



Climate Change Impacts to Fish, Wildlife, Plants and their Habitats:

Adapting to and Managing for Change



ITEP Webinar Series

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June 29, 2015



Climate Literacy:

The Essential Principles of Climate Science

(USGCRP 2009)

1. The Sun is the primary source of energy for Earth's climate system.
2. Climate is regulated by complex interactions among components of the Earth system.
3. Life on Earth depends on, is shaped by, and affects climate.
4. Climate varies over space and time through both natural and man-made processes.
5. Our understanding of the climate system is improved through observations, theoretical studies, and modeling.
6. Human activities are impacting the climate system.
7. Climate change will have consequences for the Earth system and human lives.

Climate (vs. weather)

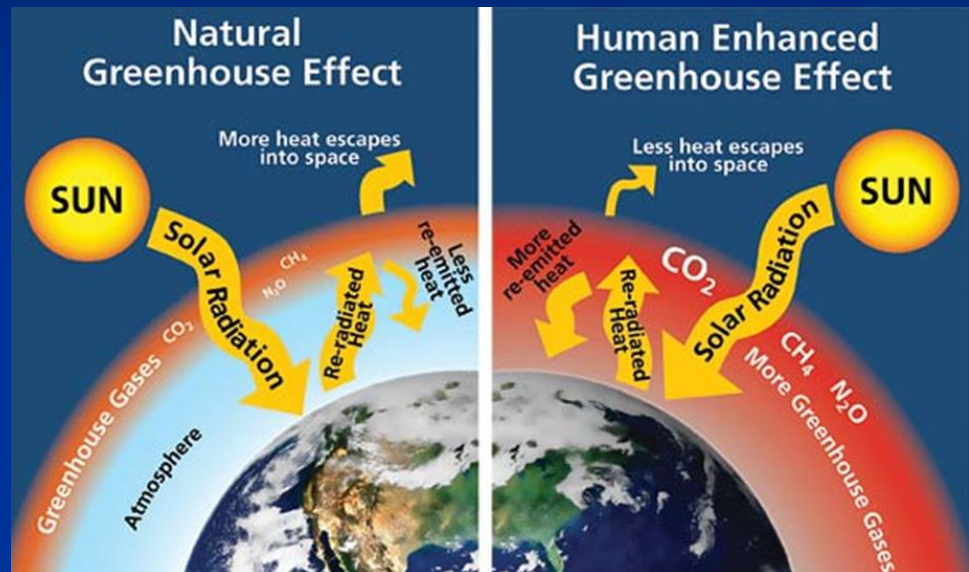
- ❑ Weather is defined as the instantaneous condition of the atmosphere at a certain time including such things as...
 - hot or cold
 - cloudy or clear
 - humid or dry
 - drizzles or downpours
 - Snowfall or blizzards
 - Snowpack or snowmelt
 - Tornadoes
 - Typhoons or Hurricanes
- ❑ **Climate is the aggregated pattern of weather, meaning averages, extremes, timing, spatial distribution of the above activities...over at least a 30-year period.**
- ❑ Weather varies greatly from day to day, and is impossible to predict more than two weeks in advance. Climate varies slowly, to a much lesser degree, and over timescales of decades to millennia.



Climate Literacy:

The Sun is the primary source of energy for Earth's climate system.

- Sunlight reaching the Earth can heat the land, ocean, and atmosphere. Some of that sunlight is reflected back to space by the surface, clouds, or ice. Much of the sunlight that reaches Earth is absorbed and warms the planet.
- When Earth emits the same amount of energy as it absorbs, its energy budget is in balance, and its average temperature remains stable.

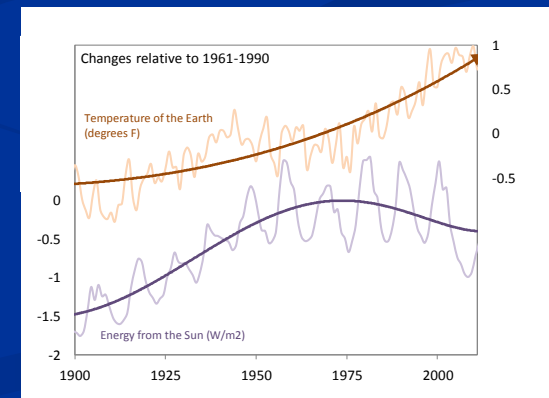
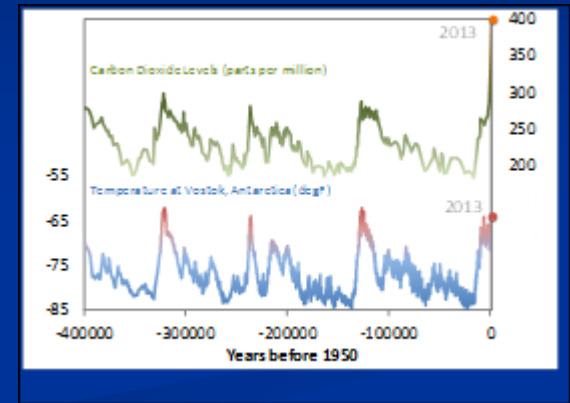


- The greenhouse effect is a natural phenomenon whereby heat-trapping gases in the atmosphere, primarily water vapor, keep the Earth's surface warm.
- Human activities, primarily burning fossil fuels and changing land cover patterns, are increasing the concentrations of some of these gases, amplifying the natural greenhouse effect.

Climate Literacy:

The Sun is the primary source of energy for Earth's climate system.

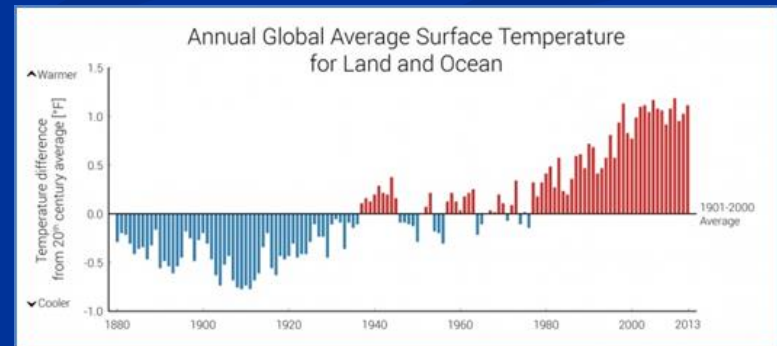
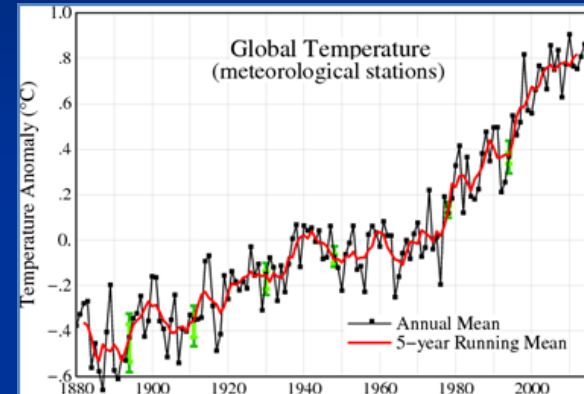
- Gradual changes in Earth's rotation and orbit around the Sun change the intensity of sunlight received in our planet's polar and equatorial regions. For at least the last 1 million years, these changes occurred in 100,000-year cycles that produced ice ages and the shorter warm periods between them.
- A significant increase or decrease in the Sun's energy output would cause Earth to warm or cool. Satellite measurements taken over the past 30 years show that the Sun's energy output has changed only slightly and in both directions. These changes in the Sun's energy are thought to be too small to be the cause of the recent warming observed on Earth.



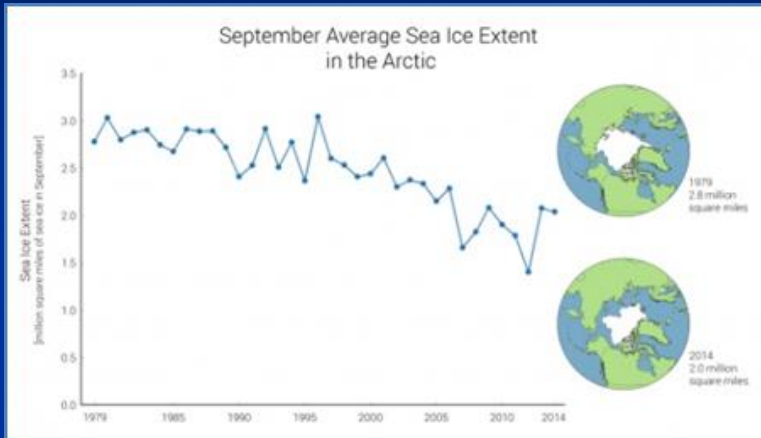
Climate Change: What Has Been Observed?

Warming Global Temperatures

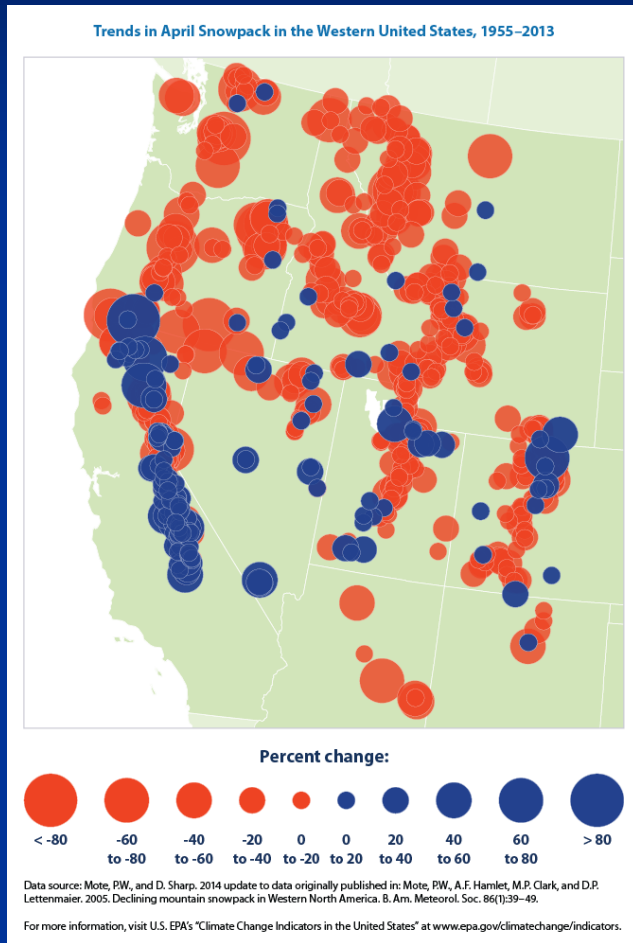
- All three major global surface temperature reconstructions show that Earth has warmed since 1880. Most of this warming has occurred since the 1970s, with the 20 warmest years having occurred since 1981 and with all 10 of the warmest years occurring in the past 12 years. Even though the 2000s witnessed a solar output decline resulting in an unusually deep solar minimum in 2007-2009, surface temperatures continue to increase.
- Source: NASA Climate Change (<http://climate.nasa.gov/evidence/>)



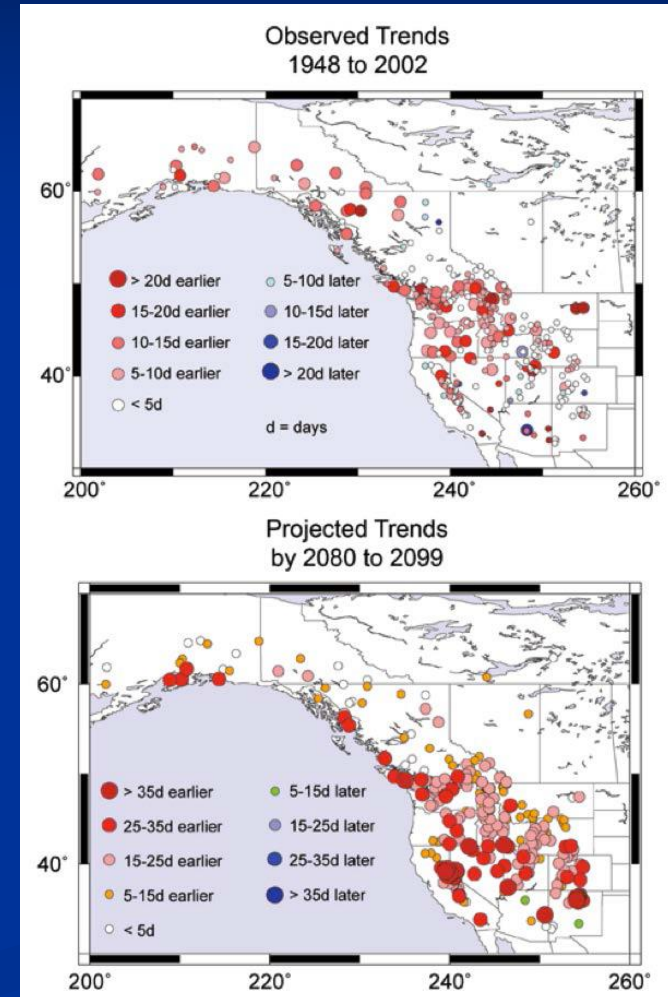
Disappearing Arctic Sea Ice



Decreasing Snow Pack & Earlier Snow Melt



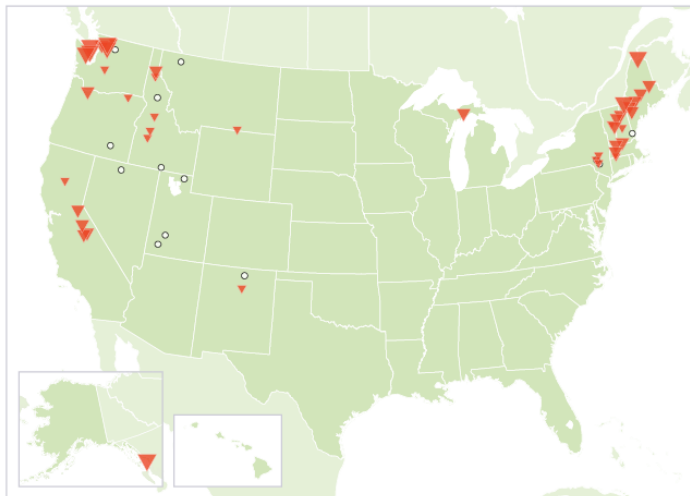
Changes in April 1 snow water equivalent in the Western United States.



Observed Spring snowmelt dates in the Western United States.

Changes in Snowpack and Precip Affect Streamflow

Timing of Winter-Spring Runoff in the United States, 1940–2012

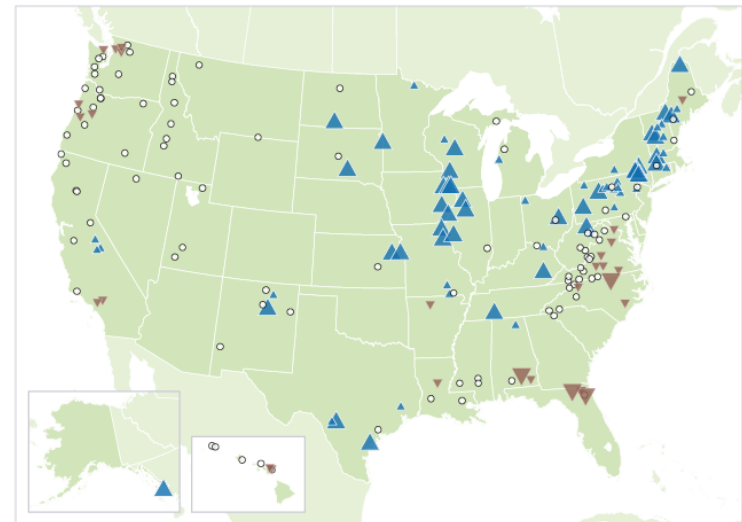


More than 10 days earlier
5 to 10 days earlier
2 to 5 days earlier
2 days earlier to 2 days later
2 to 5 days later
5 to 10 days later
More than 10 days later

Data source: USGS (U.S. Geological Survey). 2014. Analysis of data from the National Water Information System. Accessed January 2014.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climatechange/indicators.

Seven-Day Low Streamflows in the United States, 1940–2012



More than 50% decrease
20% to 50% decrease
20% decrease to 20% increase
20% to 50% increase
More than 50% increase

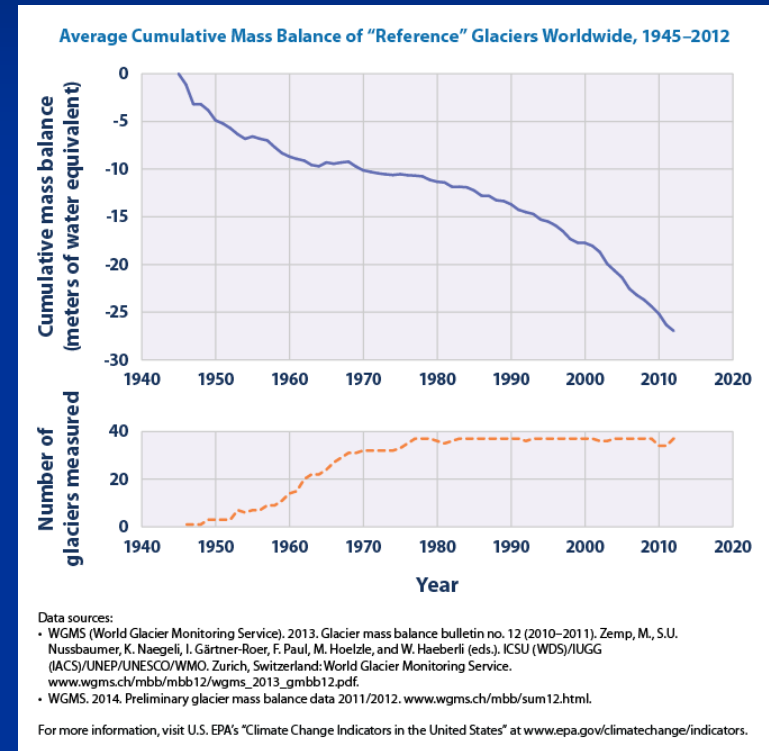
Data source: USGS (U.S. Geological Survey). 2014. Analysis of data from the National Water Information System. Accessed January 2014.

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Melting Glaciers and Ice Sheets

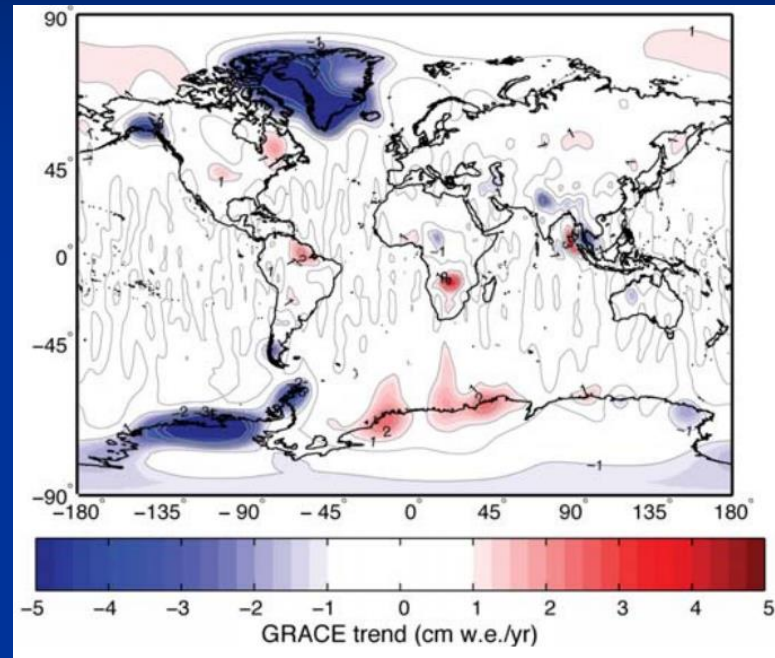


Changes in the Qori Kalis Glacier, Quelccaya Ice Cap, Peru, are shown between 1978 (top) and 2002. The glacier retreat during this time was 1,100 meters.



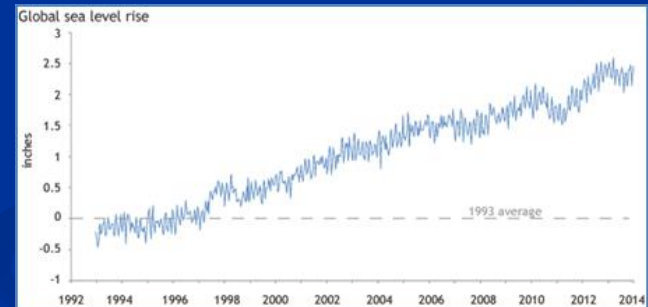
Melting Glaciers and Ice Sheets: Why so Bad?

- Glaciers are a major source of fresh water for human communities around the world
- Melting glaciers and ice sheets contribute to global sea level rise



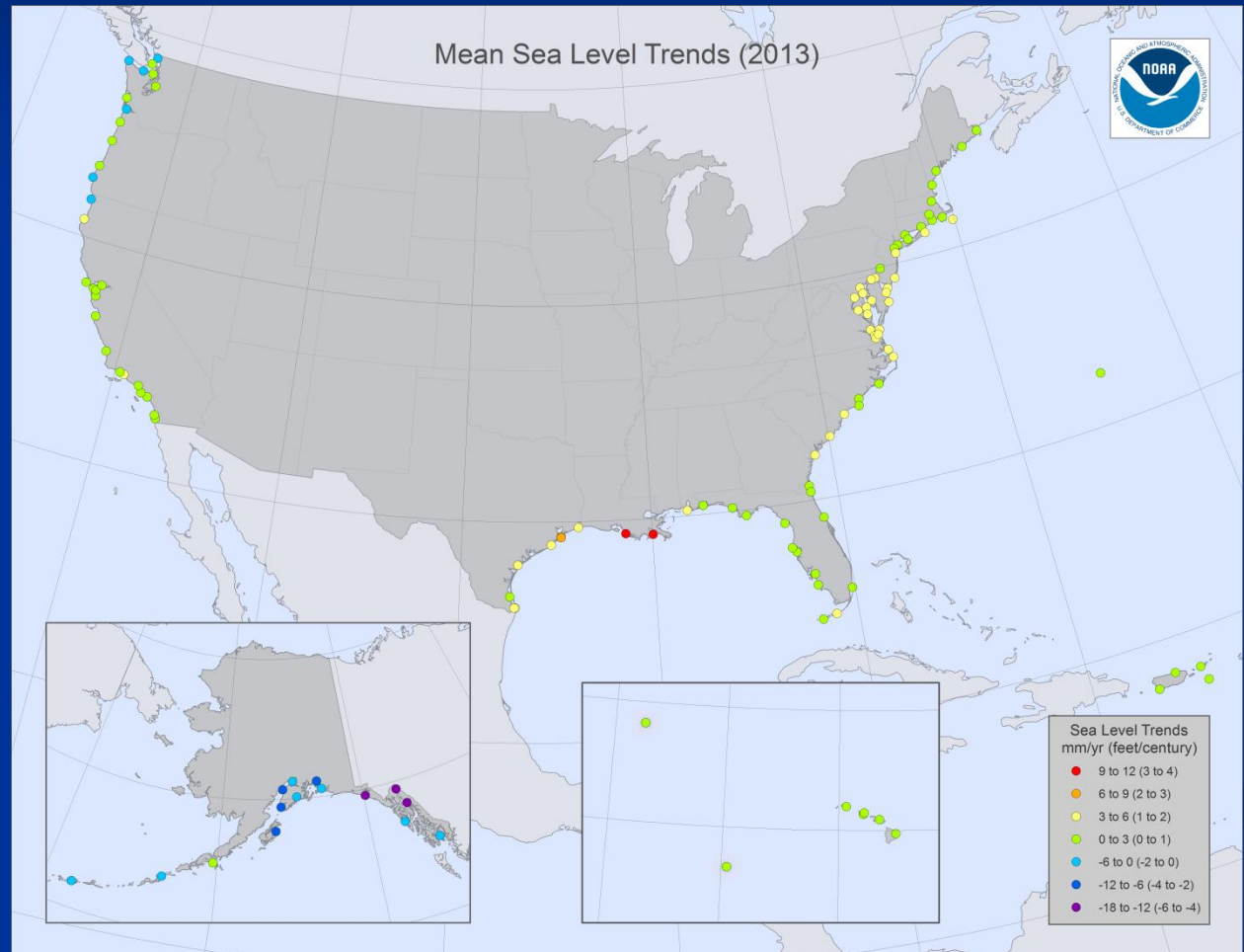
Rising Sea Levels

- GMSL has been rising at an average rate of approximately 1.7 mm/year over the past 100 years (measured from tide gauge observations), which is significantly larger than the rate averaged over the last several thousand years.
- Since 1993, global sea level has risen at an accelerating rate of around 3.5 mm/year. Much of the sea level rise to date is a result of increasing heat of the ocean causing it to expand.
- It is expected that melting land ice (e.g. from Greenland and mountain glaciers) will play a more significant role in contributing to future sea level rise.
- Source: NOAA Global Climate Change Indicators (<https://www.ncdc.noaa.gov/indicators/>)



RSLR Varies from Place to Place!

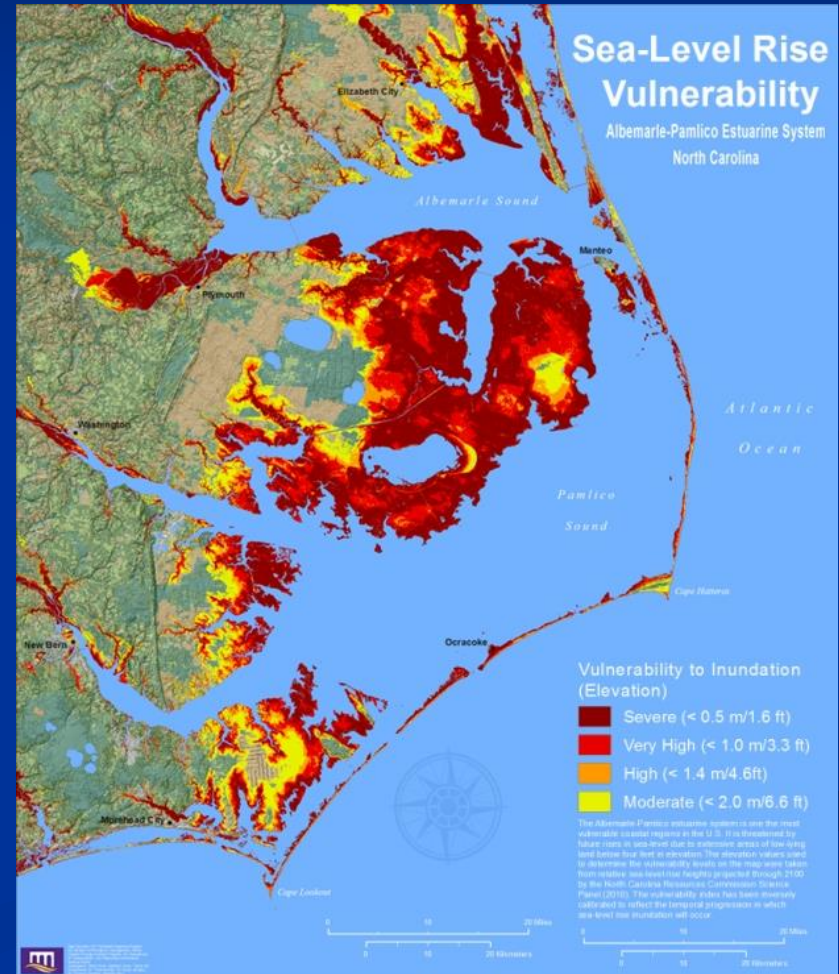
- Chesapeake Bay and coastal LA are sinking...
- Coastal AK actually uplifting....



Inundation of the Coastal Zone: Albemarle Peninsula, North Carolina



- *At right, map showing vulnerability of Albemarle Peninsula to sea level rise*

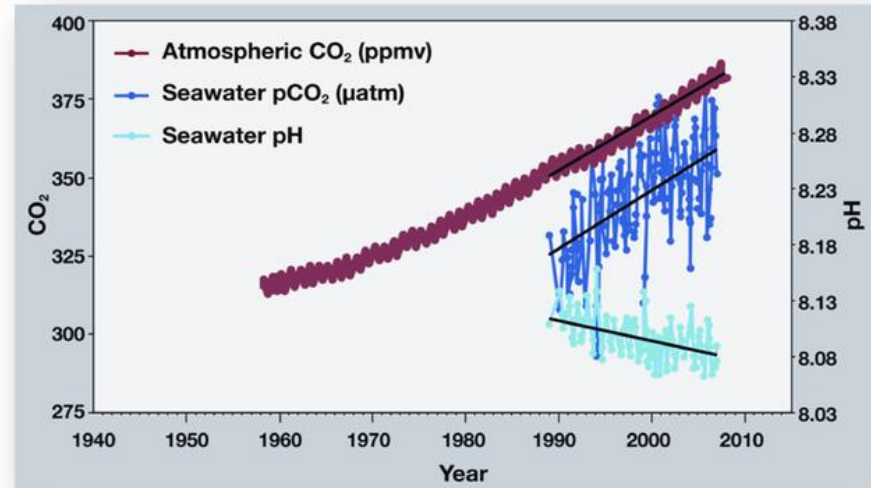


Ocean Acidification and Increasing Ocean Temperature



■ "Ocean Acidification Rate May Be Unprecedented, Study Says"

The world's oceans may be turning acidic faster today from human carbon emissions than they did during four major extinctions in the last 300 million years



This graph shows the correlation between rising levels of carbon dioxide (CO₂) in the atmosphere at Mauna Loa with rising CO₂ levels in the nearby ocean at Station Aloha. As more CO₂ accumulates in the ocean, the pH of the ocean decreases. (Modified after R.A. Feely, Bulletin of the American Meteorological Society, July 2008)

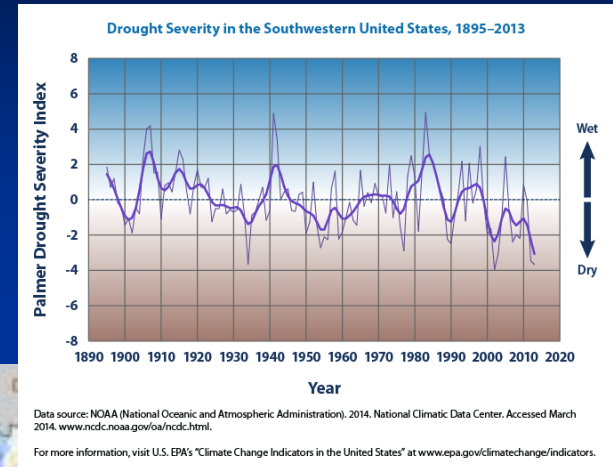
Contribute to Destruction of Coral Reefs (and other impacts)

- “Coral reefs ‘will be gone by end of the century.’ They will be the first entire ecosystem to be destroyed by human activity, says top UN scientist Peter Sale”

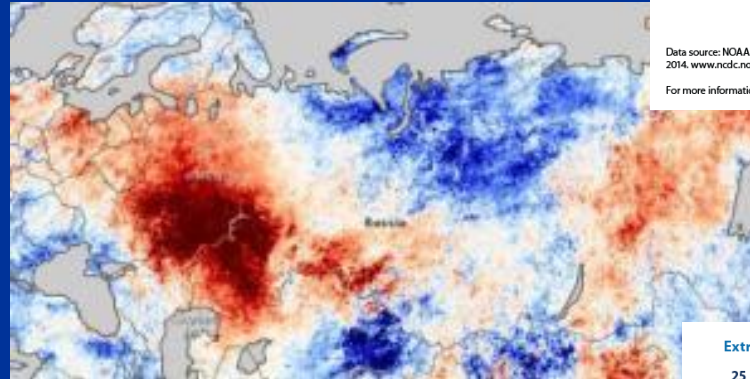


Increase in Extreme Weather

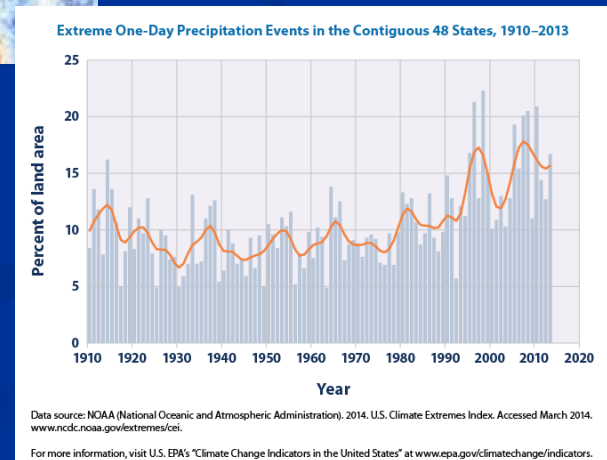
■ Drought



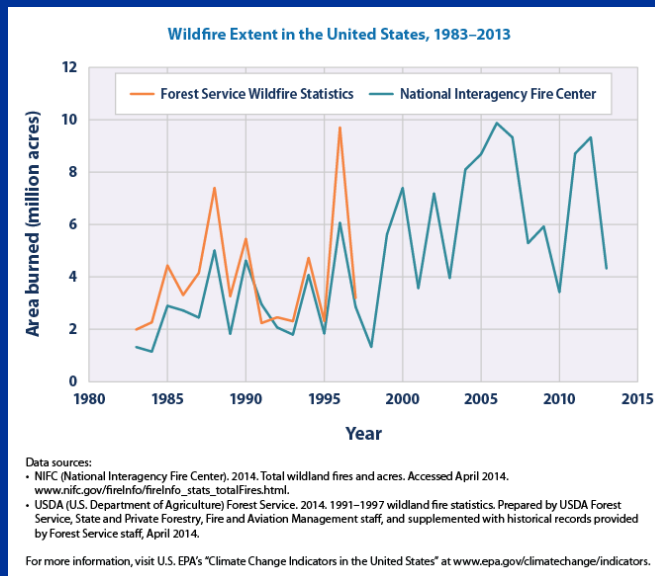
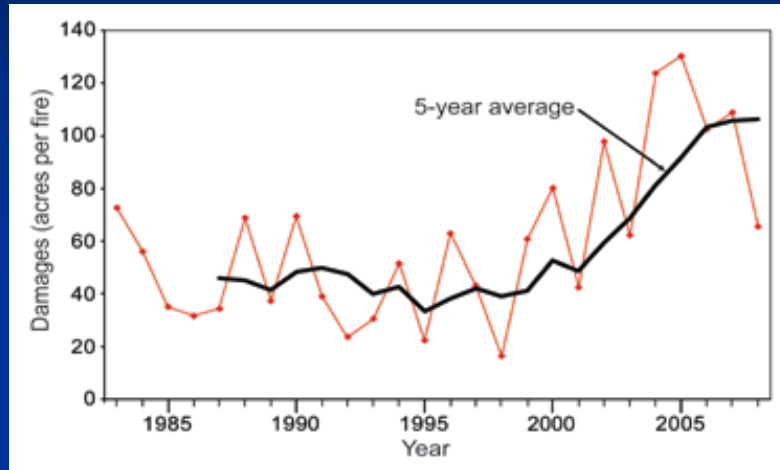
■ Heat Waves



■ Heavy Precipitation



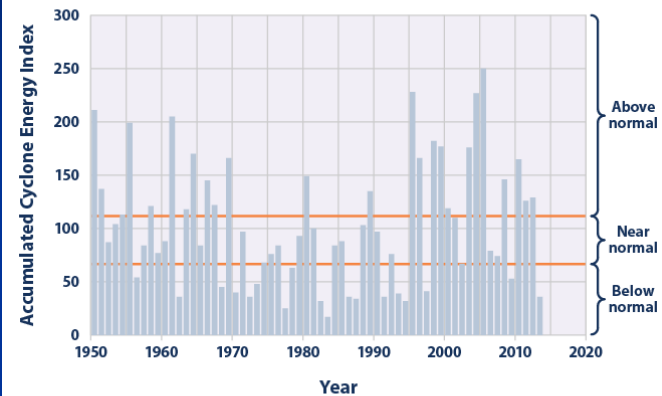
Contributing to Increases in Wildfires



Increase in Extreme Storms



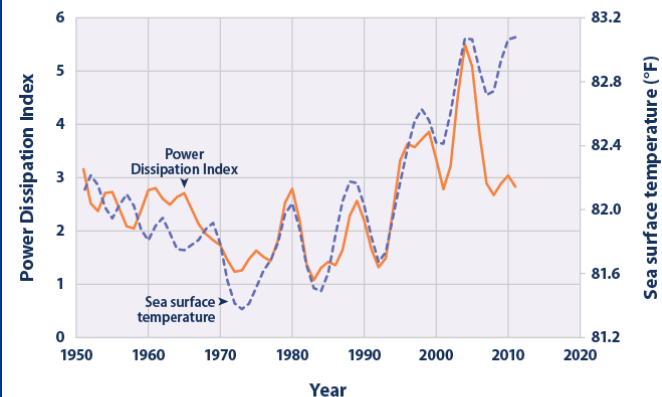
North Atlantic Tropical Cyclone Activity According to the Accumulated Cyclone Energy Index, 1950–2013



Data source: NOAA (National Oceanic and Atmospheric Administration). 2014. The Atlantic Hurricane Database Re-analysis Project. www.aoml.noaa.gov/hrd/hurdat/comparison_table.html.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climatechange/indicators.

North Atlantic Tropical Cyclone Activity According to the Power Dissipation Index, 1949–2013



Data source: Emanuel, K.A. 2014 update to data originally published in: Emanuel, K.A. 2007. Environmental factors affecting tropical cyclone power dissipation. *J. Climate* 20(22):5497–5509.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climatechange/indicators.

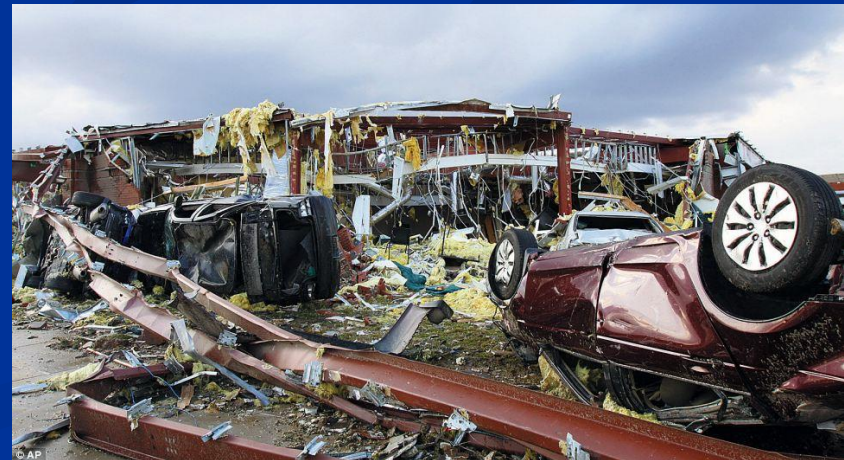
Leading to Damage and Destruction

- "Extreme Weather 2011"

From extreme drought, heat waves and floods to unprecedented tornado outbreaks, hurricanes, wildfires and winter storms, a record 12 weather and climate disasters in 2011 each caused \$1 billion or more in damages — and most regrettably, loss of human lives and property. Check out the NOAA website: <http://www.noaa.gov/extreme2011/>



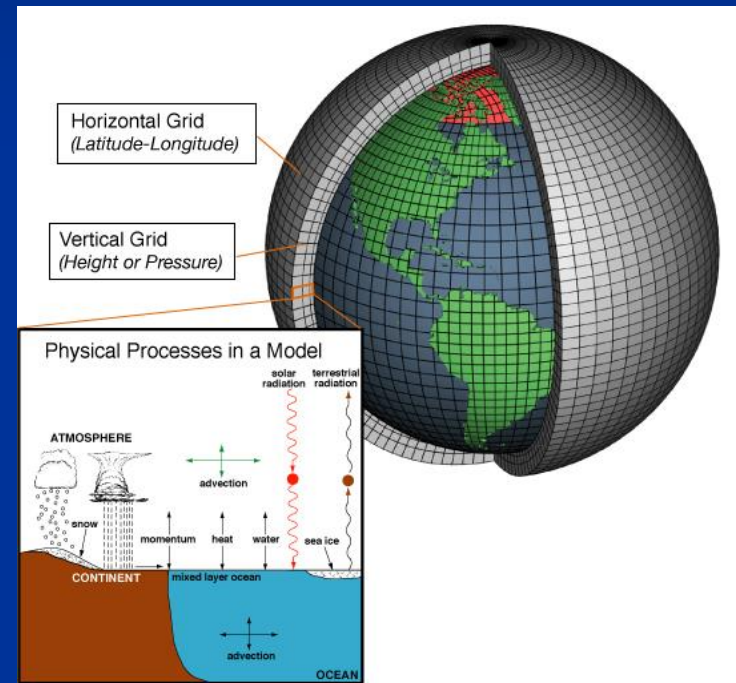
- And 2012....???? According to data from the [Storm Prediction Center](#), the count of preliminary tornado reports during January 2012 — 95 — was much-above the 1991-2010 average of 35.



What will the future bring?

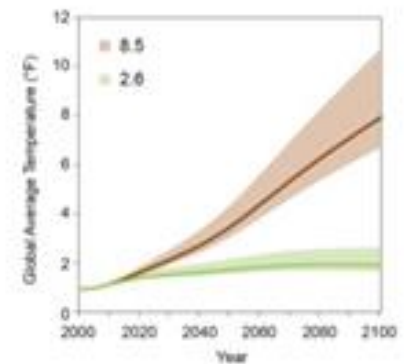
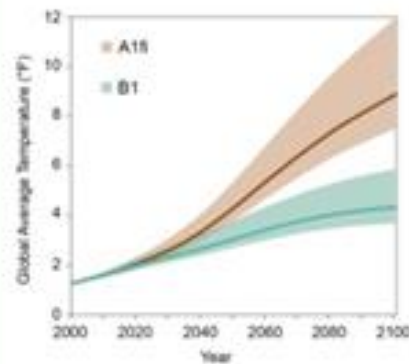
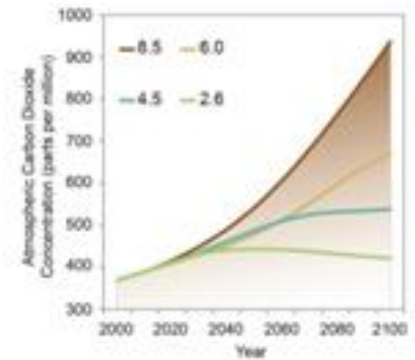
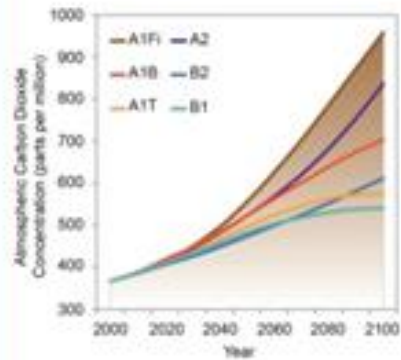
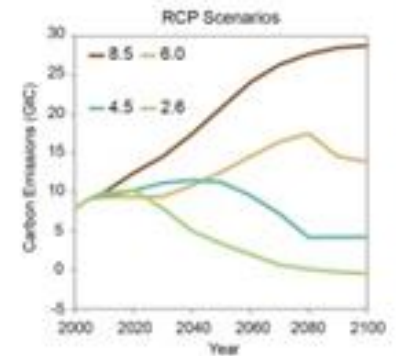
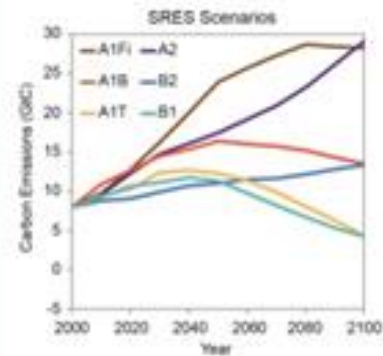
How do we know the future?

- We don't!
- But we make educated “projections” of what the future might be like, based on the results of global climate models.
- Global Climate Models divide the Earth's atmosphere, land and ocean into 3-d grids as small as 25-km.
- They reproduce the full circulation of the atmosphere and ocean.
- Can be used to simulate past – and generate future projections of – changes in temperature, precipitation, and many other climate indicators.



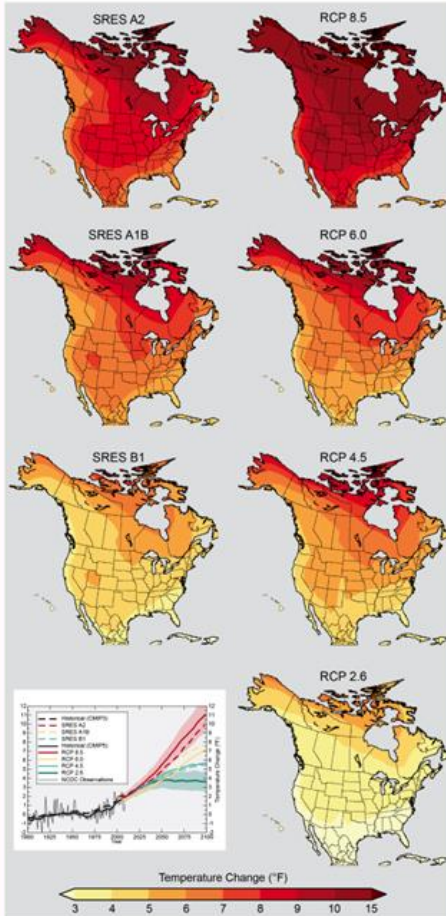
Climate Models

Emissions, Concentrations, and Temperature Projections

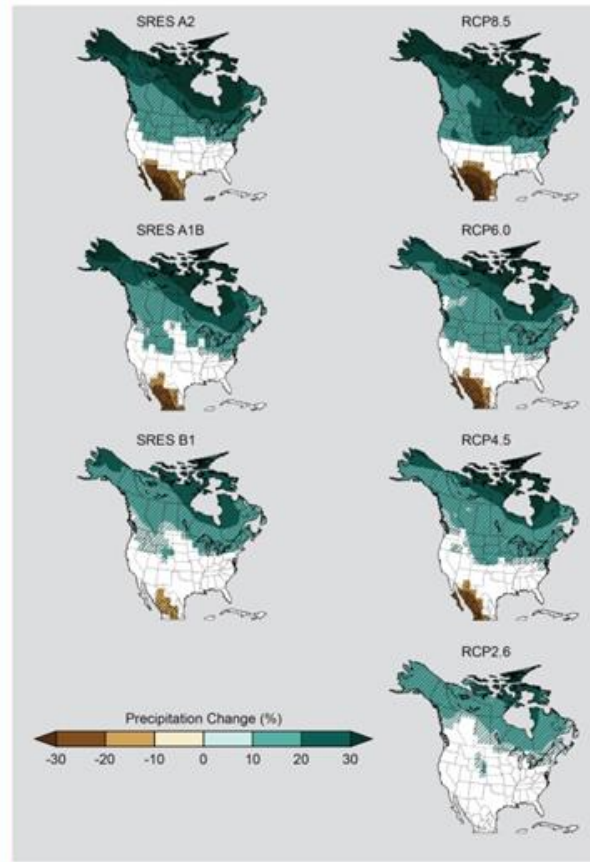


Temperature and Precipitation Projections for United States

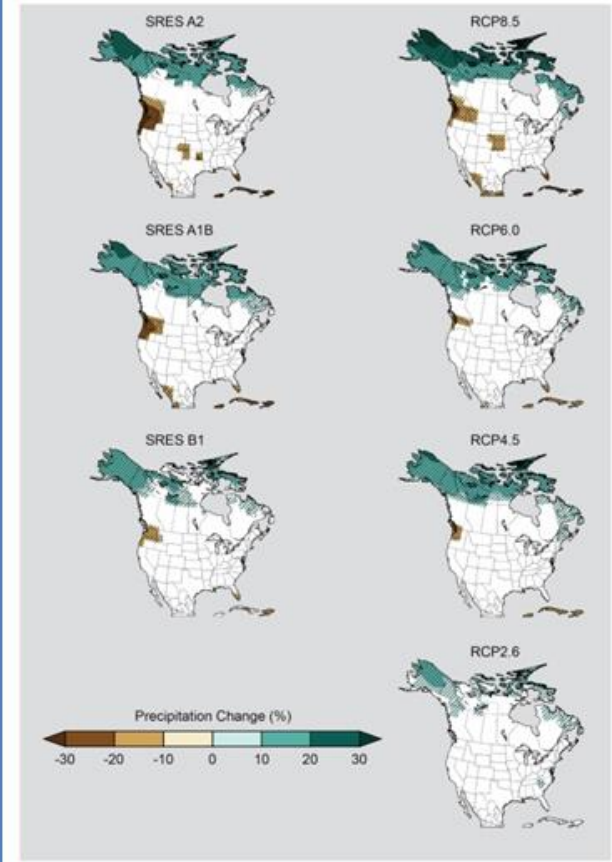
Projected Annually-Averaged Temperature Change



Projected Wintertime Precipitation Changes



Projected Summertime Precipitation Changes



Global Sea Level Rise Projections

- “Sea Levels to Continue to Rise for 500 Years? Long-Term Climate Calculations Suggest So” – ScienceDaily, October 17, 2011

