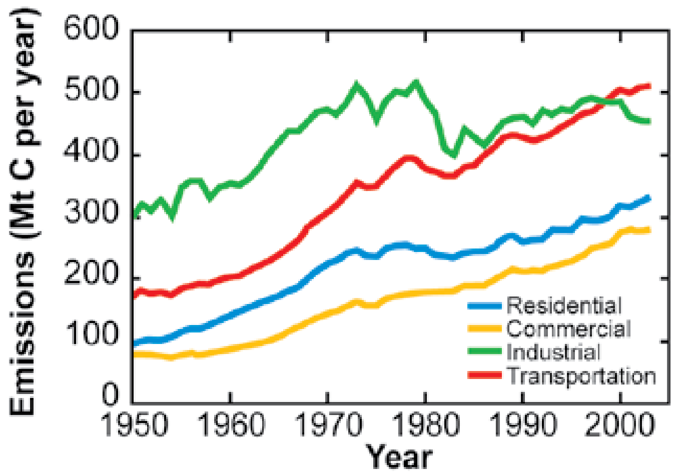
b) Daily total precipitation events that occur on average every 20 years in the present climate would, for example, occur once every 4-6 years for Northeast North America. These results are based on a multi-model ensemble of global climate models.

Extreme heatwaves that we currently consider rare will occur more frequently in the future. Hot days that are currently considered 1-in-20 year occurrences are projected to happen about every other year by the end of this century. Heavy downpours that are now 1-in-20 year occurrences are projected to occur about every 4 to 15 years by the end of this century, depending on location.

The intensity of extreme events like these will also increase in the future. For instance, a day so hot that it occurs once every twenty years at the end of the century will be as much as 11°F hotter than a day that rare at present. The once every twenty year heavy downpour is expected to be between 13 and 24 percent heavier by the end of the century than it is now.

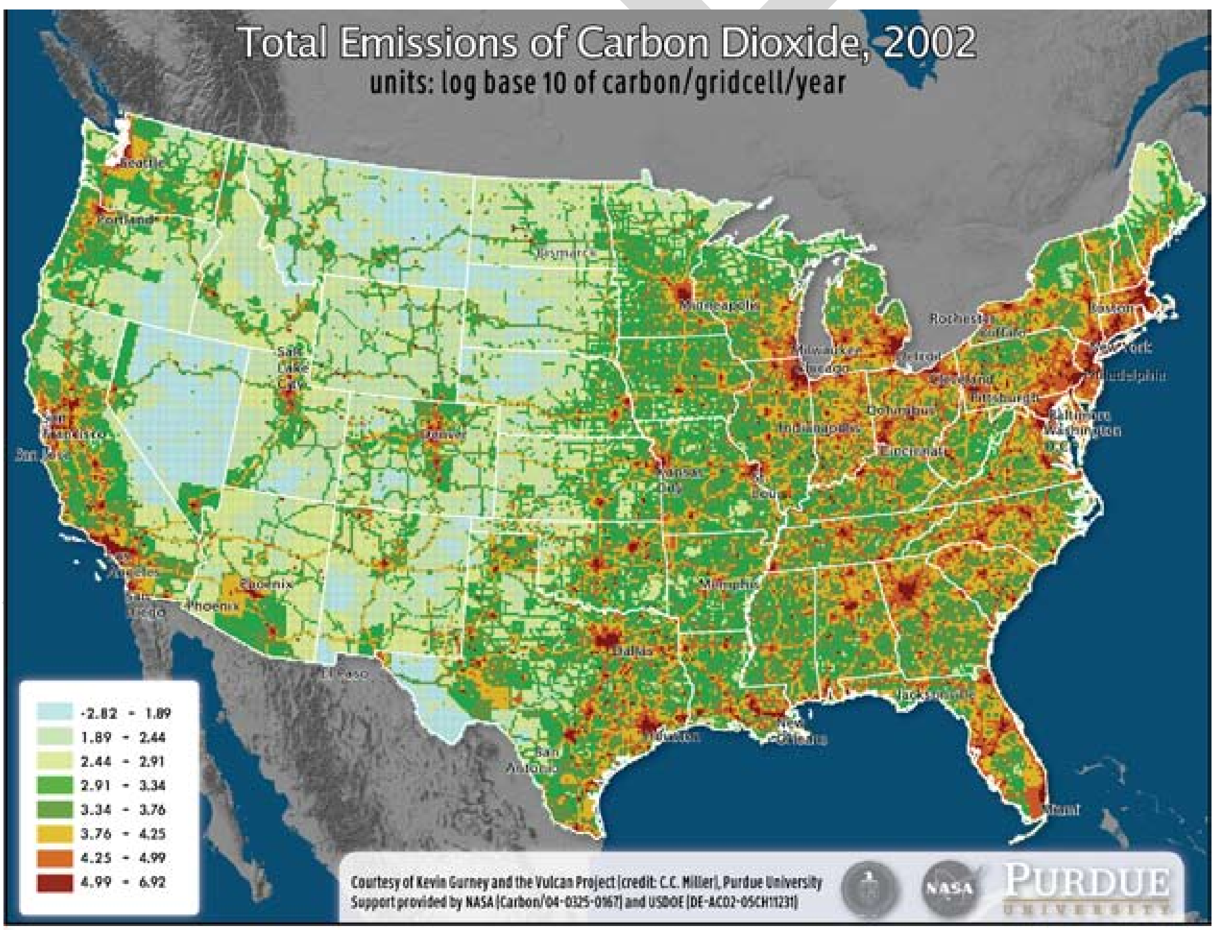
U.S. Emissions of Heat-trapping Gases

The build up of heat-trapping gases is driving global warming. Since the industrial revolution, the United States has been the world's largest emitter of those gases, though China has recently surpassed the U.S. in current emissions. Carbon dioxide, the most important of the heat-trapping gases produced directly by human activities, is a cumulative problem, because it has a long atmospheric lifetime. One third of the carbon dioxide released from fossil fuel burning remains in the atmosphere after 100 years, and one-fifth of it remains after 1000 years. As a result, the U.S. is responsible for about 28 percent of the human-induced heat-trapping gases in the atmosphere today[6].



Historical U.S. carbon emissions.

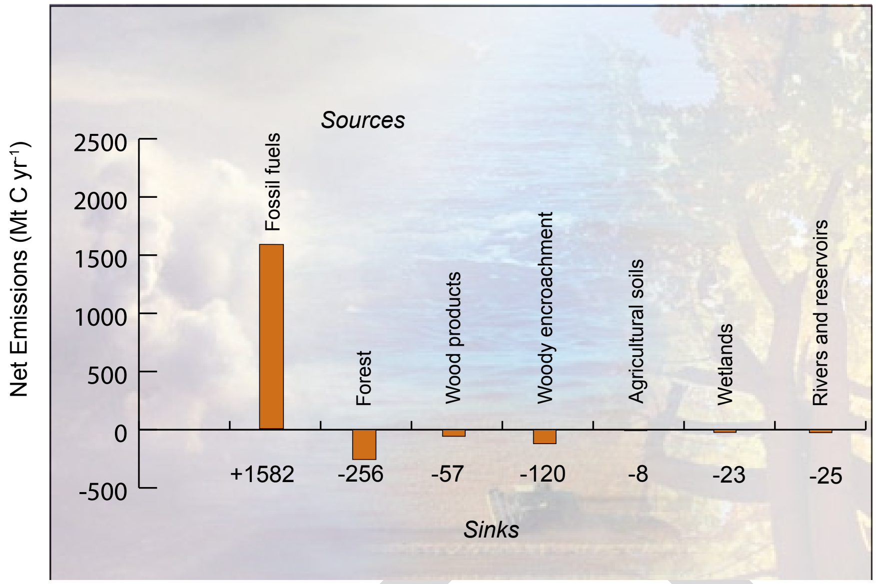
U.S. carbon dioxide emissions have been growing. These emissions are almost entirely from fossil fuels. These sources of carbon are one side of the equation, the other side of which involves "sinks" that take up carbon dioxide. In the U.S., natural sinks (primarily the growth of trees and other plants) currently take up the equivalent of about one third of our emissions. Another one-third is absorbed by the oceans and vegetation in other regions. The remaining one-third accumulates in the atmosphere, adding to the greenhouse effect, leading to further global climate change.



Carbon dioxide is the most important of the greenhouse gases produced directly by human activities. The map shows where U.S. carbon dioxide emissions came from in 2002.

There are significant uncertainties in these estimates, and the amount of carbon taken up or released from natural sources varies considerably from year to year depending on climatic and other conditions. For example, fires release carbon dioxide so years with many large fires result in more carbon release and less uptake. Similarly, the trees destroyed by intense storms or droughts release carbon dioxide, and are also not available to absorb it in the future. For example, Hurricane Katrina killed or severely damaged over 320 million large trees. As these trees decompose over the next few years, they will release an amount of carbon equivalent to the carbon taken up by all U.S. forests in a year[7]. The net change in carbon storage in the long run will depend on the regrowth as well as the original disturbance.

U.S. Carbon Sources and Sinks



U.S. carbon sources and sinks in millions of tons of carbon per year in 2003. Sources add carbon dioxide to the atmosphere while sinks remove it.

Methane from livestock accounts for about 20% of total U.S. methane emissions. A potentially far larger source of methane is the thawing of permafrost (frozen soil) in Alaska. In arctic bogs where plants grow during the summer, old plant material sinks and forms peat. In permafrost areas, old peat is frozen and preserved. Over thousands of years, this process has gradually built up and stored a great deal of carbon in a layer of peat averaging a couple of yards thick. The thawing of permafrost due to warming will cause this peat to decompose, releasing methane and carbon dioxide. The potential is enormous: Alaska's permafrost contains ten times more carbon than is released each year by U.S. fossil fuel burning, and Canada has 10 times more carbon currently locked in permafrost than does Alaska.