

# **Climate Science & Impacts Overview**

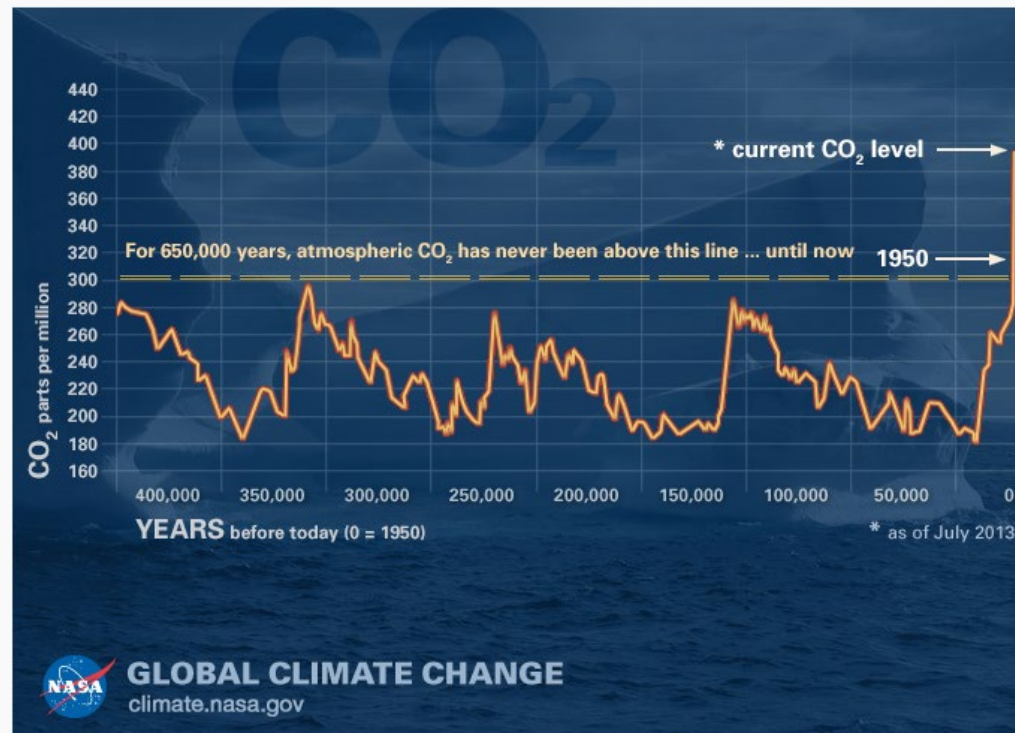
Air Quality Workshop for Teachers

July 13, 2016





- Climate Change Science
  - Evidence
  - Impacts
- Short Lived Climate Forcers
- Taking Action
- Resources



The background features a large, faint watermark of the Environmental Protection Agency (EPA) logo. The logo is circular and contains the text "UNITED STATES ENVIRONMENTAL PROTECTION AGENCY" around the perimeter. In the center is a stylized flower with three leaves and a scalloped petal. The word "Evidence" is superimposed in the center of this watermark.

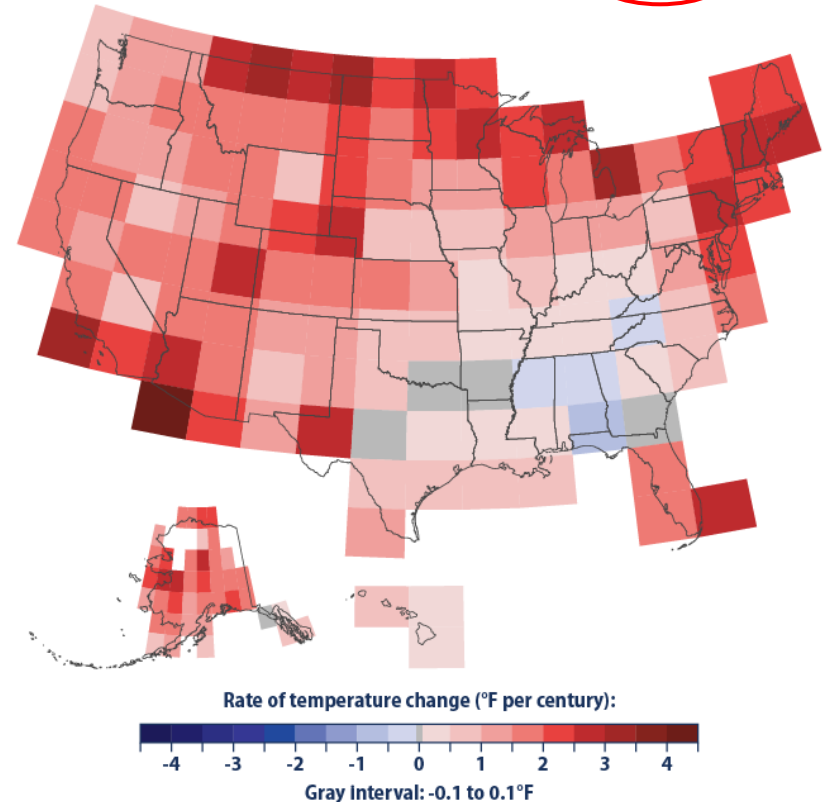
# **Evidence**

# Climate Change is Real



- The evidence is clear – the unprecedented buildup of CO<sub>2</sub> in our atmosphere is causing global and U.S. temperatures to warm with cascading climatic changes.
- These changes are impacting society now and are expected to become more disruptive as CO<sub>2</sub> levels continue to rise.
- Our lives are connected to the climate and we can reduce the risks we face from climate change.
- [http://climate.nasa.gov/climate\\_resources/139/](http://climate.nasa.gov/climate_resources/139/)

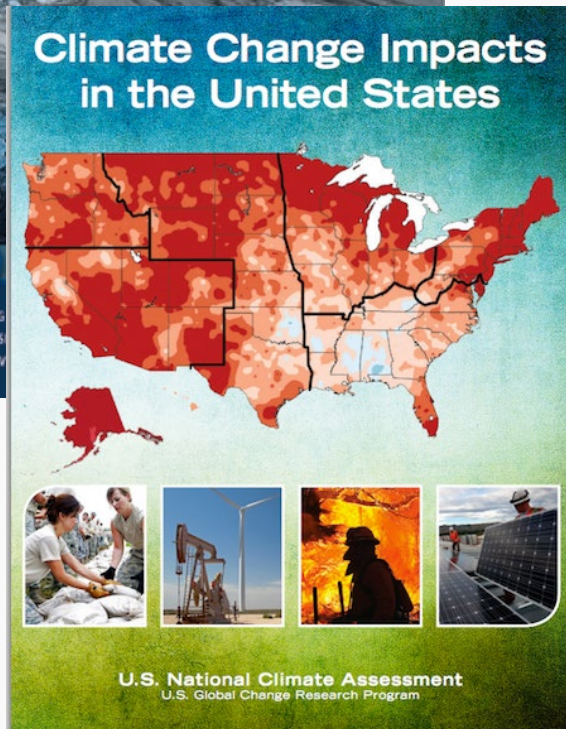
Rate of Temperature Change in the United States, 1901–2012



Data source: NOAA (National Oceanic and Atmospheric Administration). 2013. National Climatic Data Center. Accessed April 2013. [www.ncdc.noaa.gov/oa/ncdc.html](http://www.ncdc.noaa.gov/oa/ncdc.html).

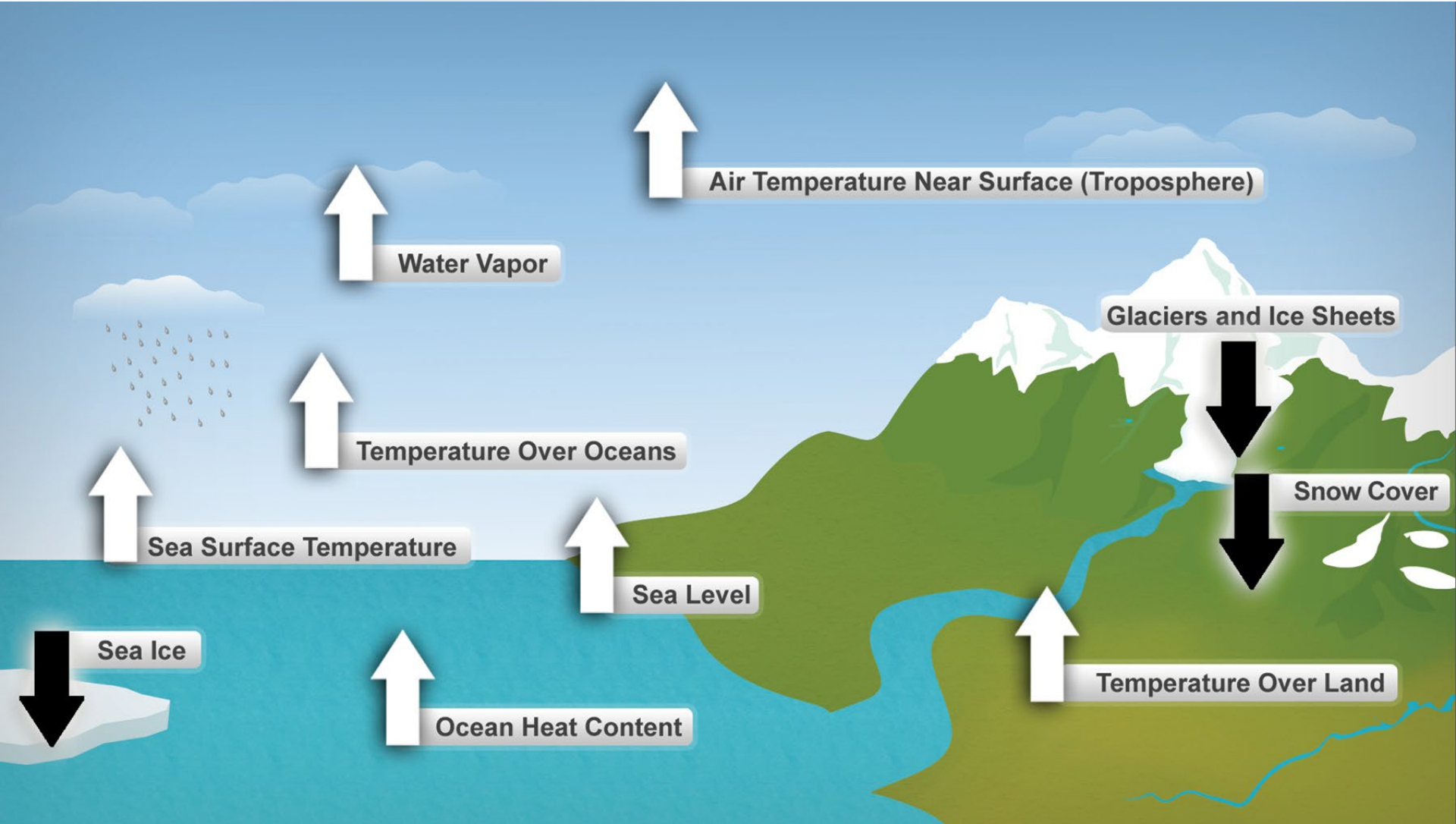
For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at [www.epa.gov/climatechange/Indicators](http://www.epa.gov/climatechange/Indicators).

# Recent Climate Assessments Show Climate Impacts Happening Now



- Third National Climate Assessment: Climate Change Impacts in the United States, May 2014
- Intergovernmental Panel on Climate Change Fifth Assessment Report (AR5)
  - Working Group I – The Physical Science Basis finalized September 2013
  - Working Group II (impacts) and Working Group III (mitigation), released early 2014
- EPA: Indicators of Climate Change in the United States, 2014

# Ten Indicators of A Warming World



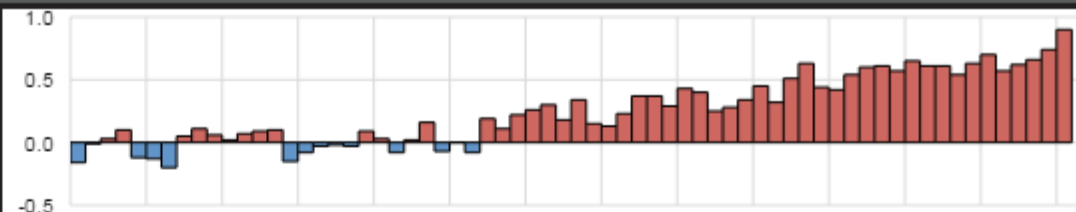
# Climate Change



## Global Average Temperature (°C)

The temperature near Earth's surface is rising: the bars show each year's average temperature compared to the 20th century average.

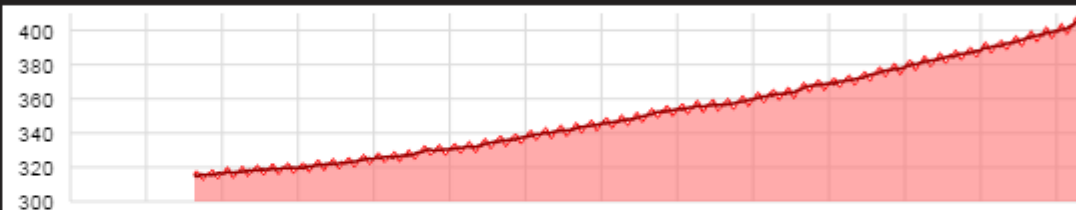
[learn more >>](#)



## Carbon Dioxide (ppm)

The amount of carbon dioxide in the atmosphere has risen by 25% since 1958, and by about 40% since the Industrial Revolution.

[learn more >>](#)



## Spring Snow Cover (million km<sup>2</sup>)

Snow is melting earlier: each bar shows spring snow cover in the Northern Hemisphere compared to the long-term average.

[learn more >>](#)



1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015

← Earlier

Later →

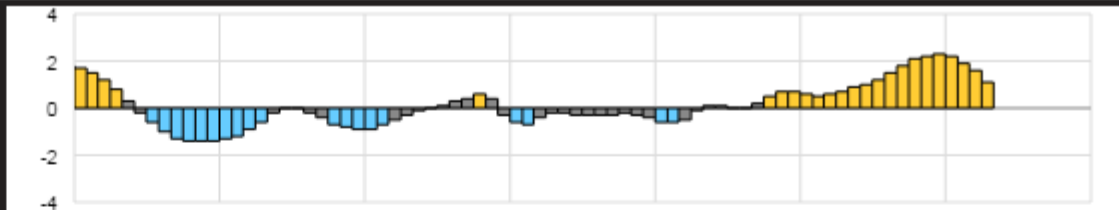
# Climate Variability



## El Niño / La Niña (Oceanic Niño Index)

Average sea surface temperature in the Eastern Pacific Ocean indicates El Niño (yellow), La Niña (blue), or neutral (gray) conditions

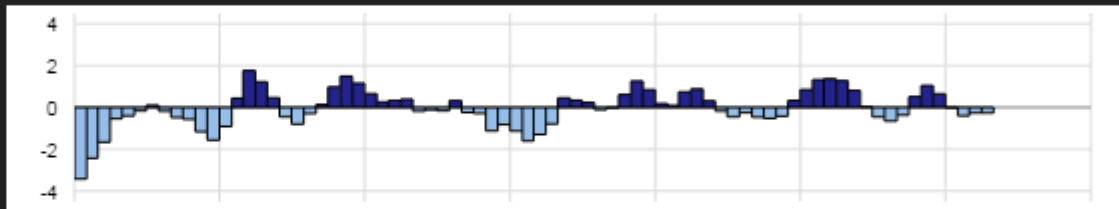
[learn more >>](#)



## Arctic Oscillation Index

When this index is negative, air pressure patterns are more likely to steer severe winter storms to the eastern U.S.

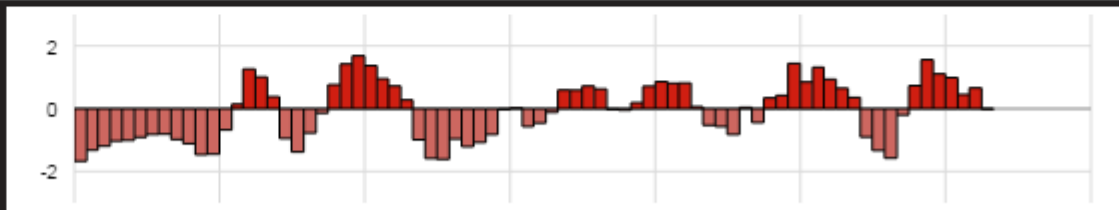
[learn more >>](#)



## North Atlantic Oscillation Index

Air pressure patterns over the North Atlantic can steer winter weather: negative values are linked to storms in the eastern U.S.

[learn more >>](#)



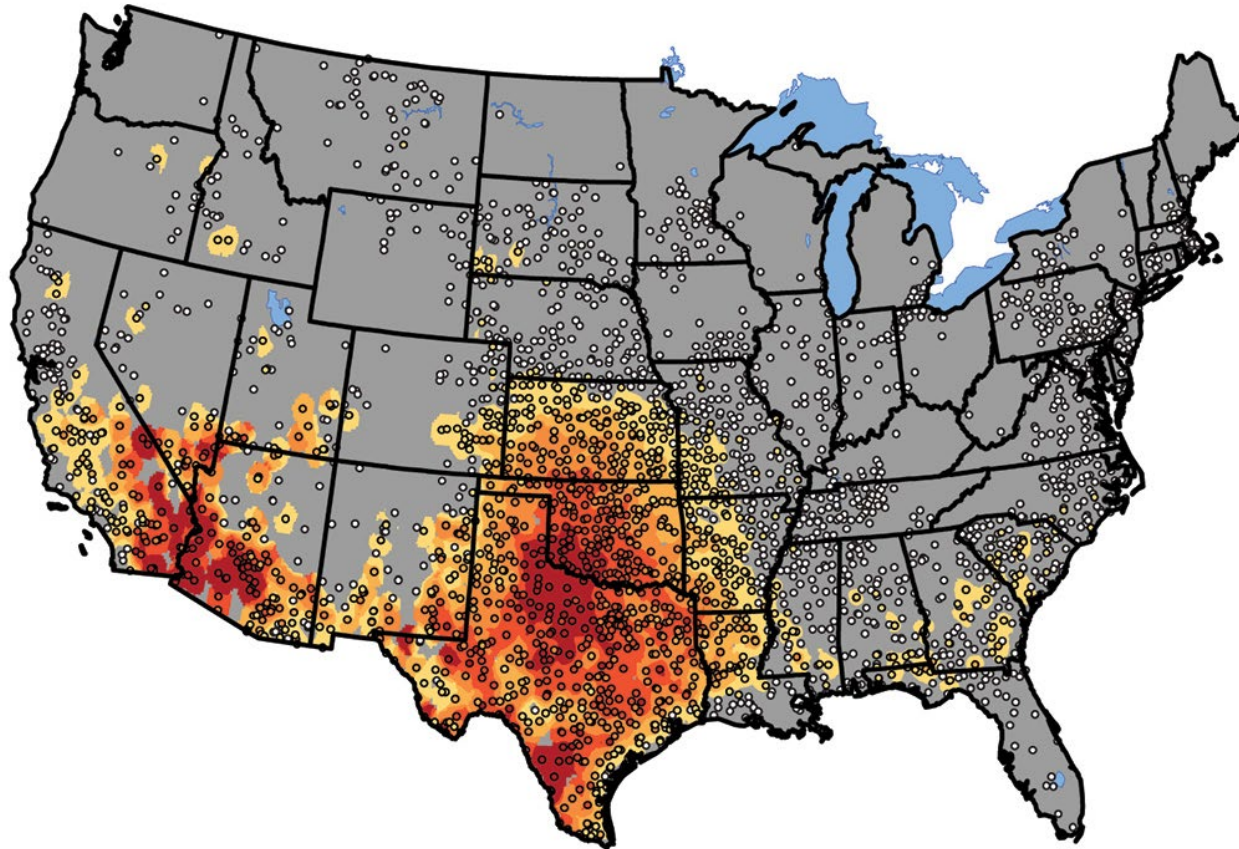
2010 2011 2012 2013 2014 2015 2016 2017

← Earlier

Later →

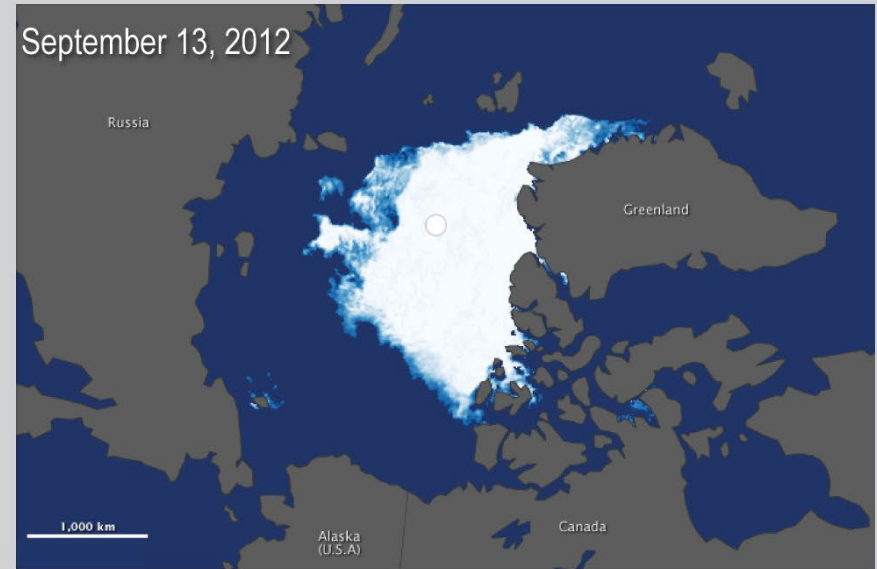
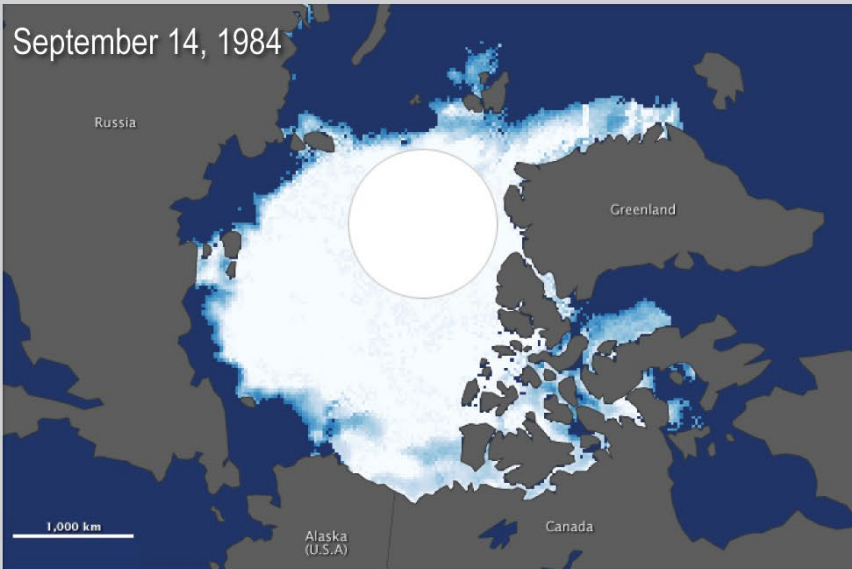


# 100-degree Days in 2011



Number of Days

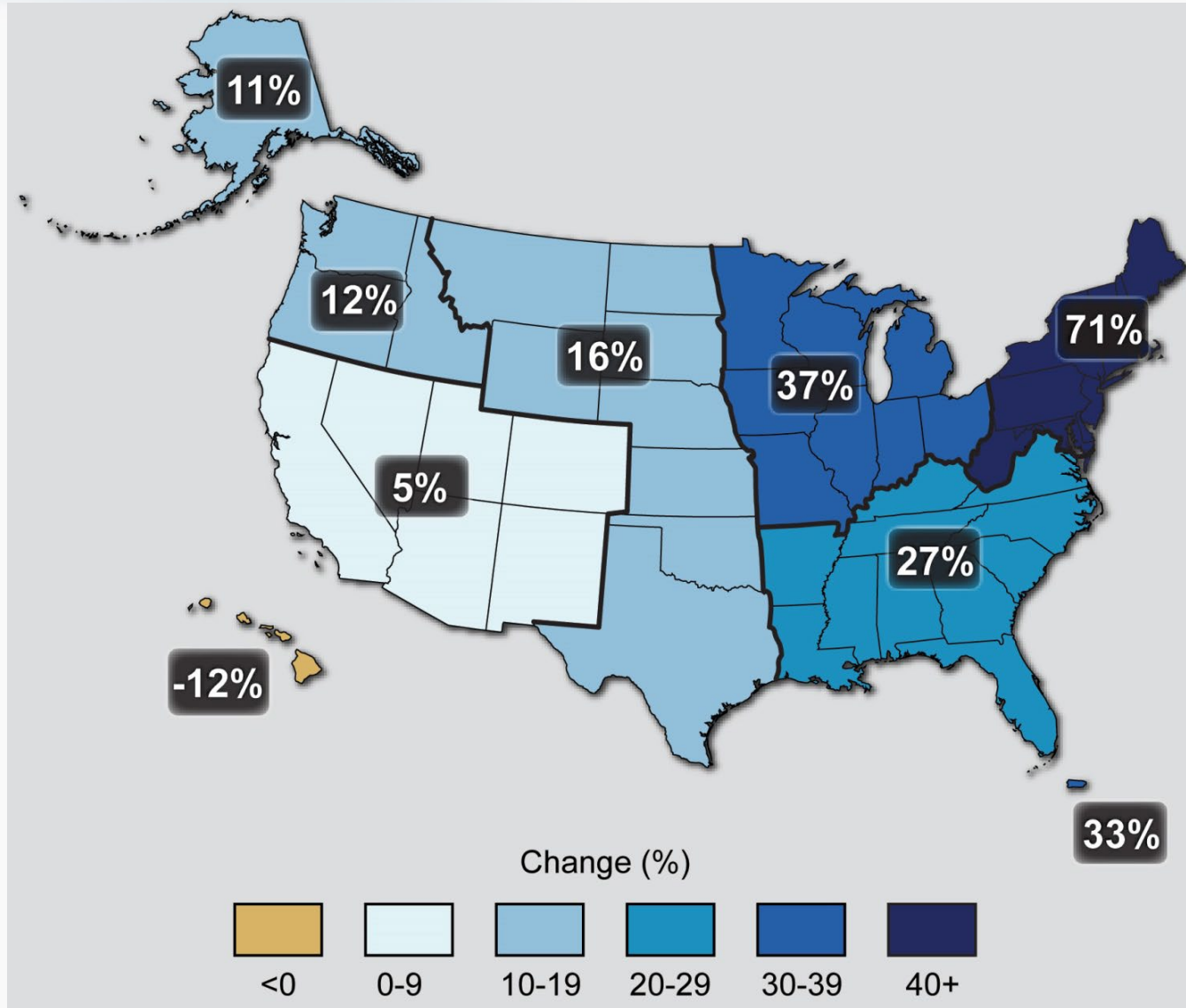
# Arctic Sea Ice Loss



Sea Ice Concentration (percent)



# Observed Change in Very Heavy Precipitation



# Impacts

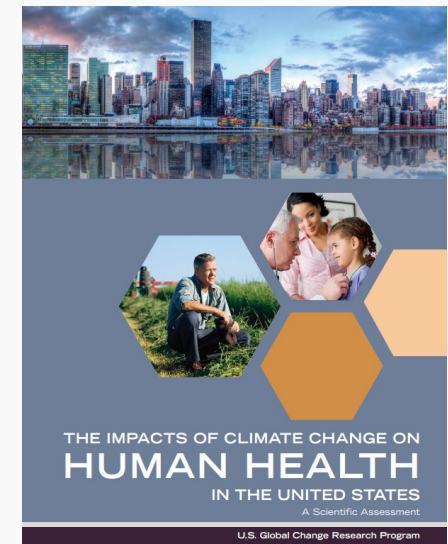


# Climate Impacts Human Health



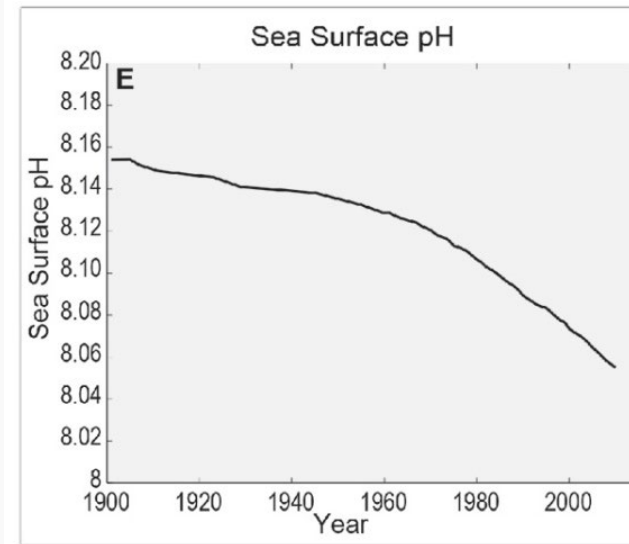
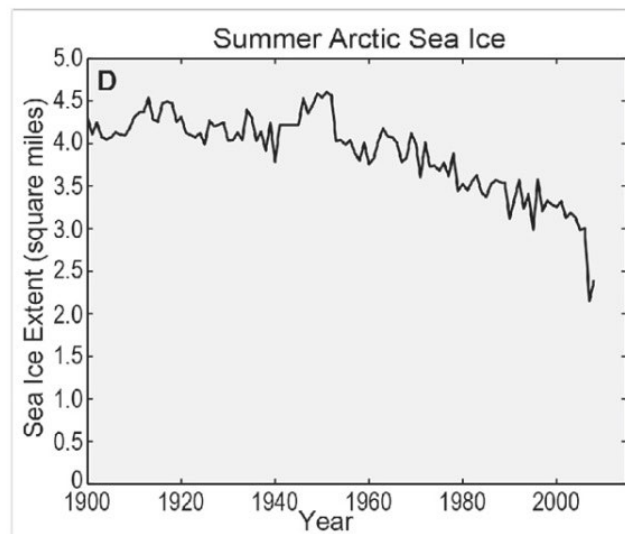
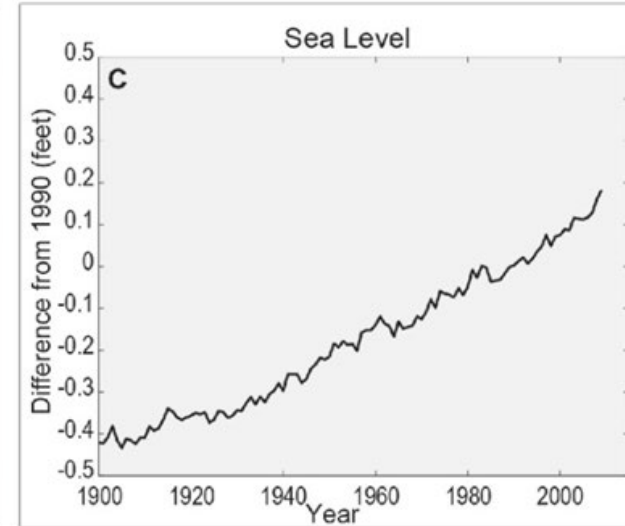
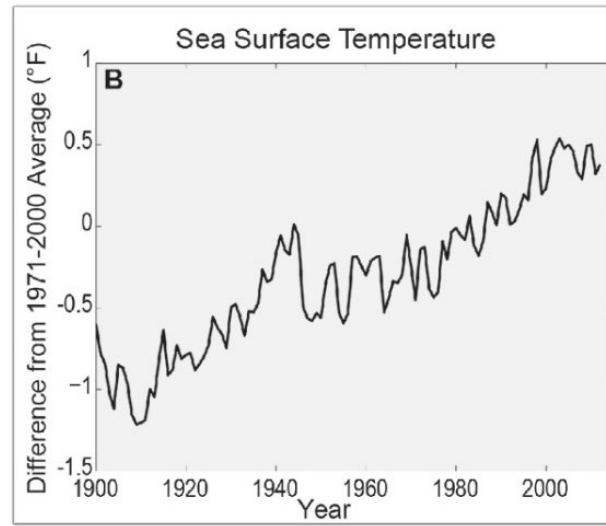
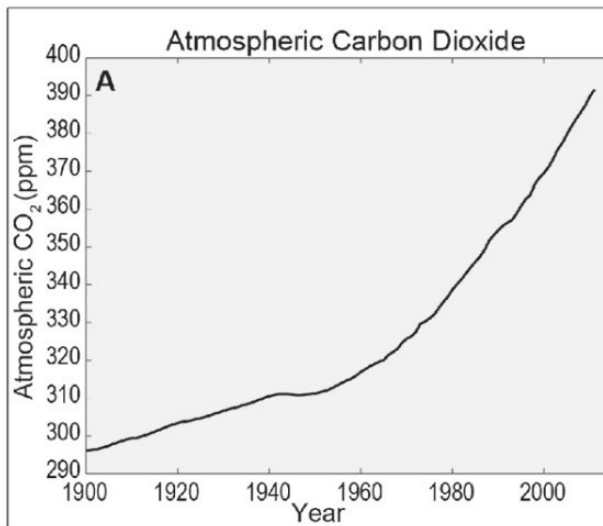
|  | Climate Driver  | Exposure  | Health Outcome  | Impact  |
|--|---|---|---|---|
| <p><b>Extreme Heat</b></p>   | More frequent, severe, prolonged heat events  | Elevated temperatures   | Heat-related death and illness  | Rising temperatures will lead to an increase in heat-related deaths and illnesses.  |
| <p><b>Outdoor Air Quality</b></p>                                    | Increasing temperatures and changing precipitation patterns   | Worsened air quality (ozone, particulate matter, and higher pollen counts)                | Premature death, acute and chronic cardiovascular and respiratory illnesses                             | Rising temperatures and wildfires and decreasing precipitation will lead to increases in ozone and particulate matter, elevating the risks of cardiovascular and respiratory illnesses and death. |
| <p><b>Flooding</b></p>   | Rising sea level and more frequent or intense extreme precipitation, hurricanes, and storm surge events | Contaminated water, debris, and disruptions to essential infrastructure                   | Drowning, injuries, mental health consequences, gastrointestinal and other illness                      | Increased coastal and inland flooding exposes populations to a range of negative health impacts before, during, and after events.   |
| <p><b>Vector-Borne Infection</b><br/>(Lyme Disease)</p>              | Changes in temperature extremes and seasonal weather patterns   | Earlier and geographically expanded tick activity   | Lyme disease  | Ticks will show earlier seasonal activity and a generally northward range expansion, increasing risk of human exposure to Lyme disease-causing bacteria.  |
| <p><b>Water-Related Infection</b><br/>(<i>Vibrio vulnificus</i>)</p> | Rising sea surface temperature, changes in precipitation and runoff affecting coastal salinity          | Recreational water or shellfish contaminated with <i>Vibrio vulnificus</i>                | <i>Vibrio vulnificus</i> induced diarrhea & intestinal illness, wound and bloodstream infections, death | Increases in water temperatures will alter timing and location of <i>Vibrio vulnificus</i> growth, increasing exposure and risk of water-borne illness.   |
| <p><b>Food-Related Infection</b><br/>(<i>Salmonella</i>)</p>         | Increases in temperature, humidity, and season length   | Increased growth of pathogens, seasonal shifts in incidence of <i>Salmonella</i> exposure | <i>Salmonella</i> infection, gastrointestinal outbreaks   | Rising temperatures increase <i>Salmonella</i> prevalence in food; longer seasons and warming winters increase risk of exposure and infection.  |

*“Climate change is a significant threat to the health of the American people.”*

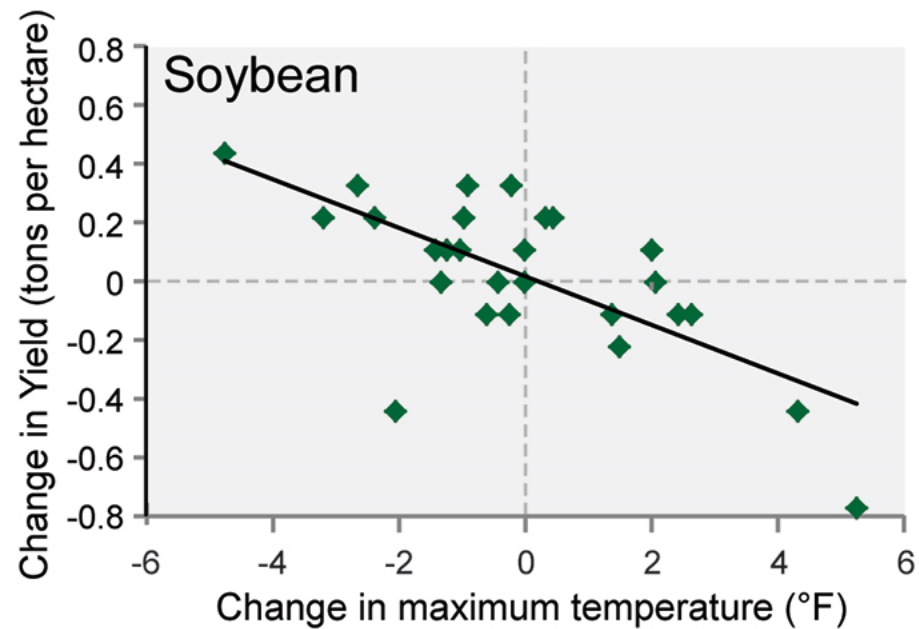
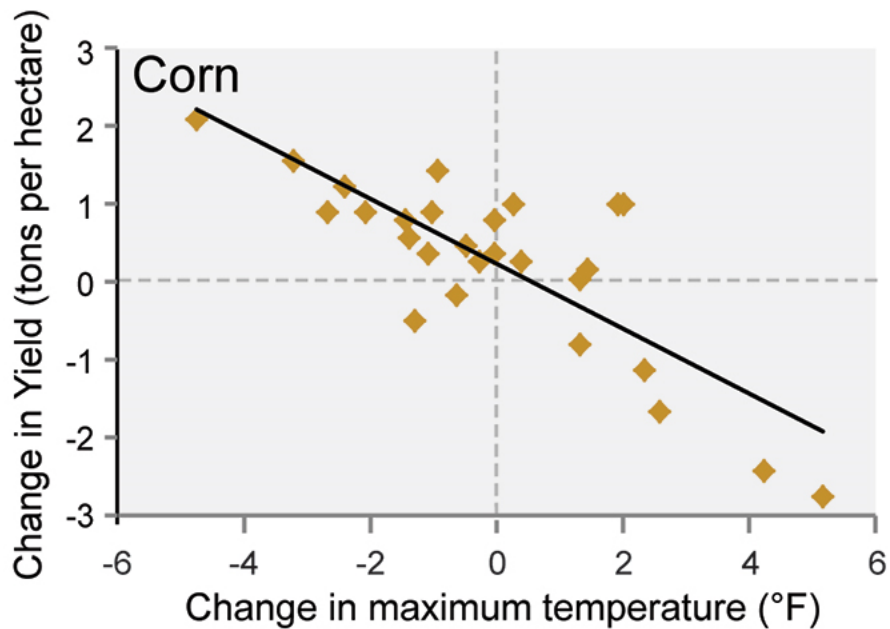


<https://health2016.globalchange.gov>

# Ocean Impacts of Increased Atmospheric Carbon Dioxide



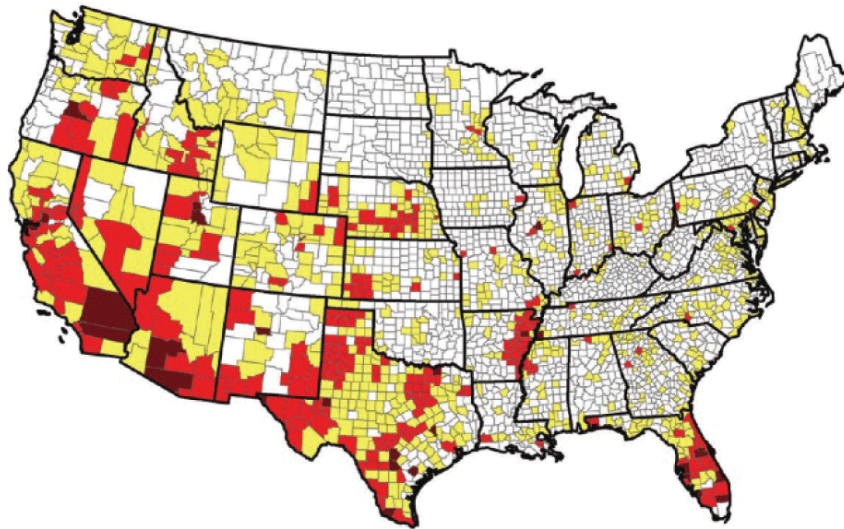
# Crop Yields Decline under Higher Temperatures



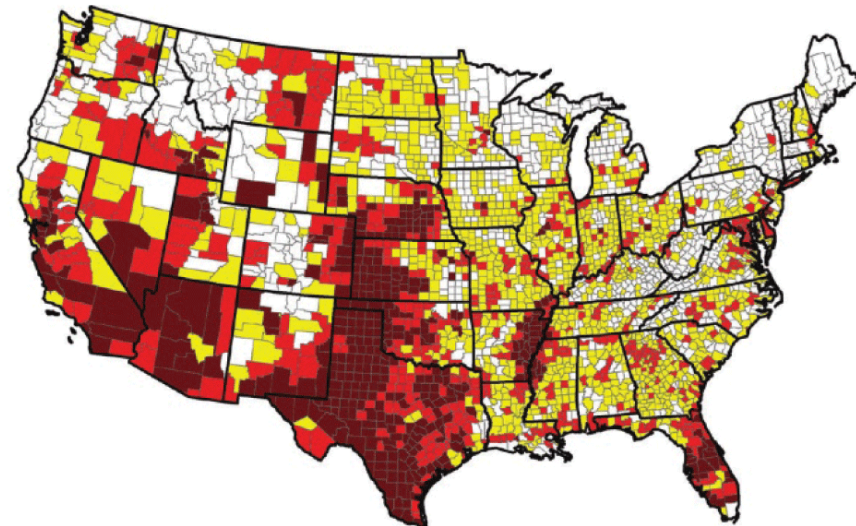
# Water Supplies Projected to Decline



(a) No Climate Change Effects



(b) Climate Change Effects



Water Supply Sustainability Risk Index (2050)

- Extreme (29)
- High (271)
- Moderate (821)
- Low (2020)

Water Supply Sustainability Risk Index (2050)

- Extreme (412)
- High (608)
- Moderate (1192)
- Low (929)



# **Short Lived Climate Pollutants (SLCPs)**



# Some Conventional Air Pollutants Affect the Climate



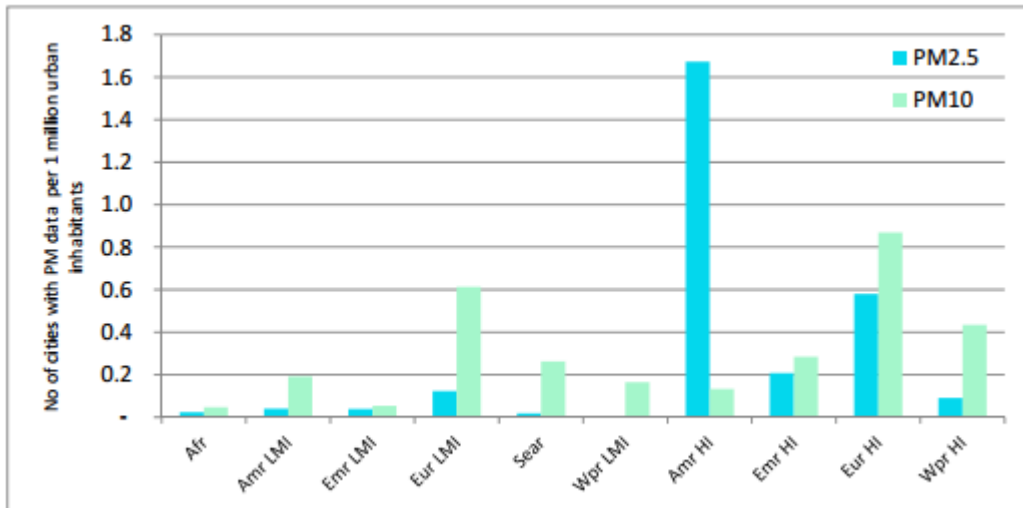
- “Climate forcer” describes any gas or particle that forces the climate to change
  - Broader than “greenhouse gas”, which describes a specific kind of forcing
- Examples of climate forcers include:
  - Greenhouse gases (e.g. carbon dioxide, methane, chloroflourocarbons, and ozone)
  - Aerosols (particles such as black carbon and sulfates)
- Long-lived climate forcers include:
  - Sulfur hexaflouride (3,200 years)
  - Nitrous oxide (115 years)
- Short Lived Climate Forcers stay in the atmosphere from days to months and include:
  - Ozone
  - Black Carbon (component of particulate matter)
  - Some HFCs
- It is the **short atmospheric lifetime** that makes SLCFs an important piece of the climate mitigation puzzle

# Air Pollution is a Major Health Risk

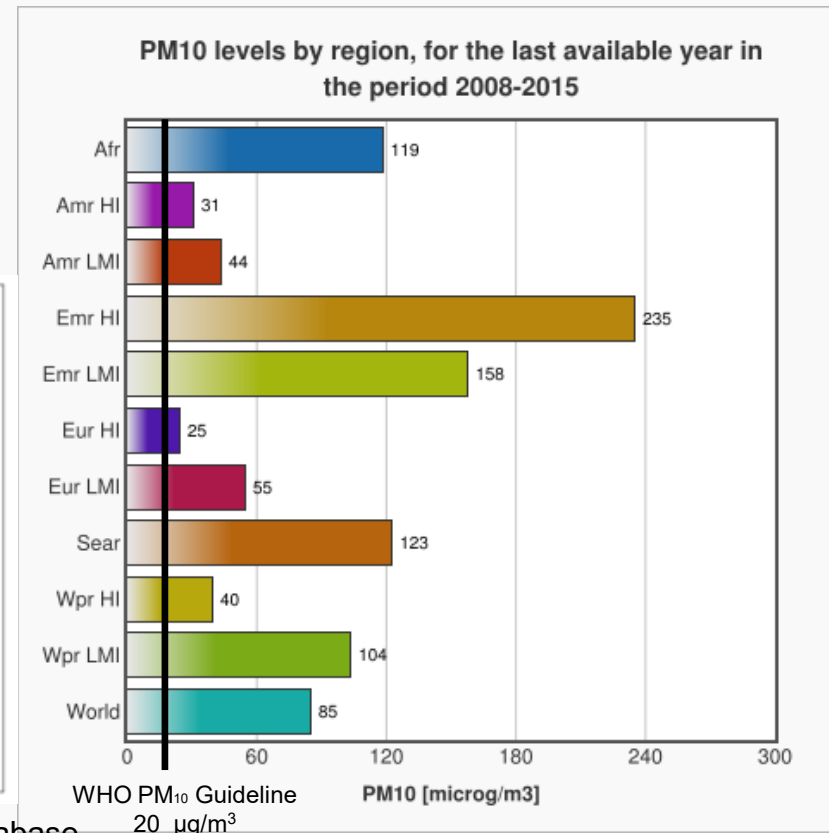


- 7 million deaths world wide attributable to air pollution
  - Increased risk of stroke, heart disease, lung cancer and respiratory diseases
- 80% of urban dwellers are breathing harmful levels of air pollution
  - In areas that measure air pollution
- Despite some regional improvements, global pollution levels are increasing.
- Caused by transportation, household energy and waste management

**Cities with accessible data in 2014**



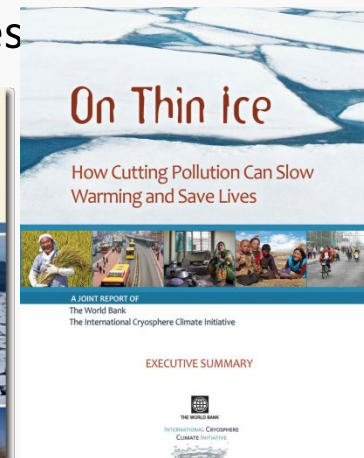
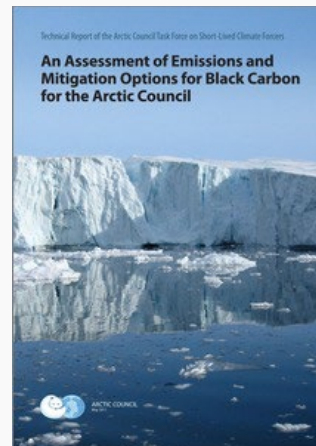
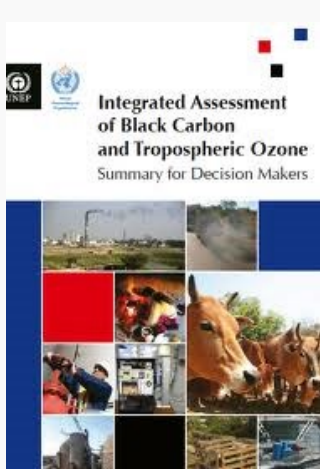
Source: WHO Global Urban Ambient Air Pollution Database



# Recent SLCP Assessments



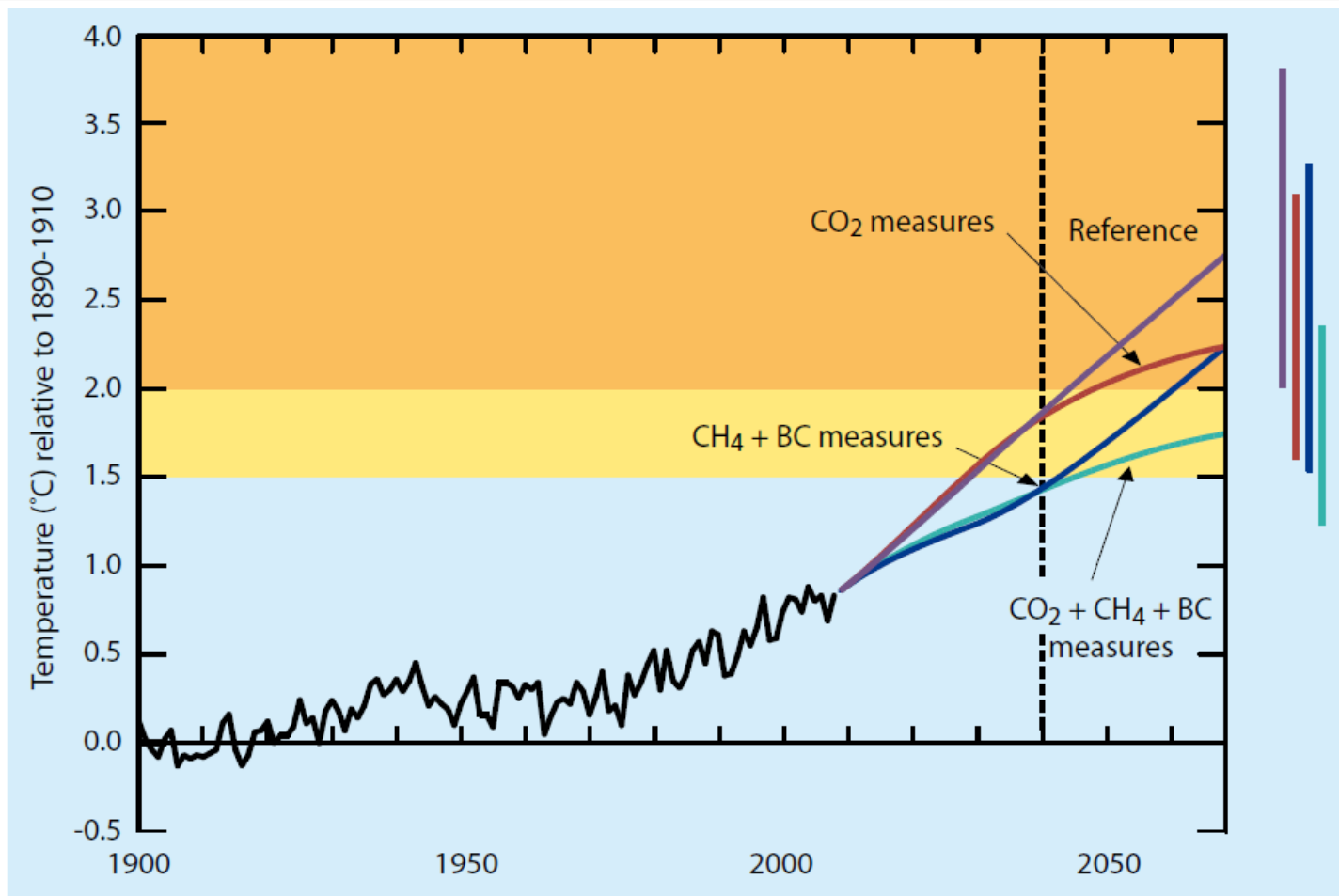
- Hemispheric Transport of Air Pollution report (LRTAP - 2010)
- Report of the Ad-hoc Expert Group on Black Carbon (LRTAP 2010)
- Integrated Assessment of Black Carbon and Tropospheric Ozone (UNEP - 2011)
- Towards an Action Plan for Near-term Climate Protection and Clean Air Benefits (UNEP - 2011)
- Actions for Controlling Short-Lived Climate Forcers (UNEP - 2011)
- An Assessment of Emissions and Mitigation Options for Black Carbon (Arctic Council - 2011)
- Black Carbon Report to Congress (EPA – 2012)
- On Thin Ice: How Cutting Pollution Can Slow Warming and Save Lives (World Bank - 2013)



# We Need To Reduce SLCPs



UNEP/WMO Result for Global Temperature Change:  
CO<sub>2</sub> and BC/Methane Reductions are Complementary Strategies



# Location of Emissions Matters



Normally cooling, organic carbon can be warming in the Arctic



Arctic melting creates negative Feedback loops



BUREAU OF LAND MANAGEMENT / ALASKA FIRE SERVICE

✓ Where People and Pollution Meet



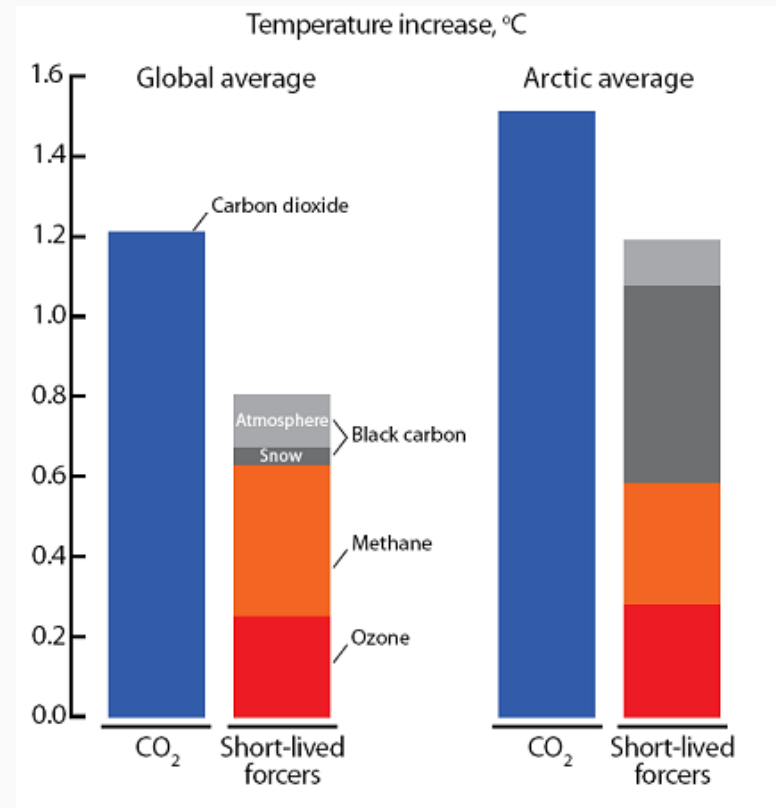
✓ Where precipitation patterns are impacted by aerosol emissions



# SLCP Impacts on the Arctic



- Black Carbon has disproportionately large impact
  - Absorbs more heat over Arctic reflective surfaces
  - Once deposited, BC darkens snow and ice leading to greater melting
  - BC emissions from lower latitudes also important
- Ozone transported from the mid-latitudes is also partially responsible for Arctic warming



(Adapted from Reiersen and Wilson, 2009)

Wood-Burning Stoves



Power Plants



Heavy Duty Diesel Engines



Natural Sources



- ✓ We know the sources of SLCP emissions and in many cases how to control them.
- ✓ These sources offer potential for integrated air quality/climate solutions
- ✓ Implementing these solutions can save lives, especially of the most vulnerable

Cars and Trucks



Non-Road Vehicles



Forest Fires



Industrial Sources



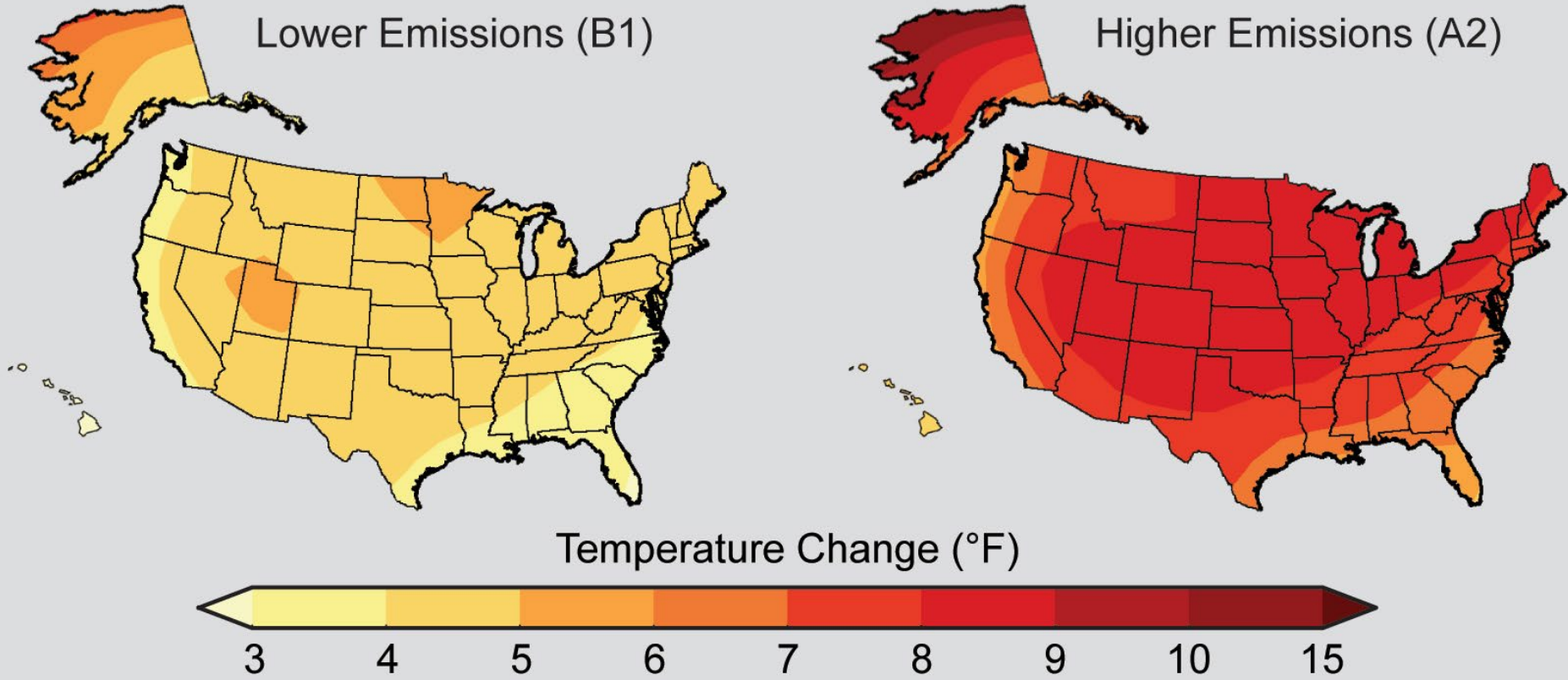


# Future Climate Change Depends Primarily on Emissions Levels



© Jim West/Imagebroker/Corbis

# Projected Temperature Change

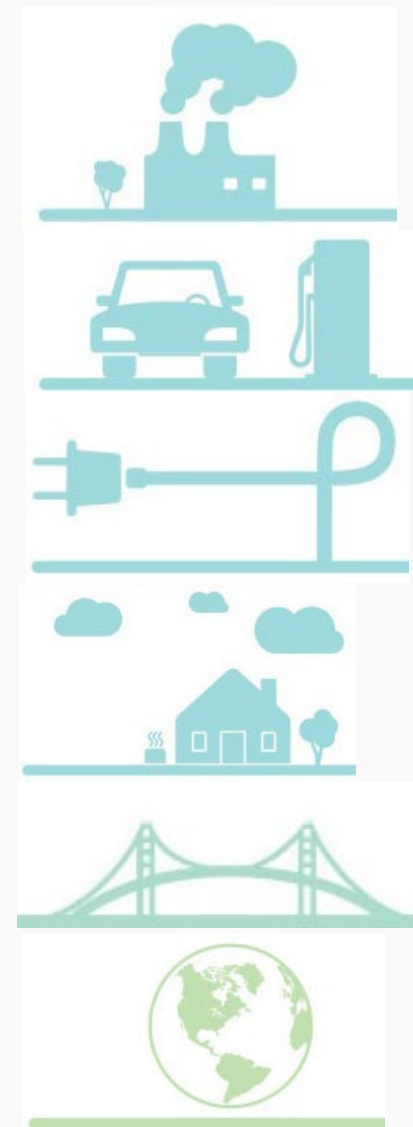




# EPA Action Under Climate Action Plan



- Reducing carbon pollution from power plants
- Building a 21<sup>st</sup> century transportation sector
- Cutting energy waste in homes, businesses, and factories
- Reducing short lived forcers
- Preparing the U.S. for the impacts of climate change
- Leading international efforts to address global climate change



# USEPA: Reducing GHG Emissions



- Dec 2005: Established Renewable Fuel program
- Dec 2009: EPA found GHG endanger public health and welfare.
- May 2010: GHG emission Standards for '12-'16 light duty vehicles
- May 2010: GHG permitting requirements for large GHG emitters
- Sept 2011: GHG emission Standards for medium and heavy duty vehicles
- Aug 2012: GHG emission Standards for '17-'25 light duty vehicles
- Aug 2015: GHG emission standards for new and existing power plants
- Aug 2015: Proposed methane emission standards for municipal solid waste landfills.
- May 2016 – Emission standards for oil and gas sources. EPA is also collecting additional information needed to develop regulations to reduce methane from existing oil and gas sources.

<https://www3.epa.gov/climatechange/EPAactivities.html>

# Combatting Short Lived Climate Pollutants



- International efforts and agreements to reduce emissions SLCPs
  - Climate and Clean Air Coalition
    - Goal: accelerate reductions in BC, methane, and HFCs
    - Country partners commit to mitigating short-lived climate pollutants in their own countries and helping others take similar actions
  - Global Methane Initiative
    - Works with 42 partner countries and an extensive network of over 1,100 private sector participants to reduce methane emissions.
  - Convention on Long Range Transboundary Air Pollution - Gothenburg Protocol
    - First international treaty to take steps to curb BC emissions. Specific provisions:
      - Parties should develop national BC emissions inventories and projections.
      - Parties “should give priority” to black carbon when implementing measures to control PM.
  - Arctic Council
    - Several SLCP Task Forces focused on assessment and mitigation projects to help slow Arctic and global climate change and improve public health.
  - Global Alliance for Clean Cookstoves
    - Goal: 100 million clean and efficient stoves by 2020



- EPA's Climate Page: <http://epa.gov/climatechange/>
- EPA's Links for Educators: <http://www.epa.gov/climatechange/links.html>
- NOAA Teaching Climate: <https://www.climate.gov/teaching>
- USG Global Change Research: <http://www.globalchange.gov/>
- NASA: <http://climate.nasa.gov/education/>
- Intergovernmental Panel on Climate Change: <http://www.ipcc.ch/>
- Climate and Clean Air Coalition: <http://www.unep.org/ccac/>



A large, faint watermark of the Environmental Protection Agency (EPA) logo is centered in the background. The logo consists of a circular border containing the text "UNITED STATES" at the top and "ENVIRONMENTAL PROTECTION AGENCY" at the bottom. In the center of the circle is a stylized flower with three leaves and a circular head with a white dot.

**Questions???**

[terry.sara@epa.gov](mailto:terry.sara@epa.gov)



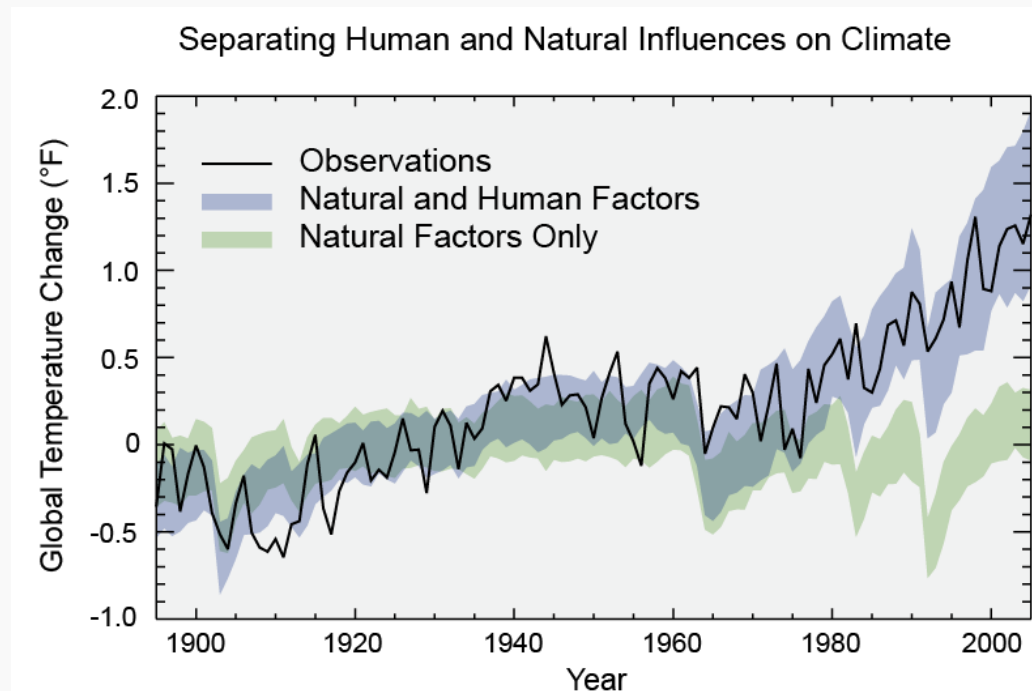
# Appendix



# Factors Affecting Climate Change



- Many factors, both natural and human, can cause changes in Earth's energy balance, including:
  - Variations in the sun's energy reaching Earth
  - Changes in the reflectivity of Earth's atmosphere and surface
  - Changes in the greenhouse effect, which affects the amount of heat retained by Earth's atmosphere
- Recent climate changes, however, cannot be explained by natural causes alone.
- 97% or more of actively publishing climate scientists agree that climate-warming trends over the past century are extremely likely due to human activities.
- Most of the leading scientific organizations worldwide have issued public statements endorsing this position.



# Surface Temperature & the Sun's Energy

