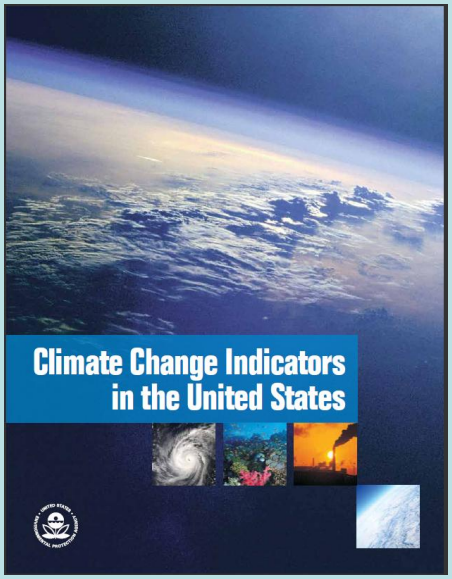
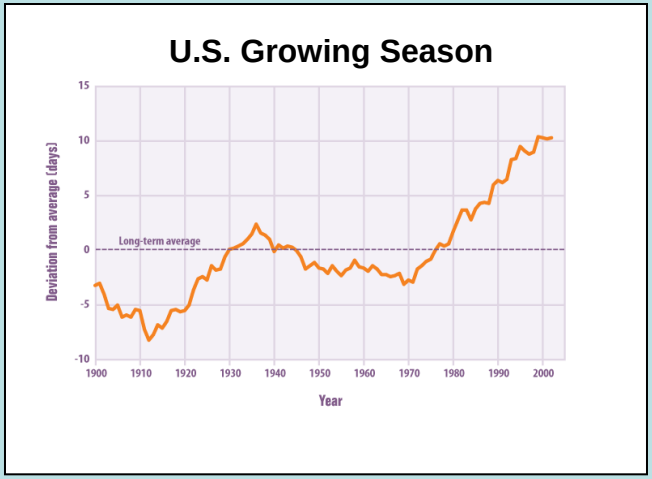
# *Climate Change Indicators in the United States*

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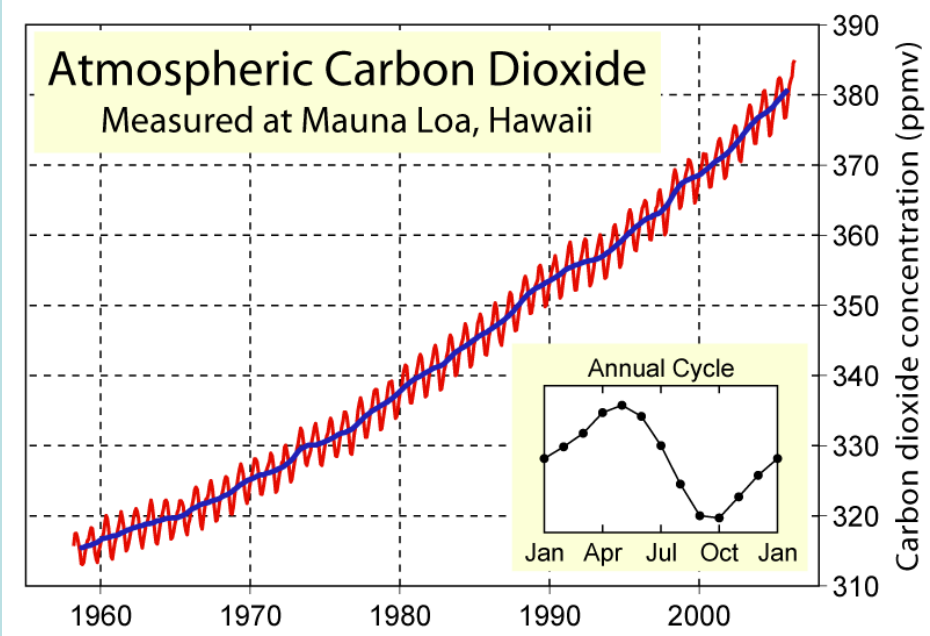
**National Atmospheric Deposition Program**
**2010 Annual Meeting and Scientific Symposium**
**Networking the Networks**
**October 20, 2010**

# Outline

- Describe what EPA is actively doing related to climate change indicators
- Provide some insight into indicator criteria and reasons for indicator selection
- Discuss next steps and path forward in EPA's indicator project and how stakeholders might contribute

# Observations

"The only way to figure out what is happening to our planet is to measure it, and this means tracking changes decade after decade and poring over the records." *Ralph Keeling*




Science, 2008, p. 1771-1772, Ralph F. Keeling

# Background

- EPA has been working on Climate Change indicators since 2002 in partnership with ORD and other agencies, primarily to support EPA's Report on the Environment (ROE)
- In 2004, EPA convened National Academy of Sciences Panel for input on developing climate change indicators
  - providing "street cred" to indicators
  - using peer-reviewed, existing climate science/data
- 2008 ROE contained 5 climate-related indicators
  - U.S. GHG Emissions
  - Global GHG Concentrations
  - Temperature and Precipitation (U.S. and Global)
  - Sea Surface Temperature
  - Sea Level

# Motivation for EPA's Indicators Report

- To serve as a useful communication tool for a complex issue serving policymakers and a range of stakeholders
- Present multiple lines of accumulated evidence of 'observed' changes
- Provide a framework for eventual ability to answer key questions and for tracking progress
- Several EPA programs have developed progress or accountability reports
  - OAQPS National Air Quality Trends Report
  - CAMD Acid Rain and Related Programs Progress Reports
  - Stratospheric Ozone Progress Report

# Report Snapshot

- Contains 24 indicators of climate change
  - Drivers or pressures (GHG emissions, concentrations, and forcing)
  - Physical state (temperature, precipitation, sea surface temperature, ocean acidification, hurricane intensity, etc.)
  - Effects (length of growing season, bird center of abundance, heat-related deaths, etc.)
- None of the results are new; report brings together datasets and analysis that have appeared elsewhere (i.e., peer-reviewed literature)
- Obtained data from EPA (GHG emissions), other government agencies (e.g. NOAA, NASA, USGS, and CDC), research institutions and NGOs
- Assembled a metadata document on how data was obtained, processed, and analyzed; full accounting of uncertainties for each indicator
- Substance, tone and balance consistent with the scientific assessment literature (e.g., IPCC's AR4, USGCRP/CCSP, NRC)

# Five Indicator Chapters

**1- Greenhouse Gases**
Global and U.S. GHG Emissions
Atmospheric GHG Concentrations
Radiative Forcing

**2- Weather and Climate**
Global and U.S. Temperature
Heat Waves
Drought
Global and U.S. Precipitation
Heavy Precipitation
Tropical Cyclone Intensity

**3- Oceans**
Ocean Heat Content
Sea Surface Temperature
Sea Level
Ocean Acidity

**4- Snow and Ice**
Arctic Sea Ice
Glaciers
Lake Ice
Snow Cover and Snowpack

**5- Society and Ecosystems**
Heat-Related Deaths
Length of Growing Season
Plant Hardiness Zones
Leaf and Bloom Dates
Bird Wintering Ranges

# Screening and Criteria for Indicators

- Screened over 110 candidate indicators to determine indicators with the following attributes:

Relevance or Usefulness:

  - Identified by 2004 NAS panel as priority indicators
  - From the literature, published data
  - Straight forward interpretation/depiction of trends
  - Significance to climate change **>>** Strength of climate signal

Data quality:

  - Objective, reproducible, and transparent (to develop and maintain the indicator)
  - Comparable methods across time and space
  - Spatially representative (significance of domain)
  - Reliability of source data (sound data collection/processing methodologies, quality assurance procedures)

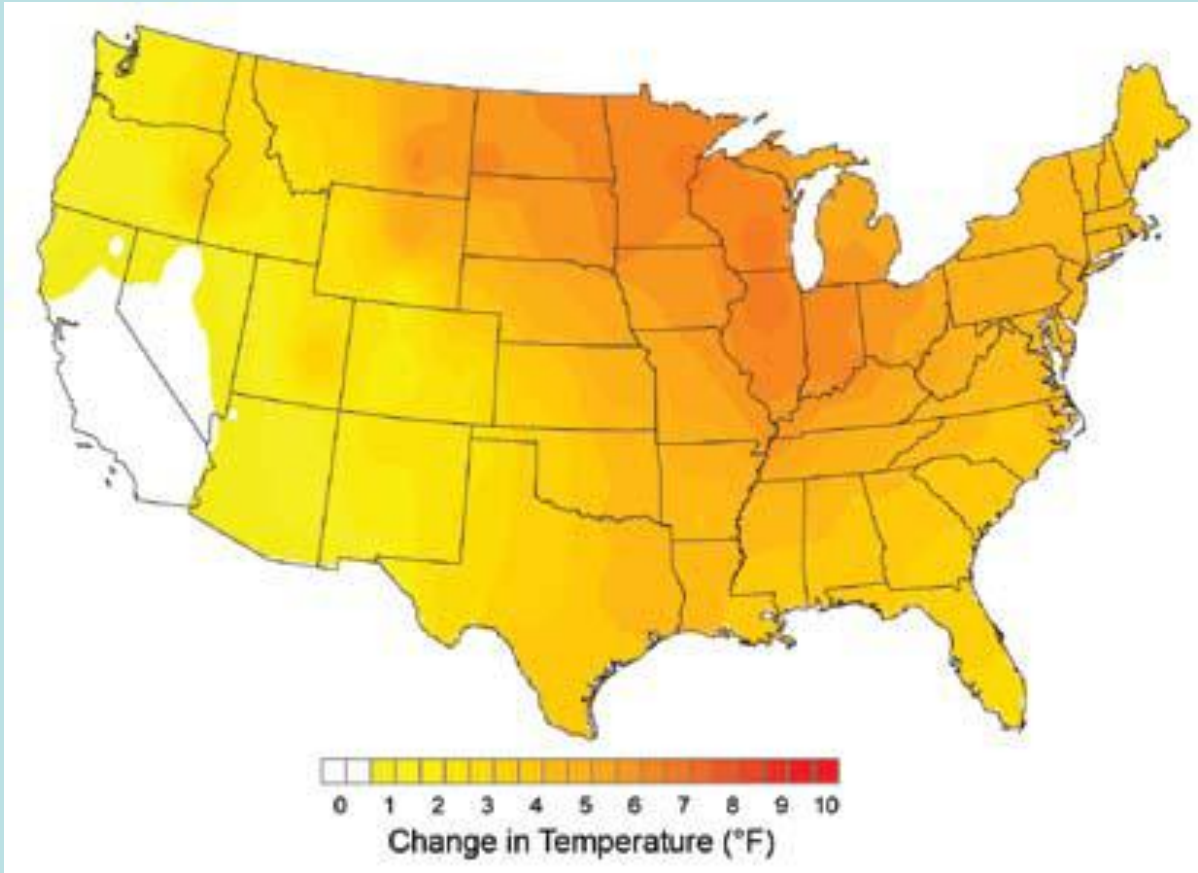
# What Do We Already Know?

"Observations show that warming of the climate is unequivocal"

USGCRP: Karl et al., 2009 (further support from IPCC 2007, NRC 2010, NOAA 2010)

- Temperatures are rising faster in winter than in any other season.
  - In the NE winter temperatures have warmed at almost 1 degree C per decade (0.7/decade) over the last 35 years (Hayhoe et al., 2007)

**U.S. Winter Temperature Trends, 1975 to 2007**




**Source: (USGCRP 2009, NOAA/NCDC)**

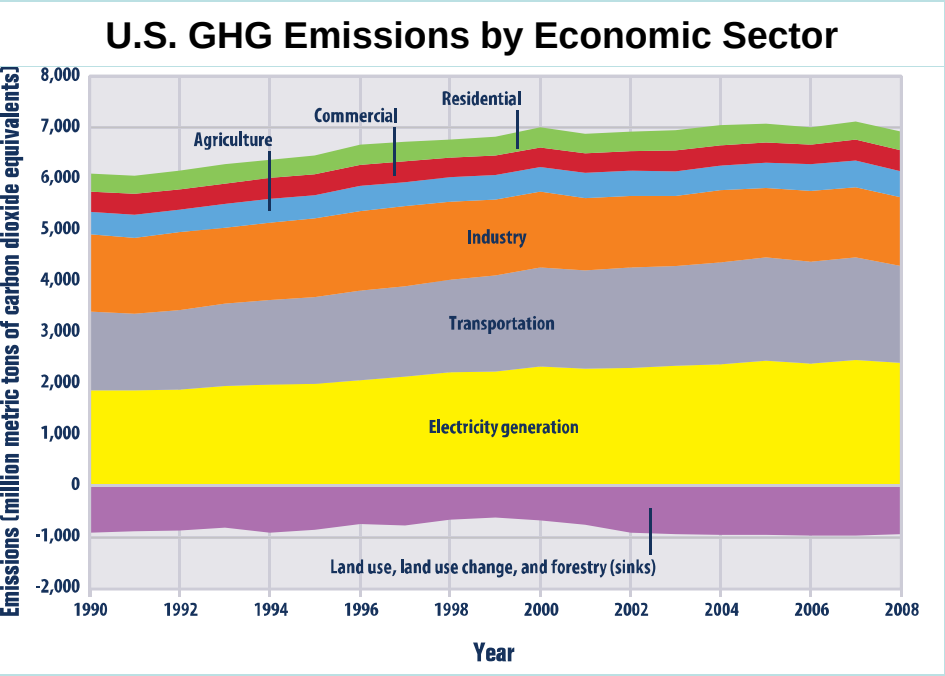
# Climate Change Indicators

**Select Indicators from the Report……**

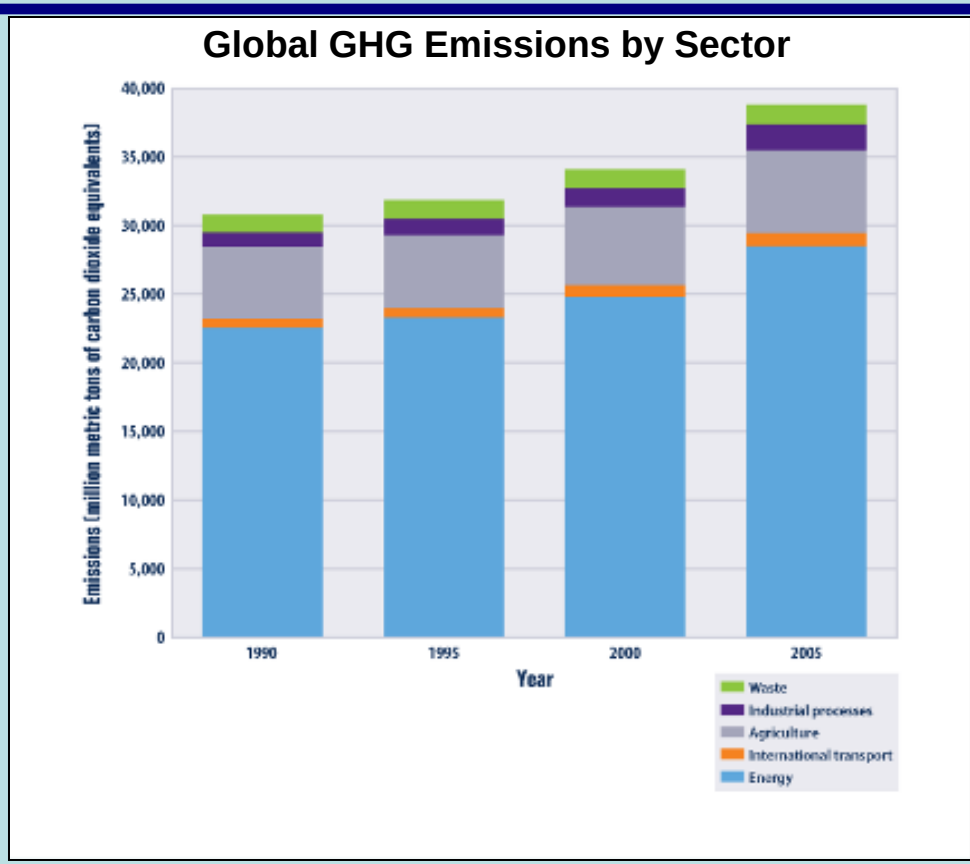
# Global and U.S. GHG Emissions

- U.S. GHG emissions have increased by 16% from 1990-2008 from human activities.

- Worldwide, emissions of GHGs from human activities increased by 26 % from 1990 to 2005.




Data Source: EPA's Inventory of U.S. GHG Emissions and Sinks (2010)

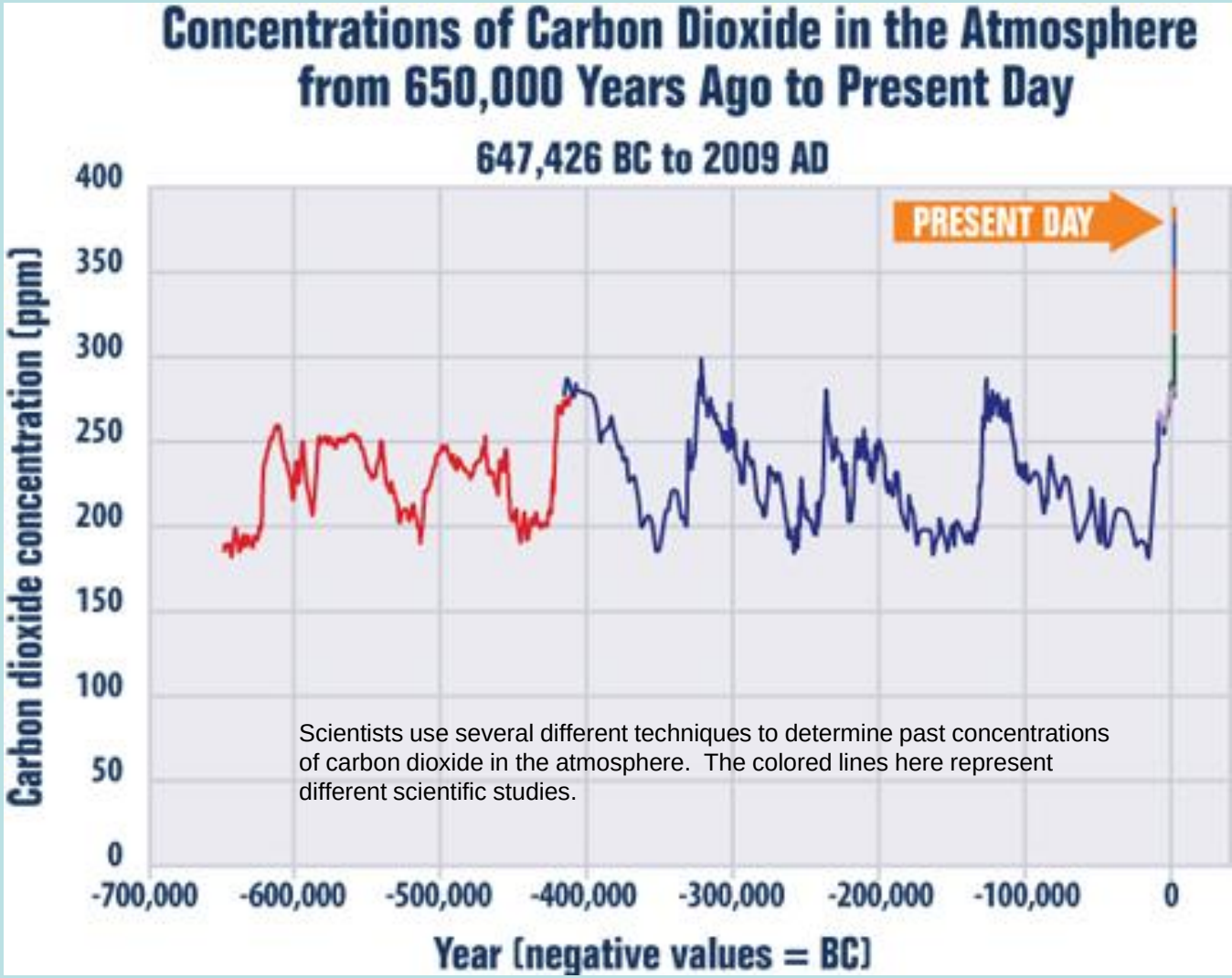



Data Source: World Resources Institute (2009)

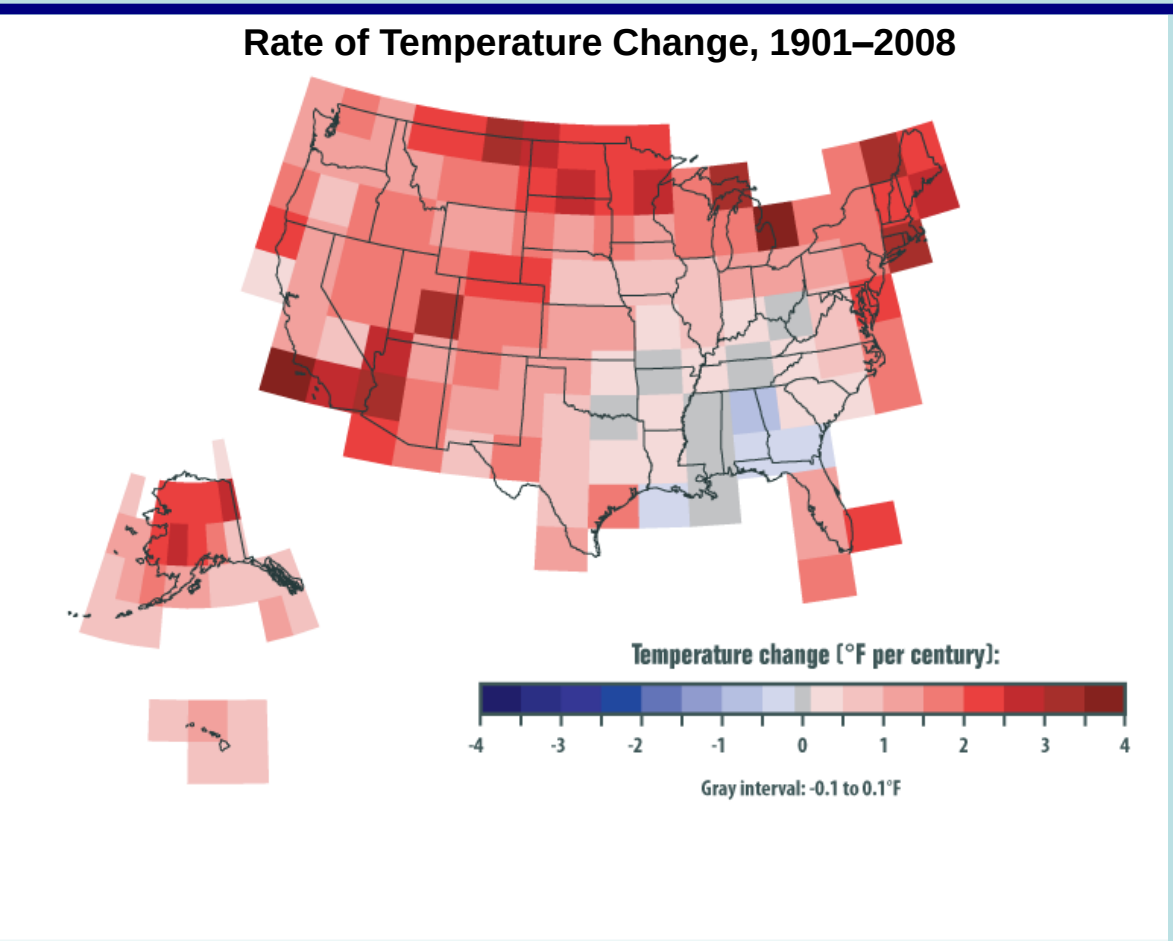
- Electricity generation is the largest source of GHG emissions in the United States, followed by transportation.

# Global Atmospheric Concentrations of Greenhouse Gases

- Concentrations of carbon dioxide and other greenhouse gases in the atmosphere have risen substantially since the beginning of the industrial era.
- Almost all of this increase is attributable to human activities.



# U.S. Temperature




* Average temperatures have risen across the lower 48 states since 1901, with an increased rate of warming over the past 30 years.

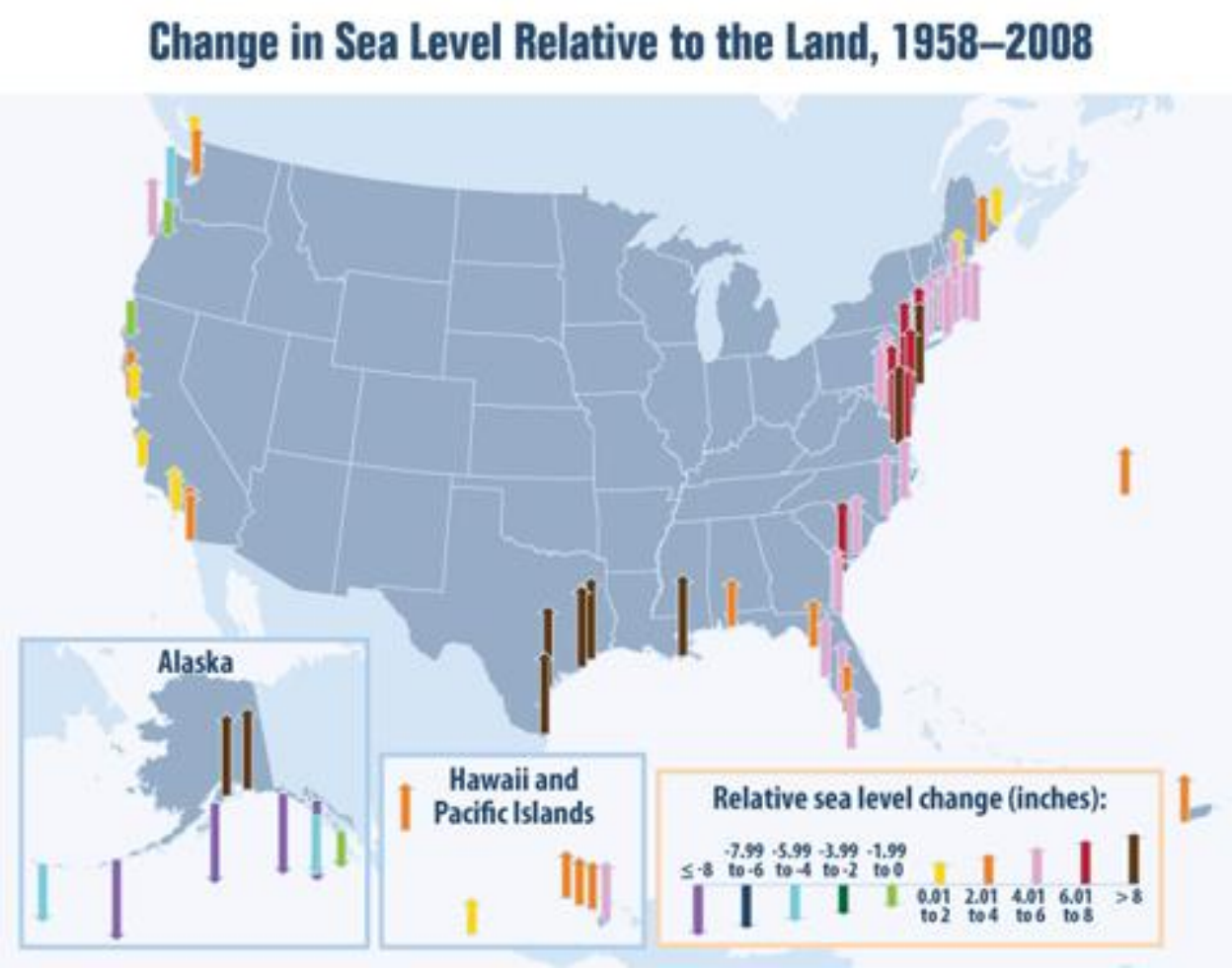
•U.S. temperature trend from 1901-2008 is 1.3°F/century
- 0.13°F per decade
- 0.40°F per decade since 1979)

Data from NOAA's National Climatic Data Center (2009)

# Sea Level

After about 2,000 years of little change, average sea levels rose worldwide throughout the 20th Century (with an accelerated rate of increase in recent years).

Relative sea level rose along much of the U.S. coastline, particularly the mid-Atlantic and some Gulf regions.



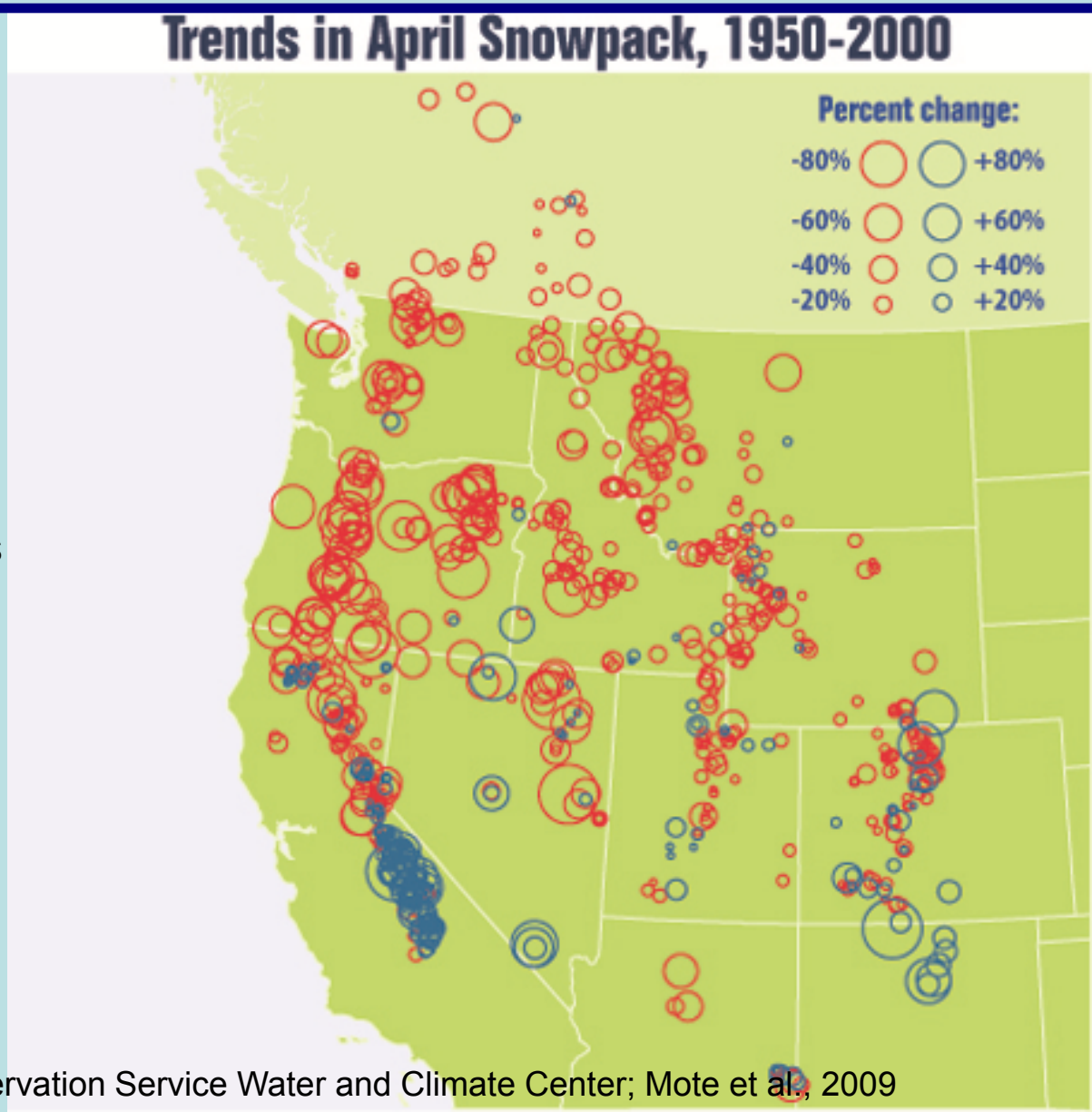

*Relative* sea level is the height of the ocean relative to land elevation at a particular location.

Data Source: NOAA, 2009 Tides and Currents: (http://tidesandcurrents.noaa.gov/sltrends/slrmap.html)

# Snowpack

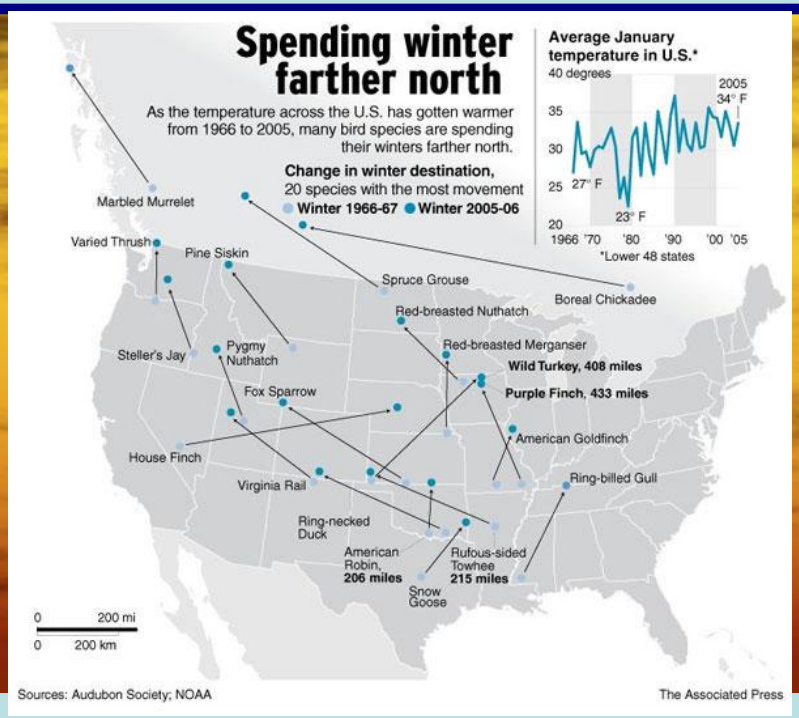
- Indicator is based on data from approximately 800 permanent research sites
- Between 1950 and 2000, the depth of snow on the ground in early spring decreased at most measurement sites in the western United States and Canada.
- Spring snowpack declined by more than 75 percent in some areas, but increased in a few others (southern Sierra Nevada of CA and the Southwest).

In most western river basins, snowpack is a larger component of water storage than man-made reservoirs.



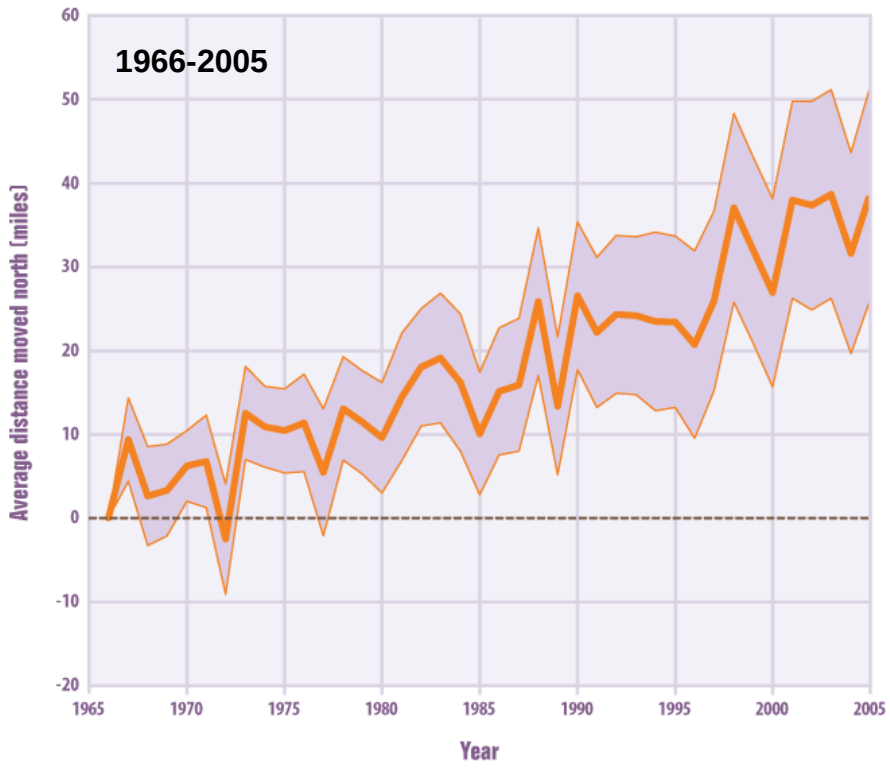

Source: USDA's Natural Resources Conservation Service Water and Climate Center; Mote et al., 2009

# Bird Wintering Ranges




Bird species in North America have shifted their wintering grounds northward by an average of 35 miles from 1966 to 2005, with a few species shifting by several hundred miles.

**Trends in center of abundance are closely related to winter temperatures.**



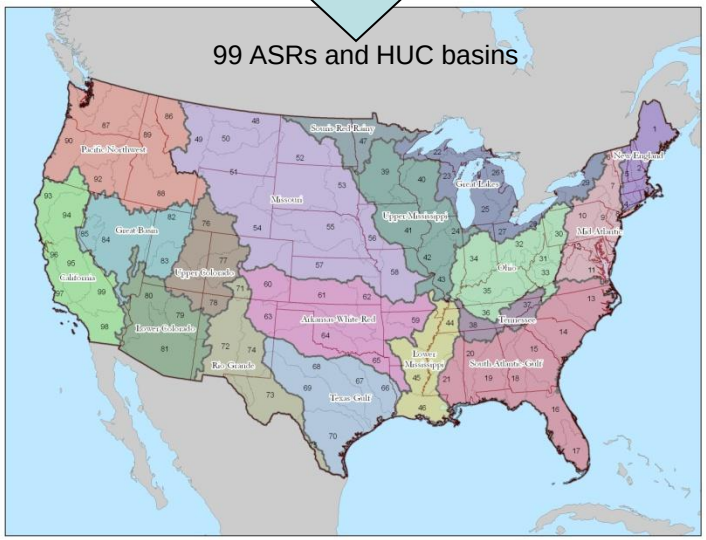

Across 305 widespread North American bird species, the center of abundance moved northward and inland.

Source: National Audubon Society, 2009

# Indicators and Usefulness?

## Considerations:

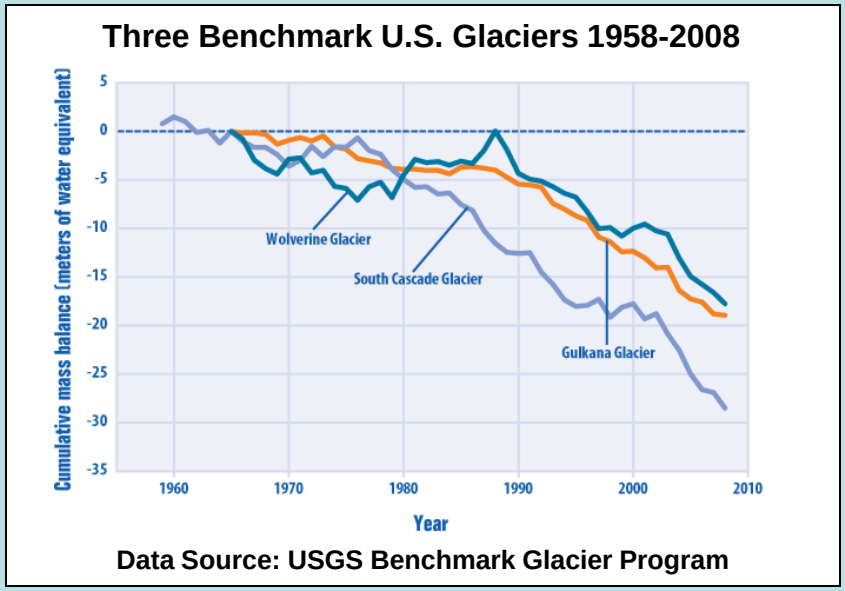
- Effects indicators related to timing indices (e.g., growing season, max flow)
- Relate or associate indicators to meaningful geographic domains
- Tie indicators to specific questions
- Consider emerging indicators which may be worth tracking
- Evaluate indicators within and across sectors (e.g., water resources + ag.)

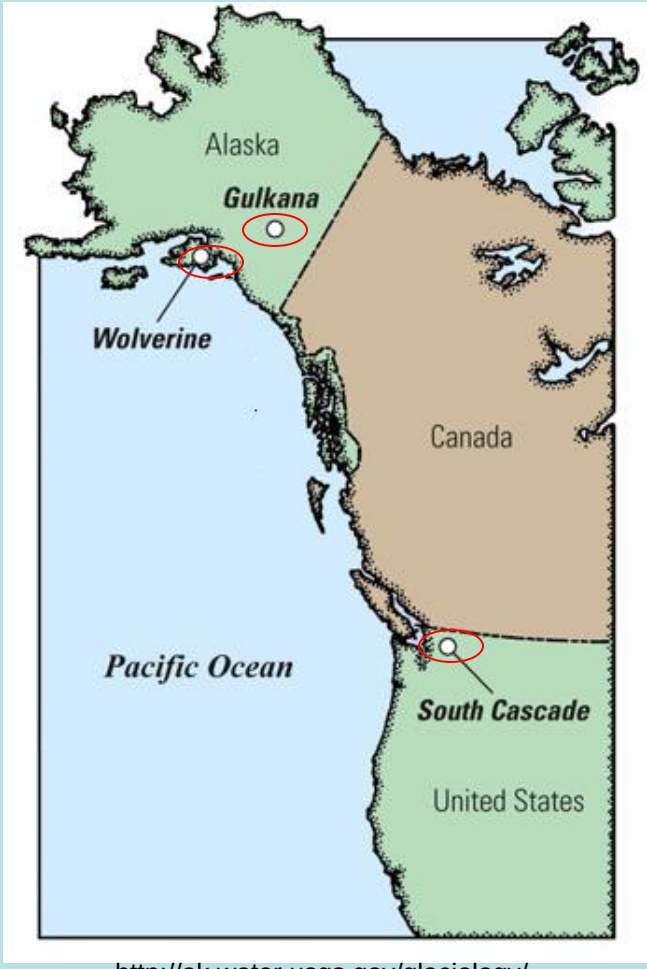



# Matters of Scale

- Indicator scale is often predetermined

- Factors associated with indicator scale
  1. Spatial representativeness (data availability)
  2. Target population of the indicator
  3. Significance to society (e.g., snow pack, iconic status)



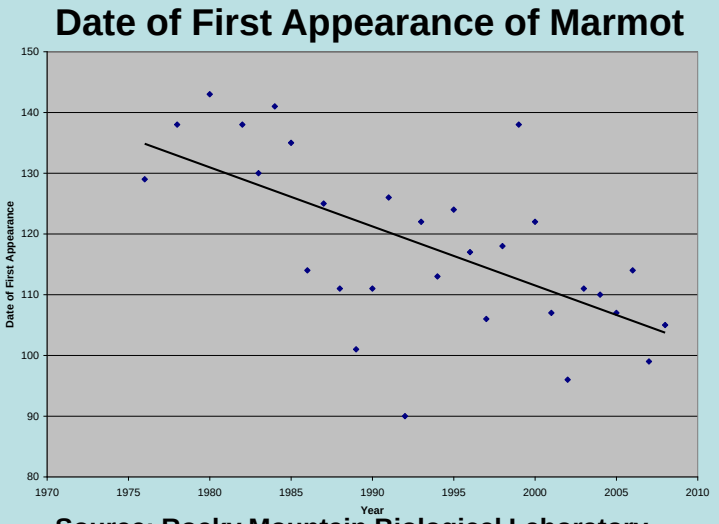




http://ak.water.usgs.gov/glaciology/

# Regional Indicator…..

## Hibernation & Yellow- Bellied Marmot

- The scale of this indicator is dependent on the target population (has an "inherent" regional context based on habitat).
- Marmots have been coming out of hibernation approximately 30 days earlier than in 1976 (when food is not available)
- Emergence from hibernation is strongly linked to winter temperatures.




Source: Rocky Mountain Biological Laboratory

Slide content courtesy of Laura Farris, USEPA Region 8

# Follow-on Report and Next Steps

- Expand to include 10-15 new indicators
- Looking at ways to improve, update, and expand the report
- Evaluate outreach strategies
- Encourage feedback from Long-term monitoring community for expanding and revising the current suite of indicators

# Options for New Indicators & Current Gaps

- Hydrologic indicators – currently exploring options with USGS (winter-spring center of volume + summer low flows)
- Air Quality indicators – (e.g. background ozone, length of ozone season)
- Forest/Ag indicators (wildfire – frequency or size, pest outbreaks, species shifts, additional drought metrics)
- Ecosystem-based indicators (biodiversity, species shifts, invasive species)
- Human Health – currently we have one, are there others?
- Do we start to track socio-economic indicators related to climate change or our response to climate change?

# Climate Change Indicators

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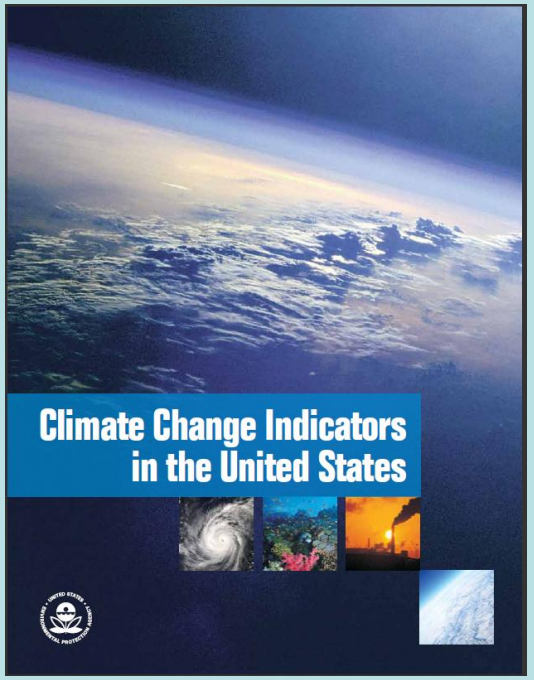


http://www.epa.gov/climatechange/indicators.html