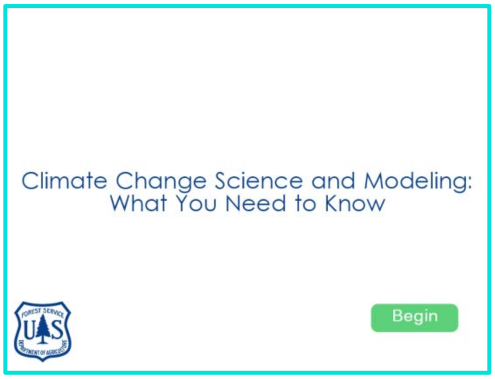
Climate Change Science and Modeling: What You Need to Know

The narration script with captioned screenshots

Title Slide

Climate Change Science and Modeling: What You Need to Know



This is a screenshot of the title slide. The title is centered on the screen, and the Forest Service shield is in the bottom left corner.

Introduction

In recent decades, many changes in the climate and in forest ecosystems have been observed in the United States.

Temperature is increasing. In the last 50 years, temperature has risen 1 to 2 degrees Fahrenheit in most of the United States, but temperature in Alaska has increased twice as much as the rest of the country. Minimum temperatures are increasing faster than maximum temperatures, and minimum temperatures in urban areas are increasing about 25 percent faster than in rural areas.

Precipitation patterns are changing. Snowfall is decreasing on both the west and east coasts. Snowpack is decreasing in the northern Rocky Mountains and elsewhere in the United States. Many glaciers in the Northwest and Alaska are losing mass and receding. Across the Midwest, the frequency of heavy precipitation events has more than doubled from 1961 to 2011.

Dry episodes are increasing in the West, Southwest, and Southeast. Particularly in the West and Southwest, droughts are longer, more severe, and more frequent, leading to water stress, low soil moisture, and low river flows.

Invasives, pests, and diseases are increasing. Close to 10 million acres of forest have been killed in the United States by epidemics of bark beetles. The growing season is increasing across the country, which may actually benefit forest and grassland ecosystems and croplands. But longer growing seasons are beneficial for invasives and pests too.

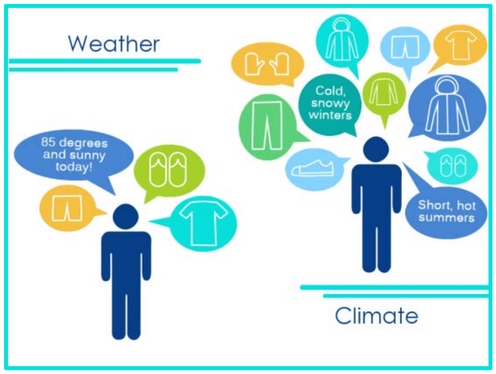
Wildfire activity is also changing. Annual area burned in the West has increased since the 1980s, and the length of fire season is increasing.

These changes are actually only a few examples of what is occurring across the United States. To better understand how and why these changes are important, and to begin planning how to cope with them in ecosystem management, we need to understand some basic information on climate, climate change, and future climate projections.

This is a screenshot of the introduction slide. It features graphic icons representing different facts listed in the narration and script.

Weather vs. Climate

Weather and climate are two different things, although they are related. Weather is a short-term trend, such as daily or monthly changes. Climate is a long-term trend, generally occurring over 30 years or more. Weather can be described as your daily outfit, while climate is your entire wardrobe.

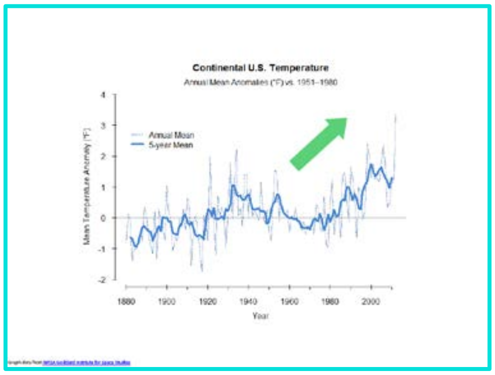


This is a screenshot of the weather vs. climate slide. The graphic illustrates the analogy of weather as your outfit and climate as your closet. An icon of a person is describing his outfit for a sunny warm day, and an icon of a person is describing his closet based on the climate of residence.

Climate Change/Increasing Temperature

The global climate is changing. The Intergovernmental Panel on Climate Change, or the IPCC, is a partnership of thousands of scientists from around the globe that reviews and assesses the most recent scientific, technical, and socio-economic information produced worldwide on climate change. The IPCC has stated that there is no doubt that global temperatures have been rising over the last 50 years. The average global temperature has increased by 1.4 degrees Fahrenheit, although specific regions may vary from the average.

For example, the average temperature in the United States has risen more than 2 degrees Fahrenheit during that same time period.



This is a screenshot of the climate change/increasing temperature slide. It shows a graph of temperature anomalies (based on 1951-1980 temperatures) from 1880 to 2010 in the United States.

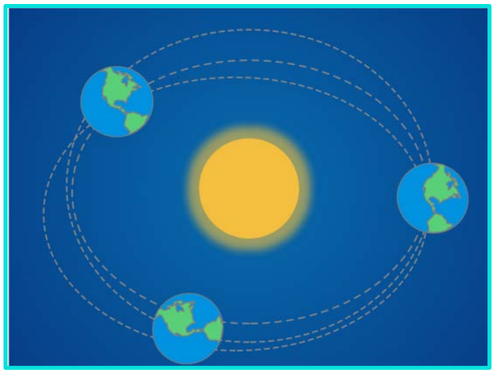
This slide features a hyperlink that leads to the NASA Goddard Institute of Space Studies (NASA GISTEMP specifically) where the data for the global and U.S. temperature graphs was retrieved: http://data.giss.nasa.gov/gistemp/graphs_v3/

Milankovitch Cycle

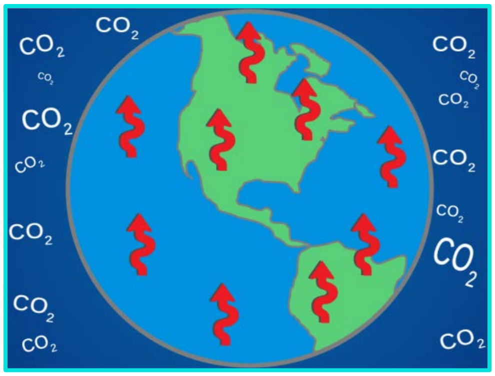
In the past hundreds of thousands of years, major fluctuations in climate have been driven by changes in the Earth's movements, called Milankovitch Cycles. The way the Earth moves and tilts on its axis as it orbits the sun affects the angle at which sunlight travels through our atmosphere, ultimately affecting our climate.

Natural climate cycles, like the Milankovitch Cycles, repeatedly cause global surface temperature changes, leading to changes in ocean temperature and the amount of carbon dioxide released into the atmosphere. When these cycles cause increased temperatures, additional carbon dioxide is released into the atmosphere from the land and oceans, which amplifies the temperature increases. These natural climate cycles last tens of thousands of years and generally shift slowly from the perspective of humans.

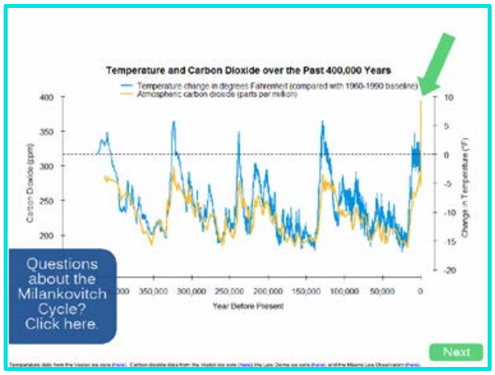
This graph shows temperature in blue and atmospheric carbon dioxide in yellow. The temperatures increase first in these natural cycles, and carbon dioxide follows with a lag of several hundred years. At the right edge of the graph there is a recent large spike in the yellow carbon dioxide data. This is where the carbon dioxide increase now precedes the temperature change. This recent atmospheric carbon dioxide spike is primarily caused by humans and is outside of the pattern of natural cycles over the last 400,000 years. This means that humans are now effectively overriding the natural climate cycle, and the resulting climate shifts are happening very rapidly.



This is a screenshot of the Milakovitch Cycle slide. This is a graphic representation of the Earth as it changes orbit shape and axis angle when orbiting around the sun.



This is a screenshot of the Milakovitch Cycle slide. A graphic representation of the Earth with red arrows is featured in the center and surrounded by carbon dioxide text. The red arrows represent increased global temperatures in response to increases in natural climate cycles and increases in atmospheric carbon dioxide.

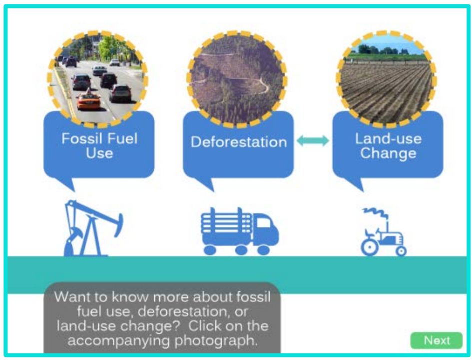


This is a screenshot of the Milankovitch Cycle slide. The graph of temperature and carbon dioxide over the past 400,000 years is centered on the slide. Temperature is in light blue, and carbon dioxide is in yellow. A box on the left-hand side of the screen asks, “Questions about the Milankovitch Cycle? Click here”. See the box below in this document for the hyperlink.

This slide features a hyperlink that leads to a NASA Earth Observatory website with more information on the Milankovitch Cycle: http://earthobservatory.nasa.gov/Features/Milankovitch/milankovitch.php. This slide also has hyperlinks to the data from the temperature and carbon dioxide graph. The temperature data was retrieved from the Vostok Ice Core, available from NOAA, National Climate Data Center (http://www.ncdc.noaa.gov/paleo/icecore/antarctica/vostok/vostok_isotope.html). The carbon dioxide data was retrieved from the Vostok ice core (http://www.ncdc.noaa.gov/paleo/icecore/antarctica/vostok/vostok_co2.html) the Law Dome ice core (http://www.ncdc.noaa.gov/paleo/icecore/antarctica/law/law_data.html), both from NOAA, National Climate Data Center, and the Mauna Loa Observatory, NOAA, Earth System Research Laboratory (http://www.esrl.noaa.gov/gmd/ccgg/trends/).

Greenhouse Gas Causes

The current changes in our climate are caused by increases in greenhouse gases in the atmosphere. These increases come primarily from our use of fossil fuels and deforestation, which is often considered a part of land-use change.



This is a screenshot of the greenhouse gas causes slide. It features an icon and photograph for fossil fuel use, deforestation, and land-use change. The box at the bottom of the screen asks, “Want to know more about fossil fuel use, deforestation, or land-use change? Click on the accompanying photograph”. See the next page in this document for the information in these pop-up boxes.

Fossil Fuel Use

U.S. transportation fossil fuel consumption in 2012 emitted 1,511 million metric tons of carbon dioxide (U.S. EIA).

81.5% of U.S. greenhouse gas emissions are from energy-related carbon dioxide (U.S. EIA 2011).

Fossil fuel carbon emissions in the U.S., Canada, and Mexico account for 27% of global fossil fuel emissions (Pacala et al. 2007).

For more information on fossil fuel use, click here.

Deforestation/Land-use Change

North American forests offset 13% of fossil fuel emissions in the U.S., Canada, and Mexico (Pacala et al. 2007).

15.8% of U.S. carbon dioxide emissions were sequestered in forests and wood products in 2011 (USDA USFS FIA).

Between 1980 and 2000 more than 55% of new agricultural land came at the expense of intact tropical forests (Gibbs et al. 2010).

For more information on deforestation and land-use change, click here.

Land-use Change/Deforestation

From 2003–2012 land-use change emissions were 8% of all human-caused emissions. This has decreased from 38% in 1960 and 17% in 1990 due to stricter policies, enforcement, and afforestation (GCP).

Agriculture accounts for 8% of total U.S. greenhouse gas emissions (EPA).

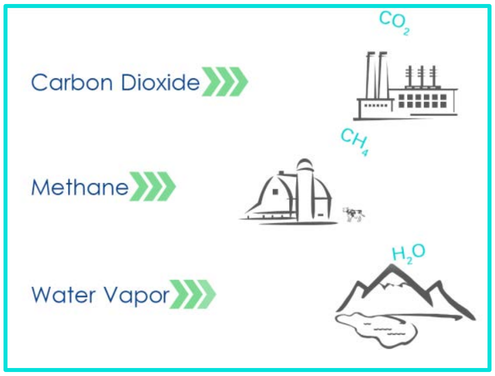
Since the 1990s, land-use change has primarily been a net sink in the U.S., but in other areas of the world large tracts of forested lands are being cleared (EPA).

For more information on land-use change and deforestation, click here.

Main Greenhouse Gases

Increases in greenhouse gases, from human-caused sources or otherwise, add to the natural greenhouse gas effect. Carbon dioxide, halocarbons, methane, nitrous oxide, and water vapor are all important greenhouse gases, but carbon dioxide, methane, and water vapor are talked about most often. The generation of electricity from fossil fuels is a large source of carbon dioxide emissions. The use of fossil fuels also releases methane, as do livestock, farming, and landfills. It surprises many people that water vapor is also an important greenhouse gas. The primary sources of atmospheric water vapor are oceans and other large bodies of water, and water vapor from these sources increases when temperatures rise.

Greenhouse gas emissions from fossil fuels are effectively an addition to the climate system and can persist for many years or decades. Water vapor, however, is transitory, mostly driven by temperature, and leaves the atmosphere quickly. Atmospheric lifetime is the average time a gas molecule spends in the atmosphere. The atmospheric lifetime of carbon dioxide is on the timescale of decades. The lifetime of methane is on the timescale of years, and lifetime of water vapor is days. As these greenhouse gases have increased in the atmosphere, the amount of energy and heat in the atmosphere has increased, disrupting the global climate system.



This is a screenshot of the main greenhouse gases slide. Carbon dioxide is represented by an icon of a power plant, methane is represented by an icon of a farm with livestock, and water vapor is represented by a lake in front of a mountain.

This is a screenshot of the main greenhouse gases slide. The atmospheric lifetime of carbon dioxide is represented by a long rectangle indicating “decades”. The lifetime of methane is represented by a shorter “years” rectangle, and water vapor is represented by the shortest rectangle, for “days”.

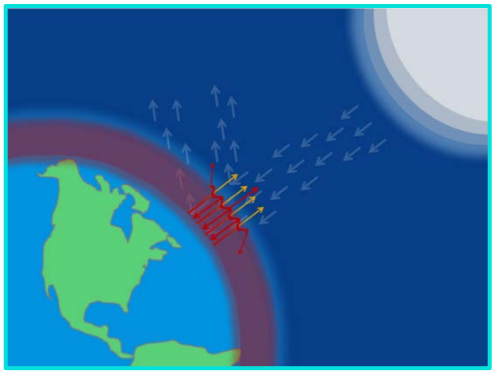
Greenhouse Effect – 1

The greenhouse effect is a natural process involving the interaction of sunlight and certain gases. Sunlight is high-energy, short-wave radiation. About 30 percent of this energy is reflected back into space by the atmosphere, clouds, and surface of the Earth. The remaining energy is absorbed by the Earth.

This is a screenshot of the first greenhouse gas effect slide. It features a representation of the earth receiving short-wave radiation arrows from the sun.

Greenhouse Effect – 2

The Earth emits long-wave, infrared radiation into the atmosphere. Some of the radiation passes through the atmosphere into space, but most of the long-wave radiation is absorbed by greenhouse gases. The greenhouse gases then re-emit the energy in all directions, which causes warming at the Earth's surface and lower atmosphere. Without the greenhouse effect the average temperature on Earth would be about 0 degrees Fahrenheit. The increase in atmospheric concentration of greenhouse gases through human activities amplifies the natural effect by absorbing and re-emitting more energy, causing global surface temperatures to increase.

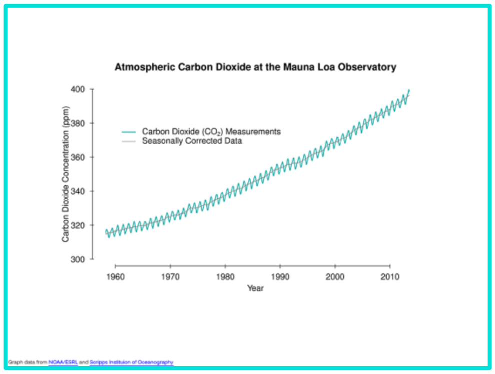


This is a screenshot of the second greenhouse gas effect slide. It features a representation of the earth emitting long-wave radiation arrows, and greenhouse gases re-emitting the radiation with red arrows and warming the atmosphere and surface.

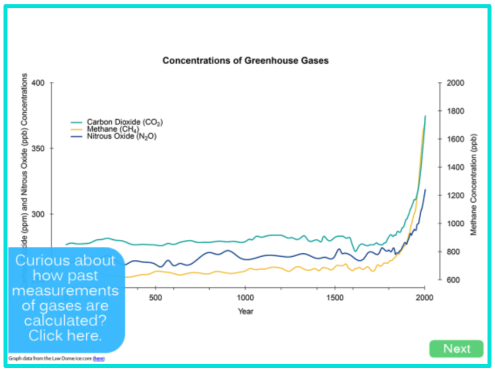
Carbon Dioxide Measurements

Carbon dioxide has been monitored at the Mauna Loa Observatory in Hawaii since the late 1950s. During this time, atmospheric carbon dioxide has steadily increased. The high-low pattern of observations shows the seasonal influence of vegetation in the Northern Hemisphere, which you can also see in this video from NASA. During the spring and summer in the Northern Hemisphere, vegetation grows and photosynthesis occurs, slightly lowering the amount of carbon dioxide in the atmosphere. During the fall and winter, growth stalls, and the carbon dioxide levels rise again.

This graph shows greenhouse gas levels over the past 2,000 years for carbon dioxide, in green; methane, in yellow; and nitrous oxide, in dark blue. Increases in concentrations since 1750 are primarily caused by human activities.



This is a screenshot of the carbon dioxide measurements slide. The graph is of carbon dioxide measurements at the Mauna Loa Observatory from about 1960 to 2012.



This is a screenshot of the carbon dioxide measurements slide. The graph is of carbon dioxide, methane, and nitrous oxide levels for the last 2,000 years. The box on the left side of the screen asks, "Curious about how past measurements of gases are calculated? Click here." See the box below for the information from this pop-up box.

Carbon Dioxide Measurements Slide Pop-up Box

Ice cores are drilled in glaciers and ice sheets in order to gather information about past climatic conditions.

Particles and dissolved chemicals get trapped by snow and compressed into the ice. This leaves a record of temperature, atmospheric chemistry, and volcanic and solar activity.

Ice cores provide very long records of past climatic behavior, up to hundreds of thousands of years.

For more information on ice cores, click here.

This slide features hyperlinks to the carbon dioxide data from the carbon dioxide measurements at Mauna Loa graph. The data was retrieved from NOAA, Earth Systems Research Laboratory (http://www.esrl.noaa.gov/gmd/ccgg/trends/) and the Scripps Institute of Oceanography (http://www.ncdc.noaa.gov/paleo/icecore/antarctica/law/law_data.html).

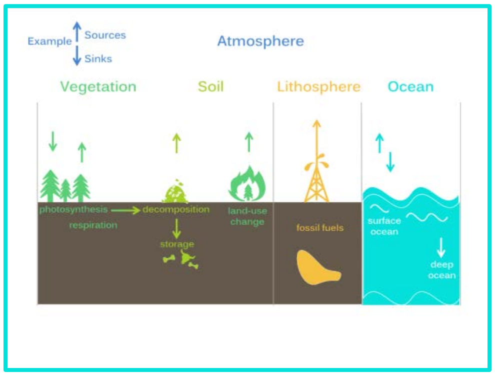
This slide also hyperlinks to the carbon dioxide, methane, and nitrous oxide measurements from the concentration of greenhouse gases graph. This data was retrieved from the Law Dome ice core from NOAA, National Climate Data Center (http://www.ncdc.noaa.gov/paleo/icecore/antarctica/law/law_data.html).

Carbon Cycle

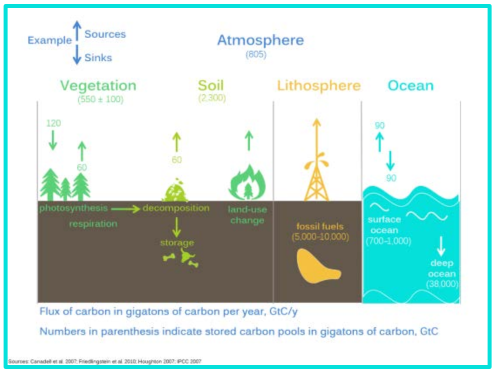
The carbon cycle is the flow of carbon through the atmosphere, ocean, vegetation, soil, and the Earth's rocky crust and upper mantle known as the lithosphere. In this graphic, down arrows indicate carbon sinks—this is where carbon is absorbed from the atmosphere. The up arrows represent sources—this is where carbon is released into the atmosphere. Vegetation acts as both a source and a sink through natural processes of respiration and photosynthesis, and wildfire can also be a significant source of carbon. Human-caused changes in land use add carbon to the atmosphere, often through vegetation clearing and burning, as well as soil disruption. Soils store large amounts of carbon, but also release some of that carbon through organic matter decomposition. Fossil fuels, such as oil and coal, are pools of carbon that were stored for millions of years, and humans are now extracting and burning these carbon pools, releasing them to the atmosphere. Carbon is readily transferred between the surface of the ocean and the atmosphere, and the deep ocean acts as a sink for carbon.

Carbon cycling between the atmosphere and land, and atmosphere and ocean, is nearly balanced. The numbers next to the carbon cycle source and sink arrows show the gigatons—1 gigaton equals 1 billion tons—of carbon per year flowing through that part of the cycle. The numbers in parentheses show the total size of the carbon pool in gigatons. The large bold numbers indicate the size of net sources or sinks. Both land and ocean are net sinks for carbon, meaning that slightly more carbon enters those pools than leaves. Photosynthesis absorbs about 122 gigatons of carbon, and plant respiration and decomposition almost counter that by releasing about 60 gigatons of carbon each. Surface mixing between the ocean and atmosphere is nearly balanced, but the ocean takes up about 2 gigatons more carbon than it releases.

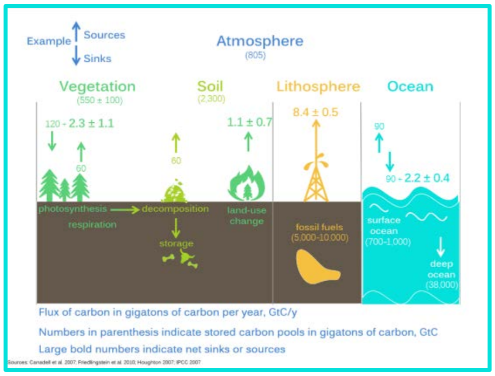
U.S. forests are an important carbon sink, providing the largest annual offset of carbon dioxide emissions of any other land use in the country. In fact, 15.8 percent of U.S. carbon dioxide emissions were sequestered in forests and long-lasting wood products in 2011, according to the USDA Forest Service Forest Inventory Analysis. In spite of the important annual carbon sinks into the land and ocean, fossil fuel combustion and landuse change still result in a net addition to the atmosphere of about 5 gigatons of carbon every year.



This is a screenshot of the carbon cycle slide. This graphic represents the major parts of the carbon cycle: vegetation, soil, lithosphere, and ocean. Each section features an icon, with arrow indicating the flow direction of carbon through the cycle.



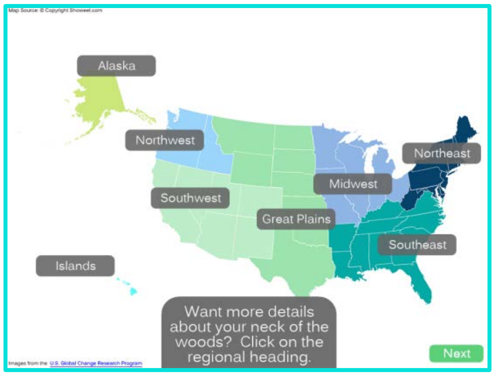
This is a screenshot of the carbon cycle slide. This graphic is the same as above, only storage in the different parts of the carbon cycle and the flux numbers of gigatons of carbon flowing through the cycle have been added.



This is a screenshot of the carbon cycle slide. This graphic is the same as above, with storage and flux numbers added. Additionally, the graphic has numbers of net sources or sinks in gigatons added.

Regional Observed Changes in Climate

A number of effects from climate change are being observed nationally and globally. Here are a few examples of the trends observed around the country. The Northeast is experiencing a rise in sea level and increases in heavy precipitation. Ocean surface temperatures are rising in the Southeast, which interacts with the severity of hurricane events. The Midwest is experiencing a decrease in lake ice. Temperatures and water stress are increasing in the Great Plains. The Northwest is experiencing changes in snowpack levels and the proportion of precipitation falling as snow. The severity of drought is increasing in the Southwest, resulting in low river flows. The Islands region is experiencing a rise in sea level. Finally, the size and frequency of wildfire is increasing in Alaska.

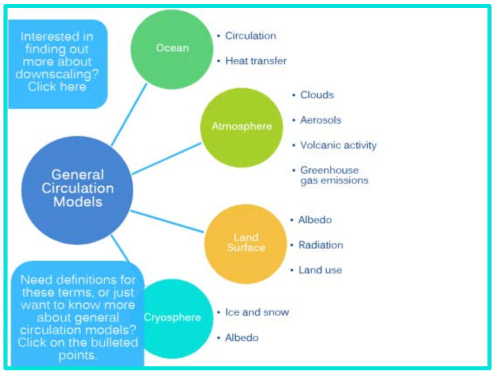


This is a screenshot of the regional observed changes in climate slide. Centered on the slide is a map of the United States, divided by region: Northeast, Southeast, Midwest, Great Plains, Southwest, Northwest, Alaska, and Islands. The box on the bottom of the screen asks, "Want more details about your neck of the woods? Click on the regional heading." See the box below for more information.

This slide features hyperlinks for each region: Northeast, Southeast, Midwest, Great Plains, Southwest, Northwest, Alaska, and Islands. These hyperlinks lead to regional pages created from the U.S. Global Change Research Program (USGCRP) 2009 National Climate Assessment Report. This slide also has a link to USGCRP image gallery, http://www.globalchange.gov/resources/gallery, which is the source for photographs used in the slide.

General Circulation Models

General circulation models, often called GCMs, are used to simulate the global climate system and its response to increasing greenhouse gas concentrations. These models are also known as global climate models, and they contain components from the ocean, atmosphere, land surface, and solid water surfaces, known as the cryosphere. General circulation models are global models that simulate global climate over very large areas. For information specific to smaller regions, other models may need to be used or outputs from the global models may need to be downscaled. If some of the general circulation model components, like albedo or radiation, are unfamiliar to you, click on the bullets to learn more.



This is a screenshot of the general circulation model (GCM) slide. It features the four main components, ocean, atmosphere, land surface, and cryosphere, branching out of the main GCM circle. The ocean circle has two bullets: circulation and heat transfer. The atmosphere circle has four bullets: clouds, aerosols, volcanic activity, and greenhouse gas emissions. The land surfaces circle has three bullets: albedo, radiation, and land use. The cryosphere circle has two bullets: ice and snow and albedo. The box in the bottom left corner asks, "Need definitions for these terms, or just want to know more about general circulation models? Click on the bulleted points". The box in the top left corner asks, "Interested in finding out more about downscaling? Click here". See the box below for more information.

General Circulation Model Bullet Definitions

Ocean

Circulation and Heat Transfer: Ocean currents move warm water to the poles and cooler water to the tropics. Oceans also circulate water up and down in some areas, as surface water sinks and deep water rises.

Atmosphere

Clouds: Clouds come in many different forms, from wispy, cirrus clouds high in the atmosphere to stormy, cumulonimbus clouds right above the surface. Clouds warm the planet by re-emitting radiation, or cool it by reflecting solar energy.

Aerosols: Aerosols are tiny solid or liquid particles that are suspended in gases, such as in smoke or smog. Aerosols generally act to cool the Earth.

Volcanic Activity: Volcanic activity sends ash particles and gases into the atmosphere. Large volcanic eruptions tend to cool the Earth for short periods of time.

Greenhouse Gas Emissions: Greenhouse gases absorb and emit long-wave radiation from the Earth. This acts to warm the Earth's surface and atmosphere.

Land Surface

Albedo: Albedo indicates how well a surface reflects solar radiation. Think of it as the "whiteness" of a surface on a scale of 0 to 1, where 0 indicates a perfect absorber and 1 indicates a perfect reflector. A desert would have a high albedo, a dark conifer forest, low.

Radiation: The Earth has a radiation budget between the incoming short-wave radiation from the sun and the outgoing long-wave radiation from the Earth.

Land Use: Changes in land use affect many different parts of the global climate system. For example, converting forest land for agricultural use changes the reflectivity, or albedo, which is turn affects the radiation budget.

Cyrosphere

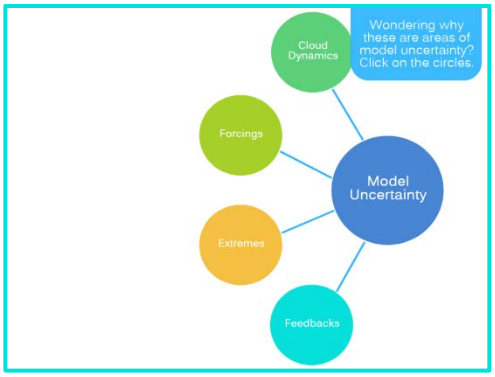
Ice and Snow and Albedo: Albedo indicates how well a surface reflects solar radiation. Think of it as the "whiteness" of a surface on a scale of 0 to 1, where 0 indicates a perfect absorber and 1 indicates a perfect reflector. A desert would have a high albedo, a dark conifer forest, low.

This slide features a hyperlink that leads to a publication with more information on downscaling and climate projections: http://www.fs.fed.us/rm/pubs/rmrs_gtr277.pdf

General Circulation Model Uncertainty

General circulation models are just that: models. They are not 100 percent accurate at reproducing the climate system because the climate system is so complex. Most of the uncertainty in the models comes from the complexities of cloud dynamics, forcings, extremes, and feedbacks – all of which vary through space and time. If you are uncertain about some of these terms, like forcings, which are factors that force the climate system and energy balance of the Earth, then click on the circles to learn more.

Although there is uncertainty in the general circulation models, the models still do a good job of replicating past climate and projecting ranges of reasonable future climates. There is scientific consensus that the global climate is changing and causing wide-ranging effects, and in spite of uncertainties, we know enough about the climate system to engage in responsible planning for a plausible range of climate futures.



This is a screenshot of the general circulation model (GCM) uncertainty slide. It features the four main components of uncertainty, cloud dynamics, forcings, extremes, and feedbacks, branching out of the main GCM uncertainty circle. The box in the top right corner asks, "Wondering why these are areas of model uncertainty? Click on the circles". See the box below for more information.

General Circulation Model Uncertainty Definitions

Cloud Dynamics: Clouds both cool the Earth by reflecting solar radiation and warm the Earth by re-emitting the Earth's long-wave radiation. There are many types of clouds, with different radiative properties and impacts on the Earth's energy budget.

Forcings: Climate forcings are factors that drive, or push, the climate system and the energy balance of the Earth. These forcings are from external sources and can either be positive or negative. Positive forcings mean more incoming energy, which warms the system, and negative forcings indicate more outgoing energy, which cools the system.

Extremes: Extreme events are difficult to model because extremes deviate from the average. Extremes are often a local phenomenon, occurring at smaller scales than GCMs model.

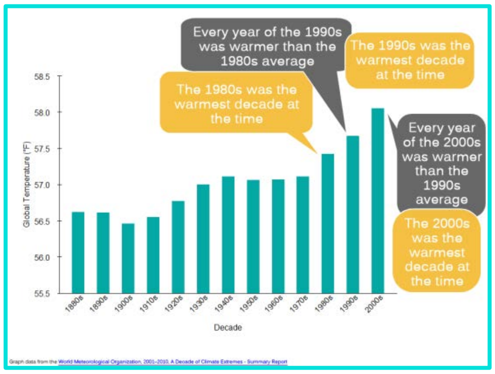
Feedbacks: Feedbacks either amplify or diminish the effects of climate forcings. Feedbacks are internal, happening inside the climate system. A feedback loop happens when the change in one force changes another, and then that change in the second force in turn changes the first.

Uncertainty with Climate Change

Climate change adds uncertainty to the future, because we can't rely on climate conditions in the future to be the same as those in the past.

For example, every decade since the 1980s has been the warmest decade on record. Each individual year in the 1990s was warmer than the average for the 1980s, and the same thing occurred in the 2000s, with each year of the 2000s warmer than the 1990s average.

For these reasons, it's important to consider a range of potential future conditions.

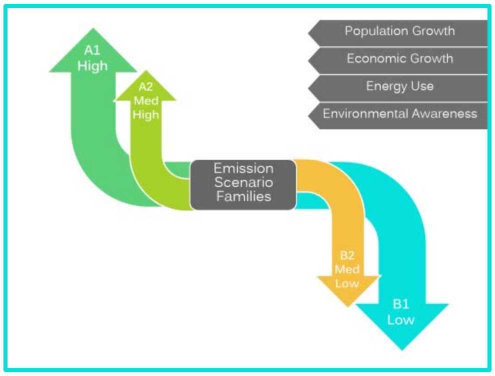


This is a screenshot of the uncertainty with climate change slide. The graph shows global temperatures per decade since the 1880s. The callouts highlight how each decade since the 1980s has been the warmest decade, with individual years warmer than the previous decade's average.

This slide features a hyperlink to the temperature data for the graph, retrieved from a World Meteorological Organization publication: http://library.wmo.int/opac/index.php?lvl=notice_display&id=15110.

Emissions Scenarios

Emissions scenarios provide a range of possible future greenhouse gas emissions based on expectations about future demographics, economics, and technology. They are used as inputs into general circulation models. The IPCC fourth assessment report used four scenario families, each with differing projections and expectations. The fifth IPCC assessment report did not use these same emissions scenarios. Instead, the IPCC used representative concentration pathways, known as RCPs, which are specific emissions trajectories leading to a set radiative forcing.

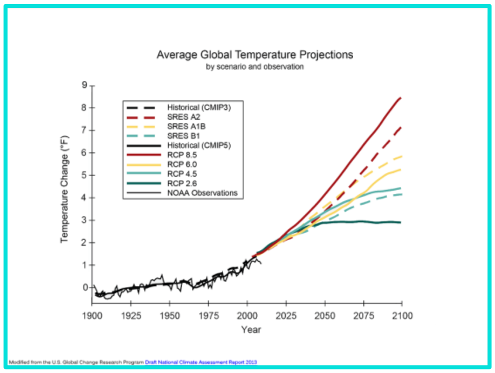


This is a screenshot of the emissions scenarios slide. The graphic visualizes emissions scenario families. The highest scenario family, A1, is a large arrow pointing up, and the lowest family, B1, is a large arrow pointing down. The second highest scenario family, A2, is a smaller arrow pointing up, and the second lowest family, B2, is a smaller arrow pointing down.

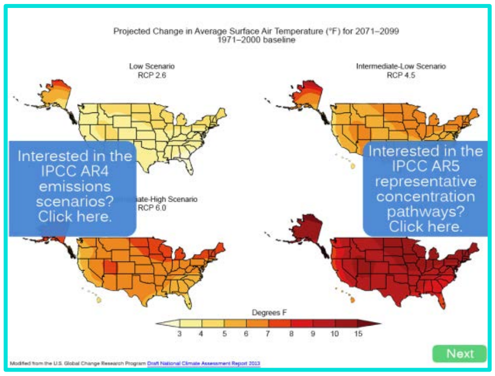
Emissions Scenarios Continued

All climate models project there will be further warming in the future, but the extent of projected warming depends on the different emissions scenarios or representative concentration pathways. Higher emissions scenarios would result in larger temperature increases than lower emissions scenarios.

This graph shows temperature increases across the United States. As each pathway leads to a higher radiative forcing, the United States is getting warmer and the colors transition into red.



This is a screenshot of the continued emissions scenarios slide. The graph shows the average observed global temperature until about 2010 and the average global temperature projections until 2100 using different emissions scenarios and representative concentration pathways.



This is a screenshot of the continued emissions scenarios slide. The graphic shows the projected change in average surface temperature by the end of the century in the United States for a low scenario representative concentration pathway in the upper left corner, to a high representative concentration pathway in the lower right corner. The box on the left-hand side asks, “Interested in the IPCC AR4 emissions scenarios? Click here”. The box on the right-hand side asks, “Interested in the IPCC AR5 representative concentration pathways? Click here”. For more information, see the box below.

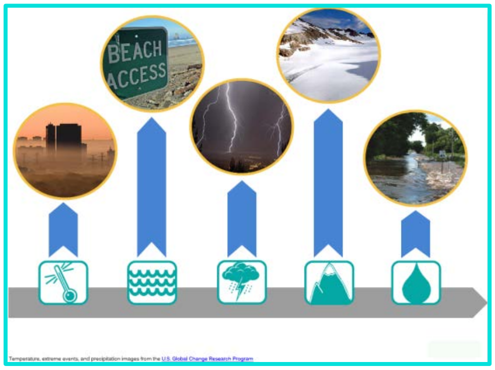
This slide features a hyperlink that leads to more information on the emissions scenarios used the Intergovernmental Panel On Climate Change (IPCC) Fourth Assessment Report, http://www.ipcc.ch/ipccreports/sres/emission/index.php?idp=91. This slide also has a hyperlink that leads to more information on representative concentration pathways from the IPCC Fifth Assessment Report, http://sedac.ipcc-data.org/ddc/ar5_scenario_process/RCPs.html.

Projected Changes in Climate

The average global temperature is projected to rise another 2 to 11.5 degrees Fahrenheit by 2100, depending upon future greenhouse gas emissions and sensitivity of the climate system to those increases.

Many of the effects currently observed are expected to continue, and often intensify. Besides warmer temperatures, these include rising sea levels, increases in extreme events, retreat of glaciers, and changing precipitation patterns.

These projected future impacts will vary by region.



This is a screenshot of the projected changes in climate slide. Each of the example projected changes has a graphic icon and photograph as a visual representation.

This slide features a hyperlink to USGCRP image gallery, http://www.globalchange.gov/resources/gallery, which is the source for some of photographs used in the slide.

If you would like additional accessibility resources not available on the site, please contact ccrc@fs.fed.us, or contact Kailey Marcinkowski at kfmarcinkowski@fs.fed.us.