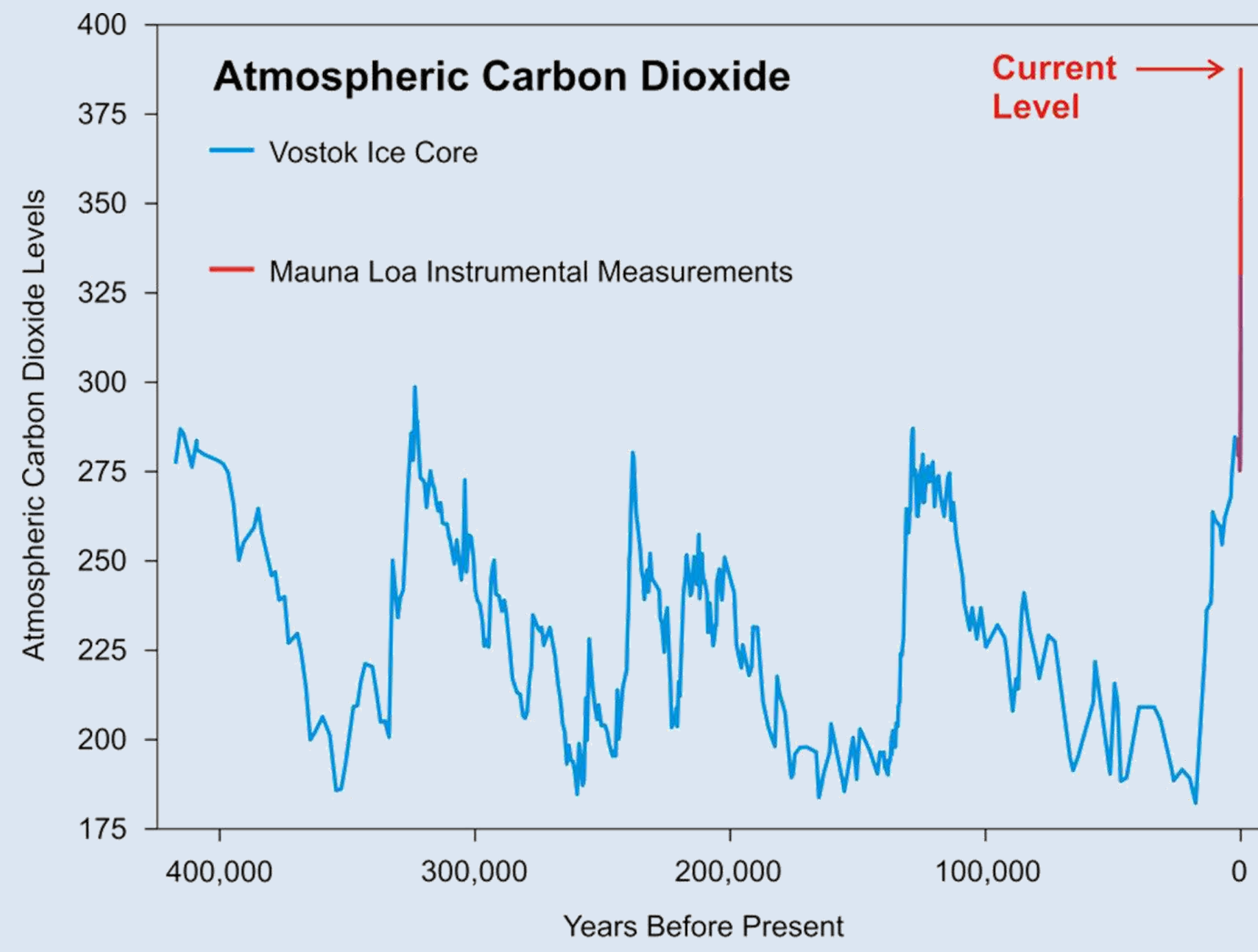


Climate Change FAQs

What is climate change and what causes it?

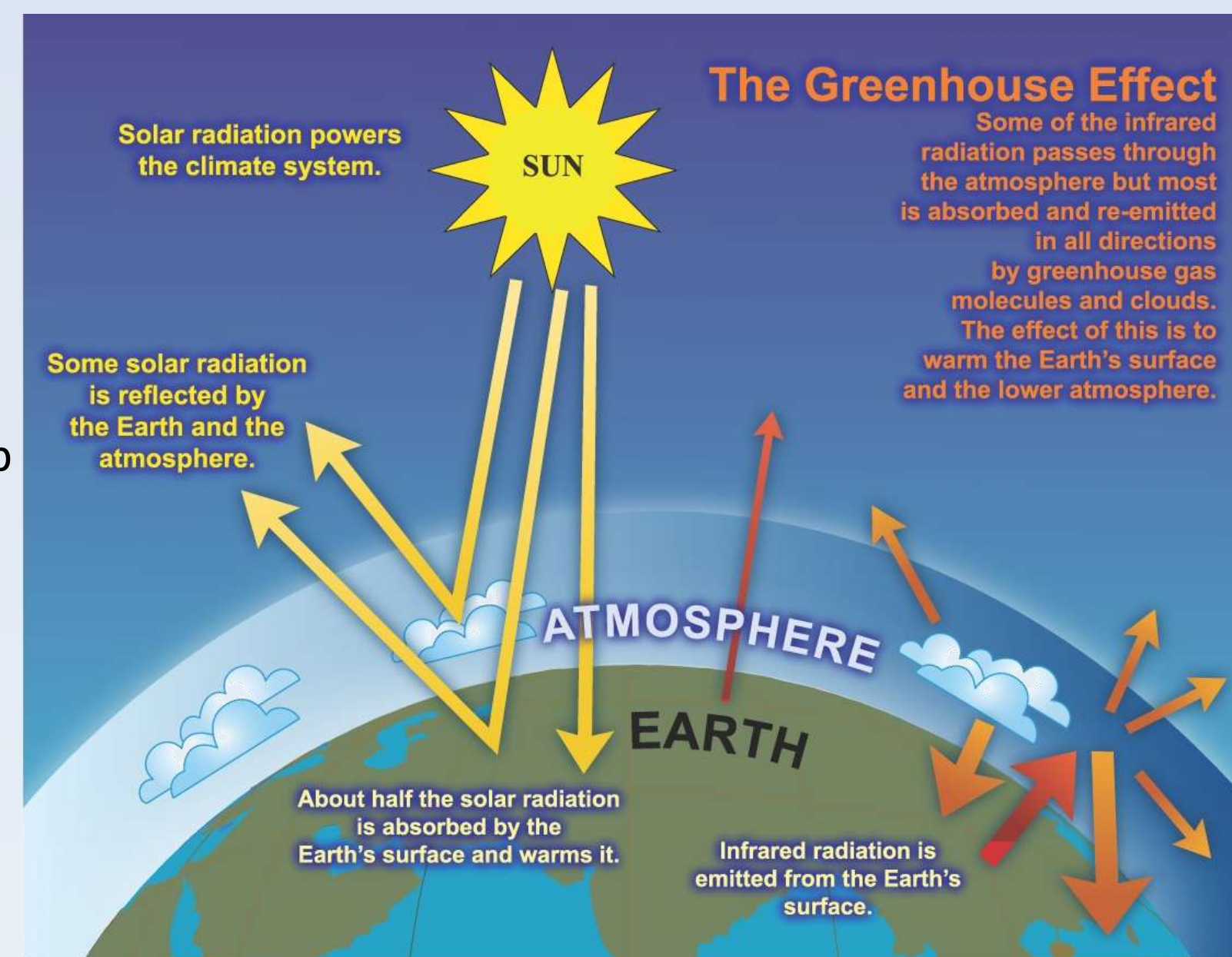
Climate change refers to any significant change in temperature, precipitation, or wind patterns, among other effects, that occur over several decades or longer. Over the history of the earth, climate has changed many times due to natural causes like changes in solar radiation, volcanic eruptions, and changes in greenhouse gases.

Currently, however, the Earth is undergoing rapid climate change that cannot be explained by natural causes. **Earth's average temperature has risen by 1.4°F over the past century**, and is projected to rise another 2 to 11.5°F over the next hundred years. Small changes in the average temperature of the planet can translate to large and potentially dangerous shifts in climate and weather.



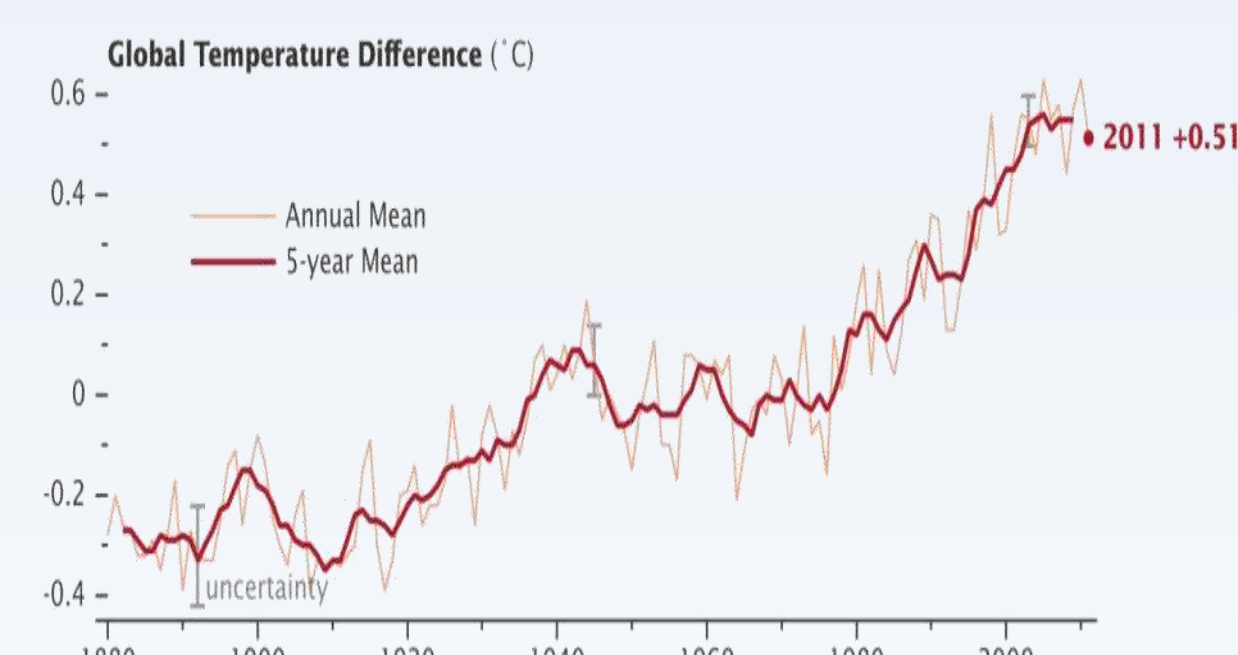
Over the past century, human activities have released large amounts of carbon dioxide and other greenhouse gases into the atmosphere. The majority of greenhouse gases come from burning fossil fuels to produce energy, although deforestation, industrial processes, and some agricultural practices also emit gases into the atmosphere. Levels of carbon dioxide are higher than they have been for hundreds of thousands of years.

CO₂ levels measured at Vostok, Antarctica (blue) and Mauna Loa, Hawaii (red).



Greenhouse gases act like a blanket around Earth, trapping energy in the atmosphere and causing it to warm. This phenomenon is called the greenhouse effect and is natural and necessary to support life on Earth. However, the buildup of greenhouse gases can change Earth's climate and result in effects to human health and welfare and to ecosystems.

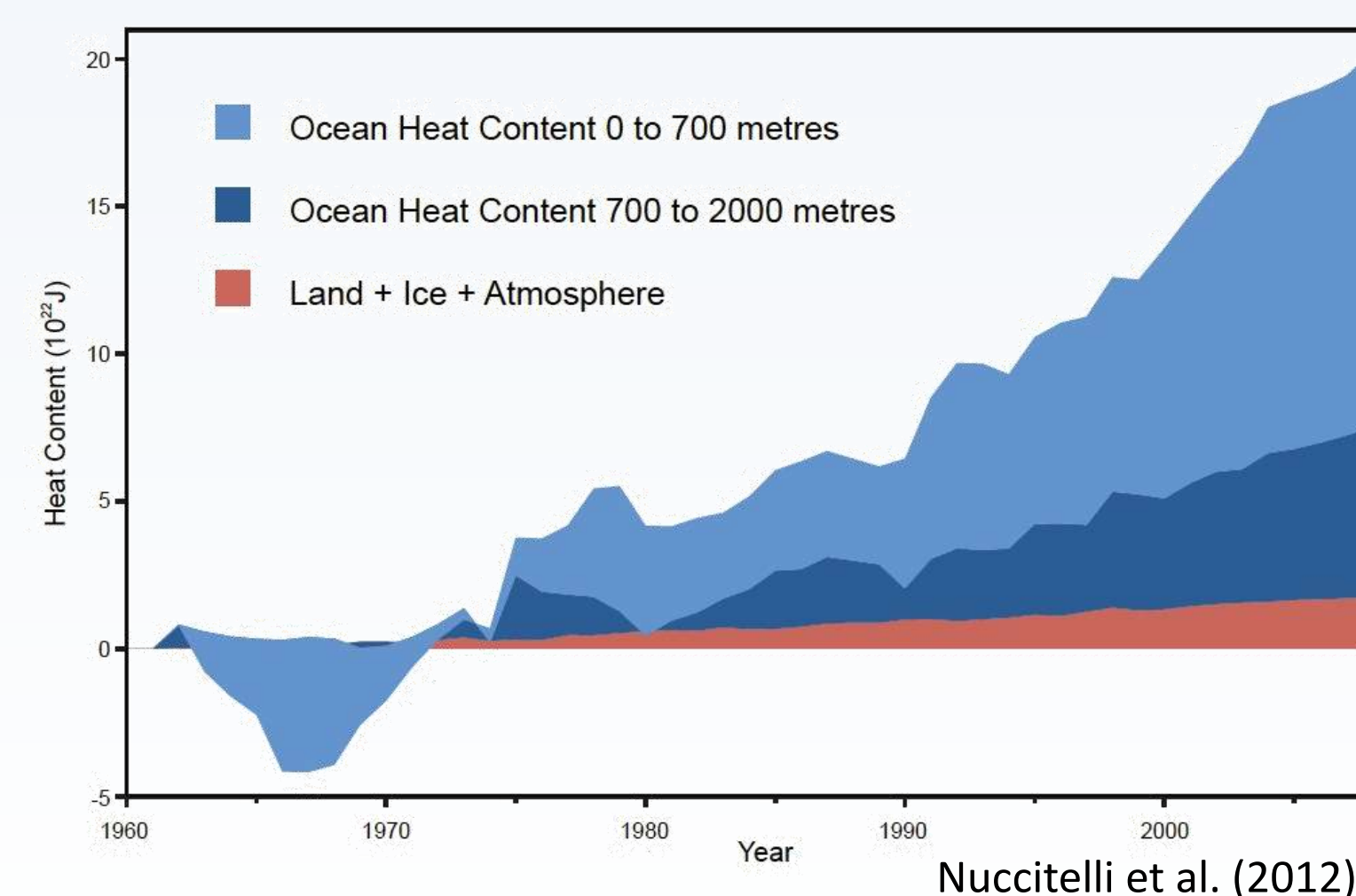
Have global temperature increases stopped?



credit: NASA Earth Observatory, Robert Simmon; www.giss.nasa.gov/research/news/20120115/

Still not convinced? It's also important to remember that the Earth is largely covered in water, and observing temperature trends over the land surface only tells us part of the story. Studies examining changes in ocean temperature show a steady increase over the past several decades.

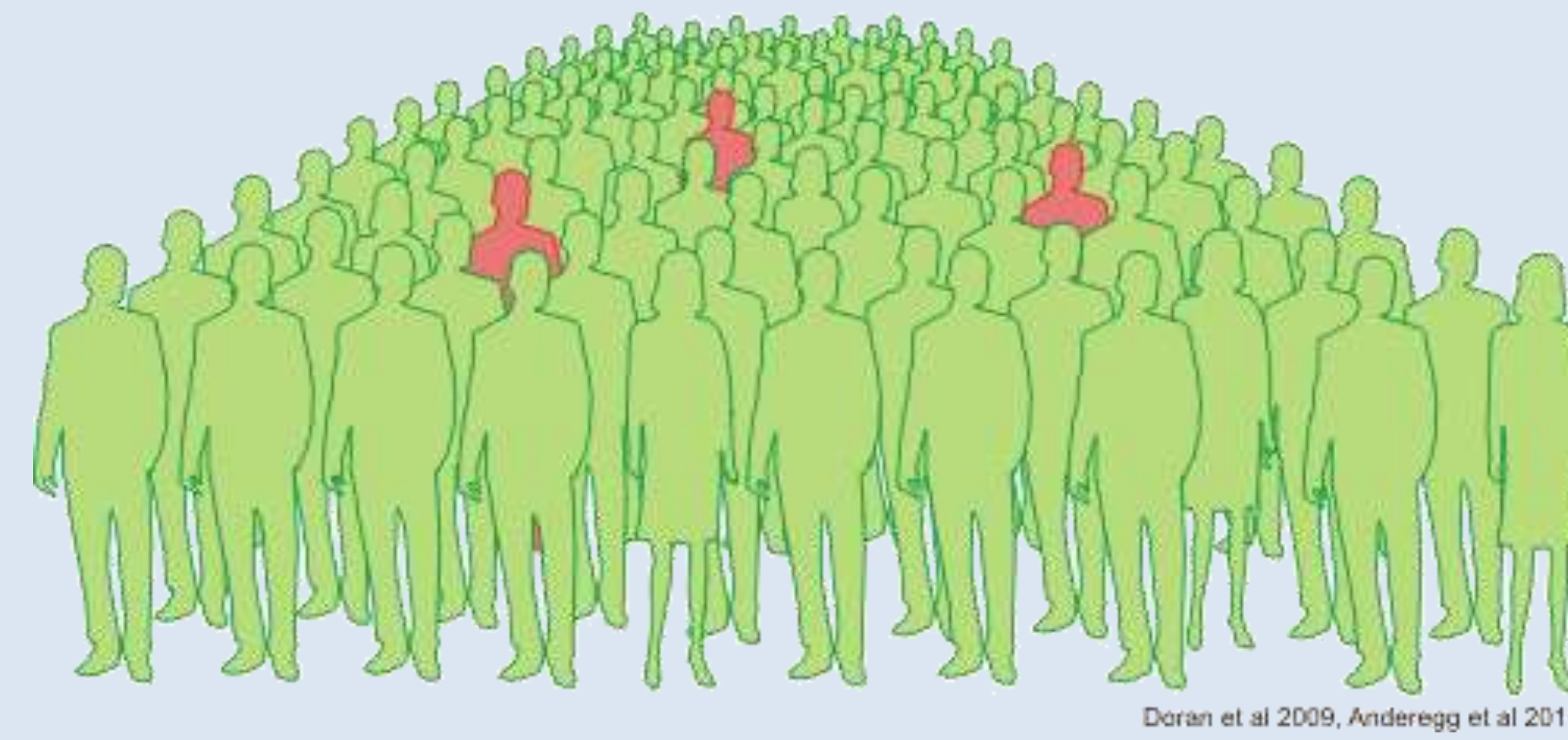
Some people argue that temperatures have decreased since 1998. This is not true. First, several independent records suggest that 2005 was the warmest year on record, and many of the years over the past decade were among the warmest in the historical record. Second, to determine trends in climate, you have to look at the historical record across many decades. Year-to-year variation from ocean circulation patterns, volcanoes, and changes in solar activity will still lead to some warmer and some cooler years, but the overall trend is an increase in temperature.



Nuccitelli et al. (2012)

How certain are scientists?

97 out of 100 climate experts think humans are changing global temperature



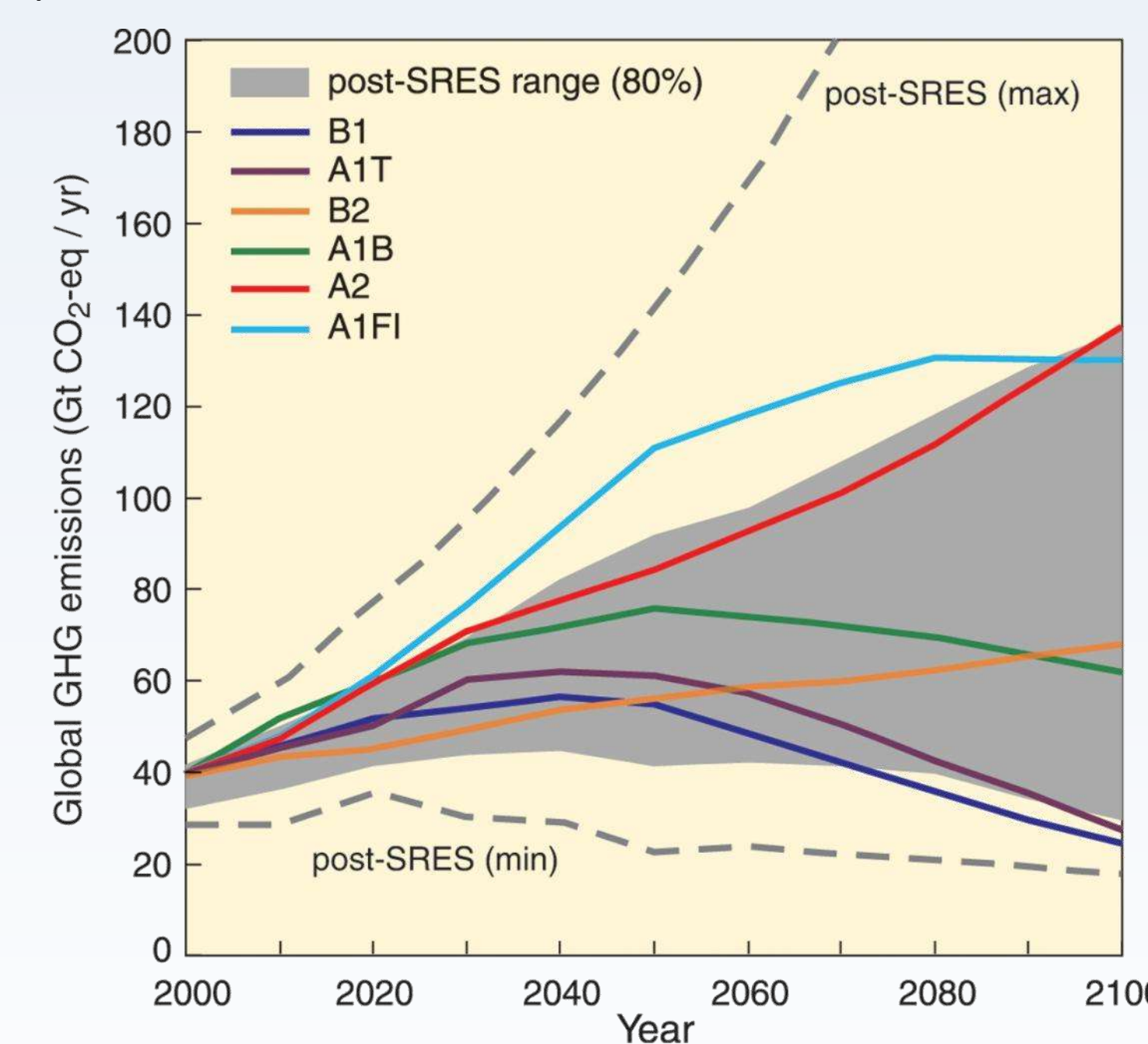
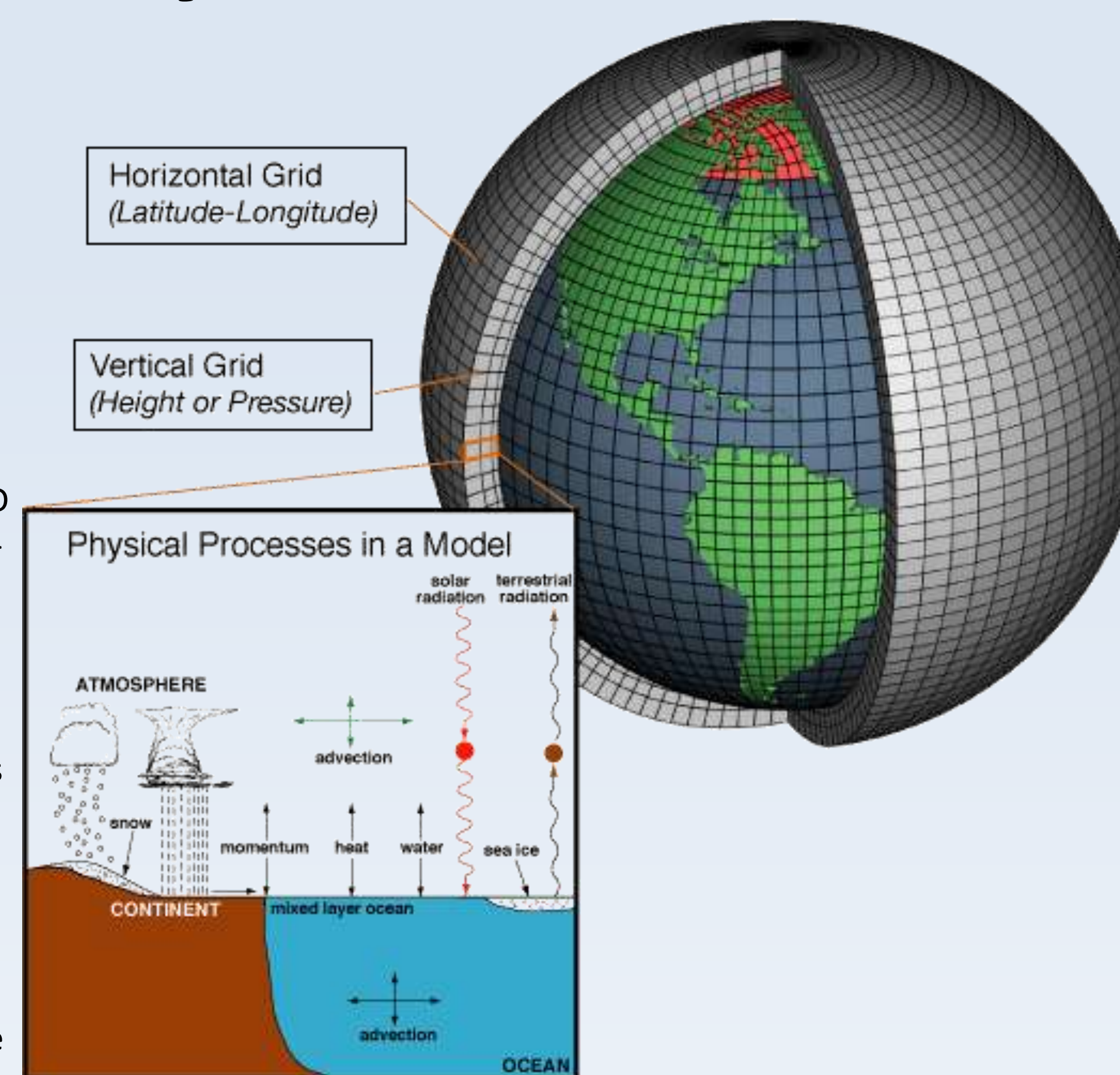
Doran et al 2009, Anderegg et al 2010

What are climate models and how do they work?

Scientists cannot measure the future, and instead rely on mathematical models to understand how climate may change.

To build a climate model, scientists construct a 3-D map of the Earth's climate system. The basic building blocks of climate models are 3-D "grid cells" that contain climate-related physical information about a particular location. Within each grid cell, key physical, chemical, geological, and biological climate processes are represented.

The mathematical equations representing Earth's climate system are then translated into computer code and run on large supercomputers over many decades at daily or hourly time steps.



We don't know how greenhouse gases will change in the future. Instead, scientists must use a range of plausible future greenhouse gas emissions to examine future climate.

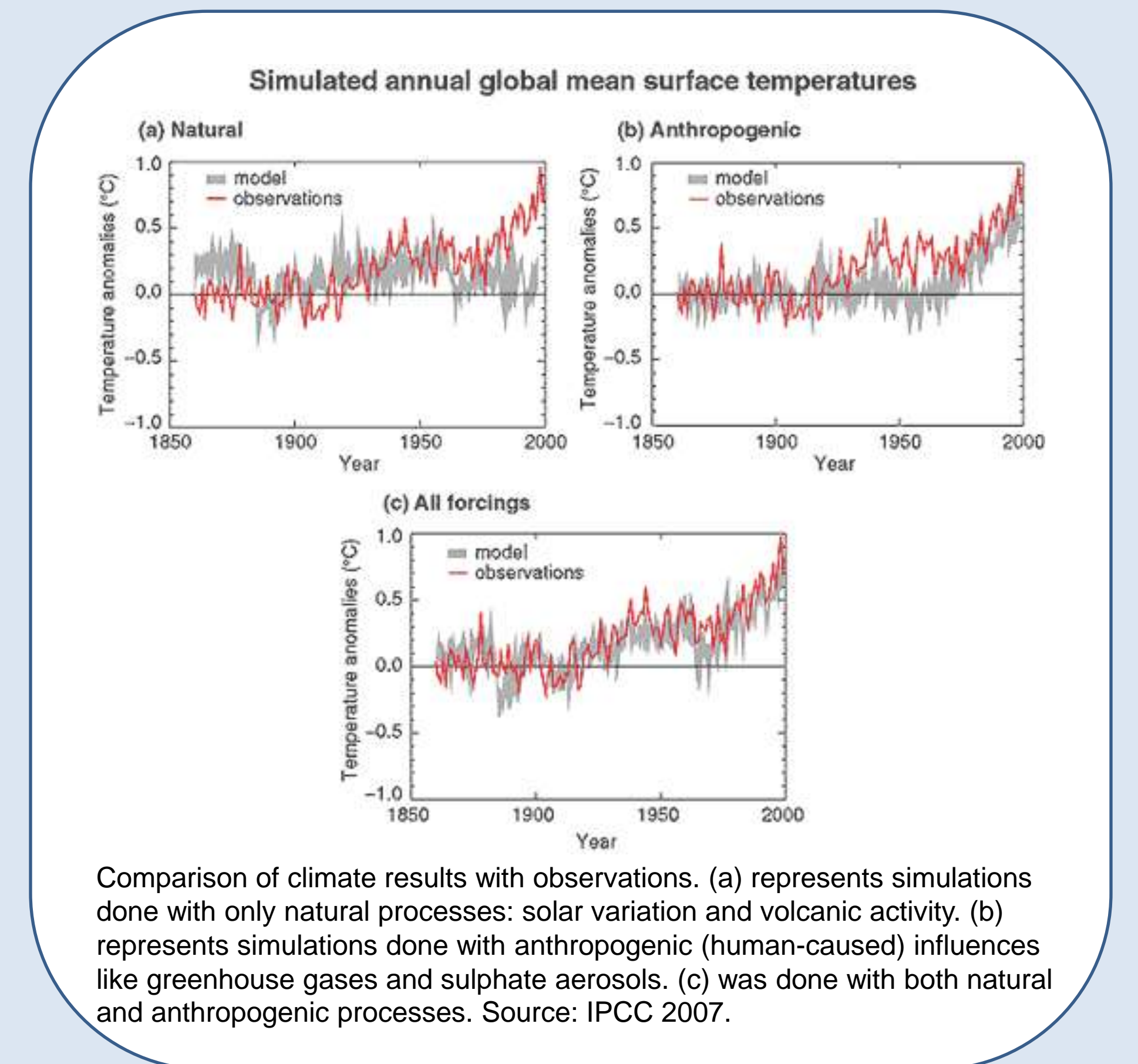
The most recently published Intergovernmental Panel on Climate Change (IPCC) report used a set of "emission scenarios" that were based on alternative storylines of how the global population, technological developments, and economic growth may change.

A1FI represents a fossil fuel-intensive scenario, while B1 represents a scenario where fossil fuel emissions are dramatically reduced.

How reliable are climate models?

To validate whether or not climate models are providing us with accurate information about the Earth System, outcomes from model simulations are compared to observational data to assess where they are similar and where they diverge.

All the models are unable to explain recent warming without taking rising greenhouse gas levels into account.



Comparison of climate results with observations. (a) represents simulations done with only natural processes: solar variation and volcanic activity. (b) represents simulations done with anthropogenic (human-caused) influences like greenhouse gases and sulphate aerosols. (c) was done with both natural and anthropogenic processes. Source: IPCC 2007.

Why should I care about climate change?

It's not just about penguins and polar bears. Changes in global climate have local implications.

Research suggests that southern Illinois may experience longer, more regional droughts, more heavy precipitation events, and more early-season tornadoes.

Your health and well-being may also be affected. Higher summer temperatures may lead to more frequent heat waves, which may also reduce air quality in some areas. A longer growing season could also extend the hay fever season.

	2020-2029	2045-2055	2080-2099
Chicago	143	185	300
Cincinnati	19	23	31
Detroit	255	291	701
Minneapolis	119	112	142
St. Louis	67	109	189

Source: Green et al. 2011.
Higher summer temperatures and heat waves are projected to increase as our climate warms. One recent study projected a notable rise in heat-related deaths across the Midwest over the course of the twenty-first century under a high-emissions scenario (A2FI), as indicated above.



Local changes in climate have important implications for forests and other ecosystems in Illinois. Changes in temperature and precipitation can alter growing season length, make conditions more or less favorable for some species, and increase the risk of wildfire.

Where can I learn more?

The following websites provide a great general overview of climate change and frequently asked questions:

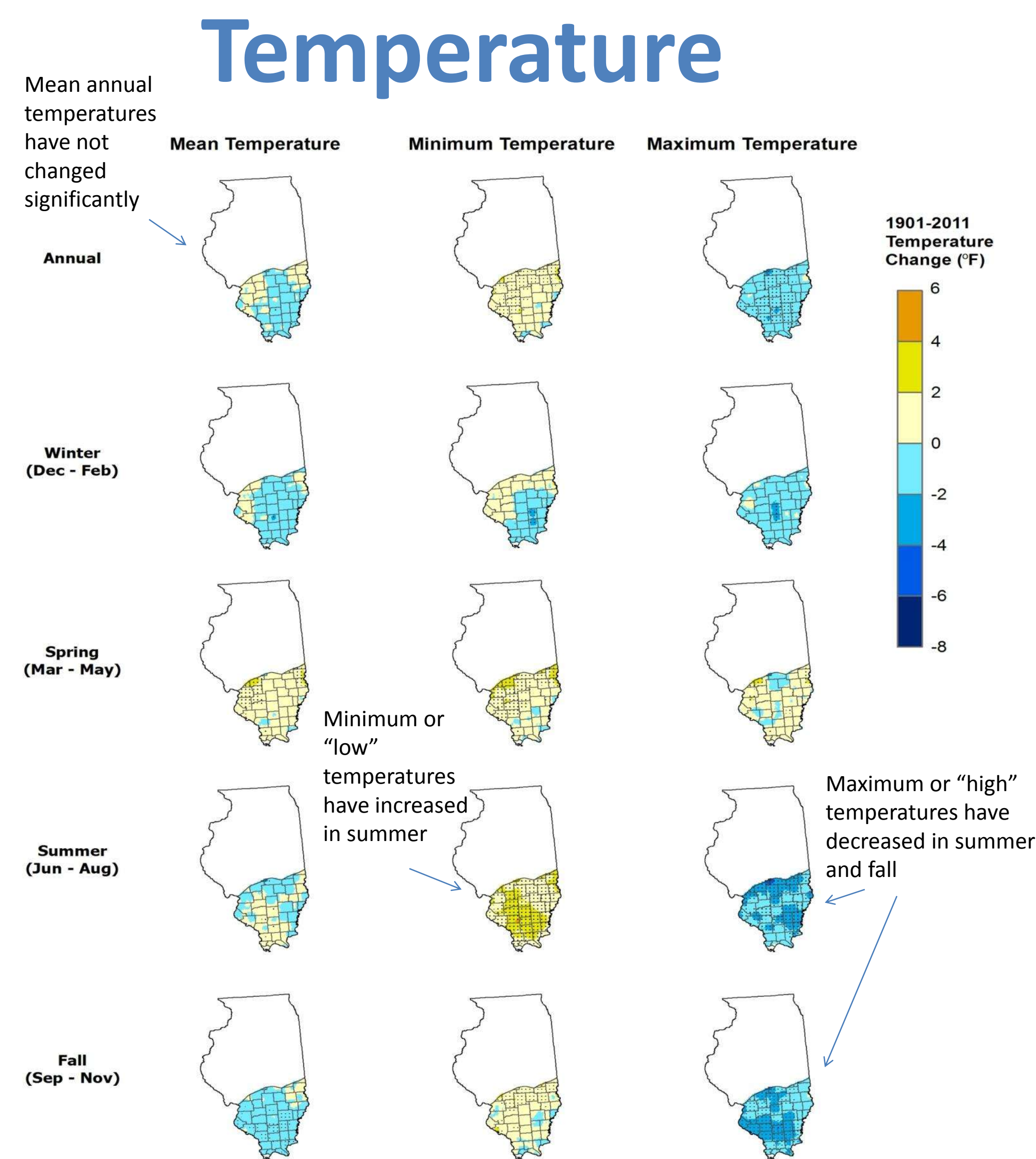
- US EPA: epa.gov/climatechange/science
- Forest Service Climate Change Resource Center: fs.fed.us/ccrc/climate-basics/climate-primer
- Skeptical Science: skepticalscience.com

Past and Future Climate Change in Southern Illinois

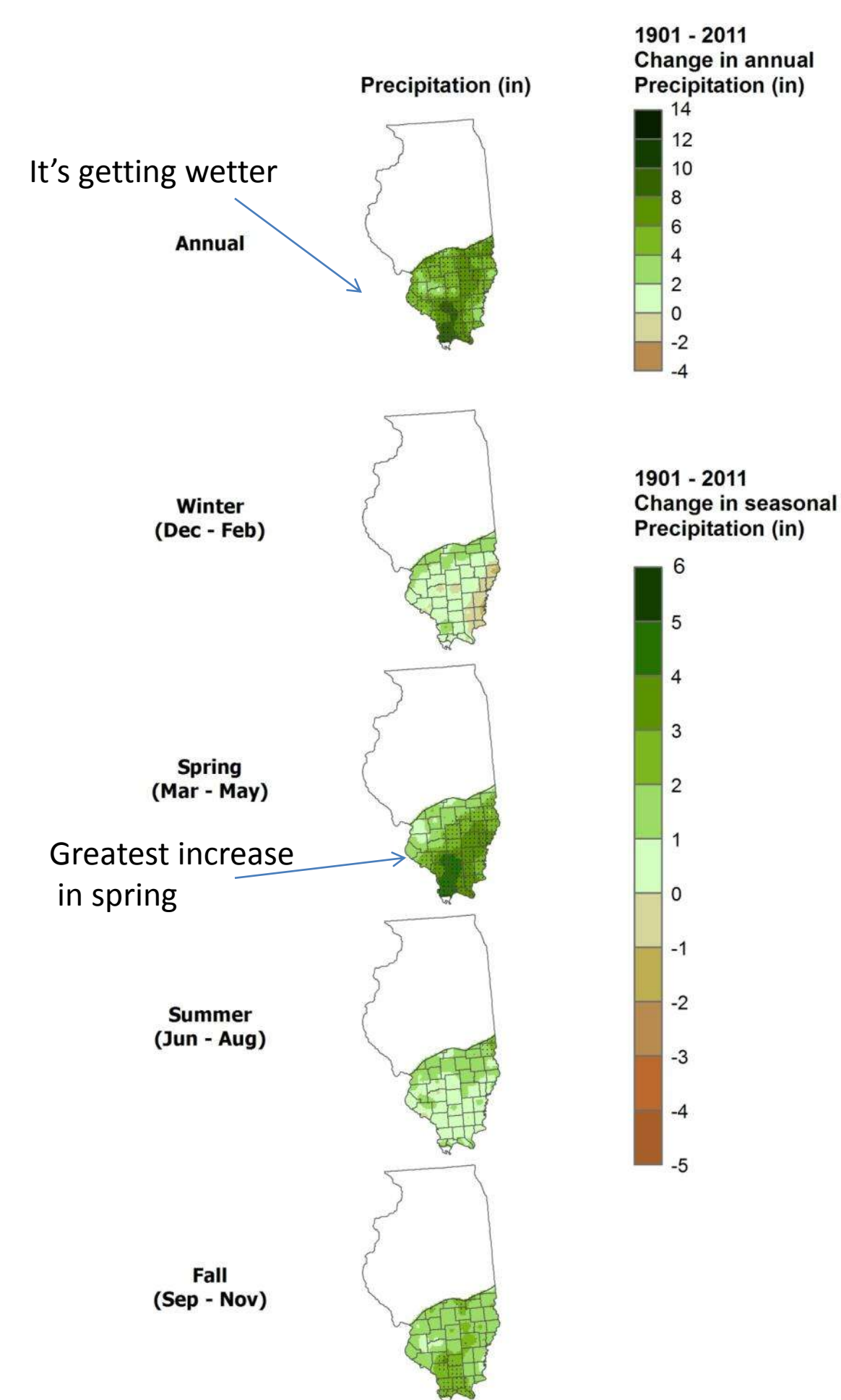
Past Changes

We can use measurements from weather stations to understand how temperature and precipitation has changed in southern Illinois. Reliable weather records go back to about the beginning of the 20th century.

The following maps were generated using the ClimateWizard Custom tool (climatewizardcustom.org). Historical data from weather stations were translated to a 2.5 by 2.5 mile grid and then analyzed for statistical trends from 1901-2011. Areas with stippling indicate areas of high statistical confidence (less than 10% probability of the trend occurring by chance).



Precipitation



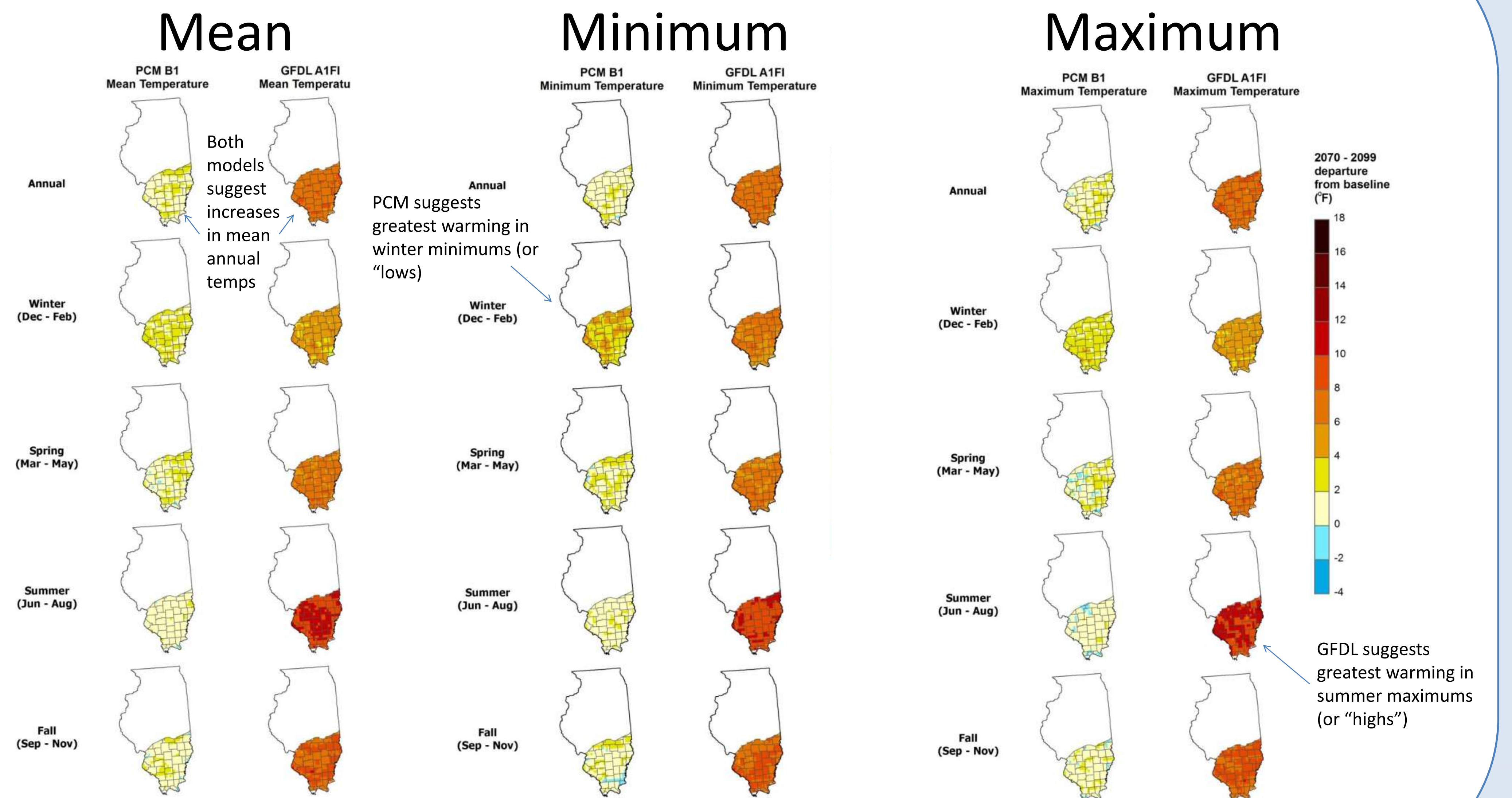
Future Changes in Temperature: End of Century

How may temperatures in southern Illinois change in the future? To explore this, we relied on two climate model-emissions scenario combinations. Two models were selected from models used in the IPCC's 4th assessment report (2007).

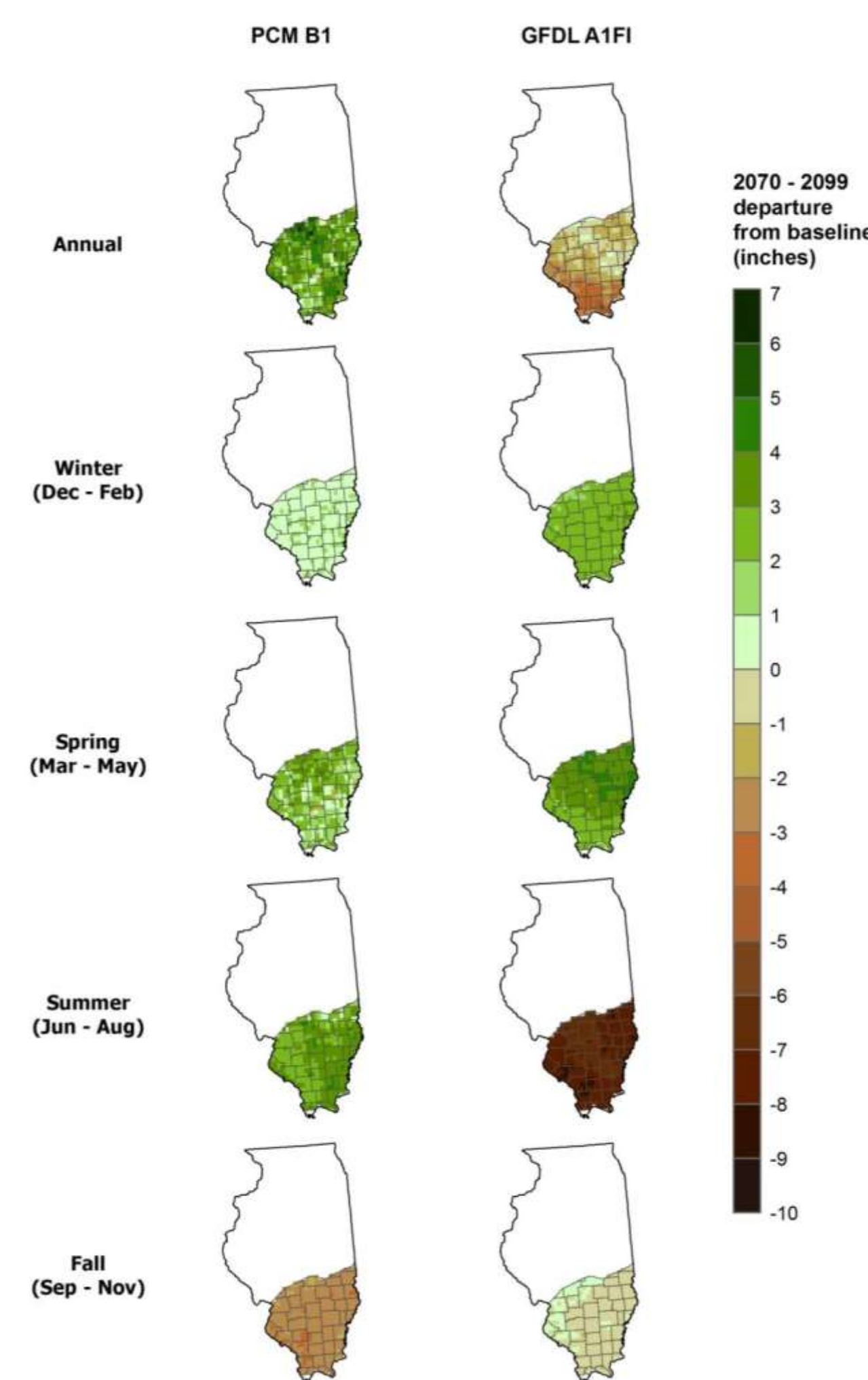
One model (GFDL) is relatively sensitive to changes in greenhouse gas emissions. The other model (PCM) is less sensitive to changes in greenhouse gas emissions. The GFDL model was paired with a high greenhouse gas emissions scenario (A1FI), and the PCM model was paired with a low emissions scenario (B1). Selecting these two combinations helped us bracket a range of possible futures.

Climate models run on very large grid scales (about 4,000 square miles). To examine finer-scale changes (about 50 square miles), scientists use a technique called statistical downscaling, which uses relationships between local weather station data and large-scale climate model data to develop finer-scale projections.

The data shown here shows results from a statistically-downscaled dataset available through the US Geological Survey (cida.usgs.gov/climate/gdp). The maps show the difference between the 30-year average temperature for 2070-2099 and the measured 30-year average from 1971-2000.



Future Changes in Precipitation



The same statistically-downscaled data were used to examine future changes in precipitation.

Models are less reliable at making projections of future precipitation than temperature at local scales because precipitation is driven by regional processes that cannot be modeled well at large grid scales (especially in summer).

Models tend to agree that precipitation will increase in the winter and spring.

They disagree about how precipitation will change in the summer, because most summer precipitation in the region falls during heavy rain events such as thunderstorms.

Scientists are currently fairly certain that regardless of whether precipitation increases or decreases, more rain will fall during heavy storm events, leaving more dry periods in between.

Other Likely Changes

Higher certainty

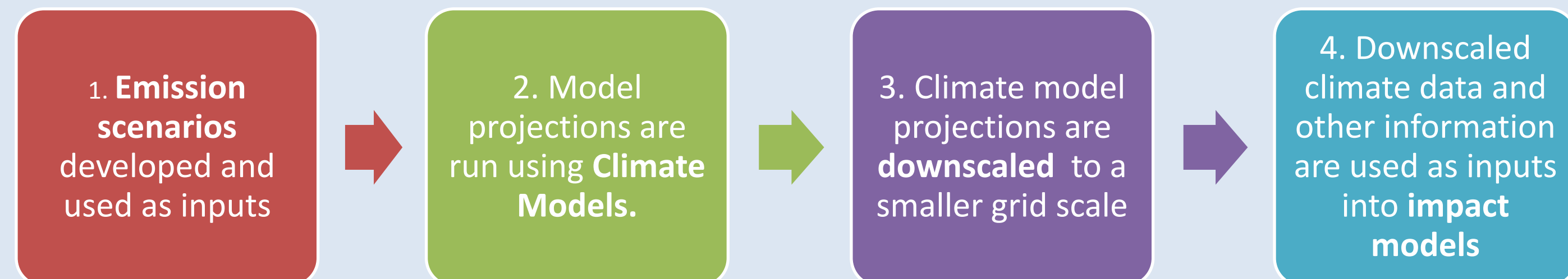
- Less snow and soil frost
- Longer growing seasons
- More heavy precipitation events
- Longer, more regional-scale droughts
- Reduction in soil moisture during summer or fall
- More extreme storms
- Increased flooding
- More winter tornadoes

Lower certainty

Using Models to Understand Forest Change

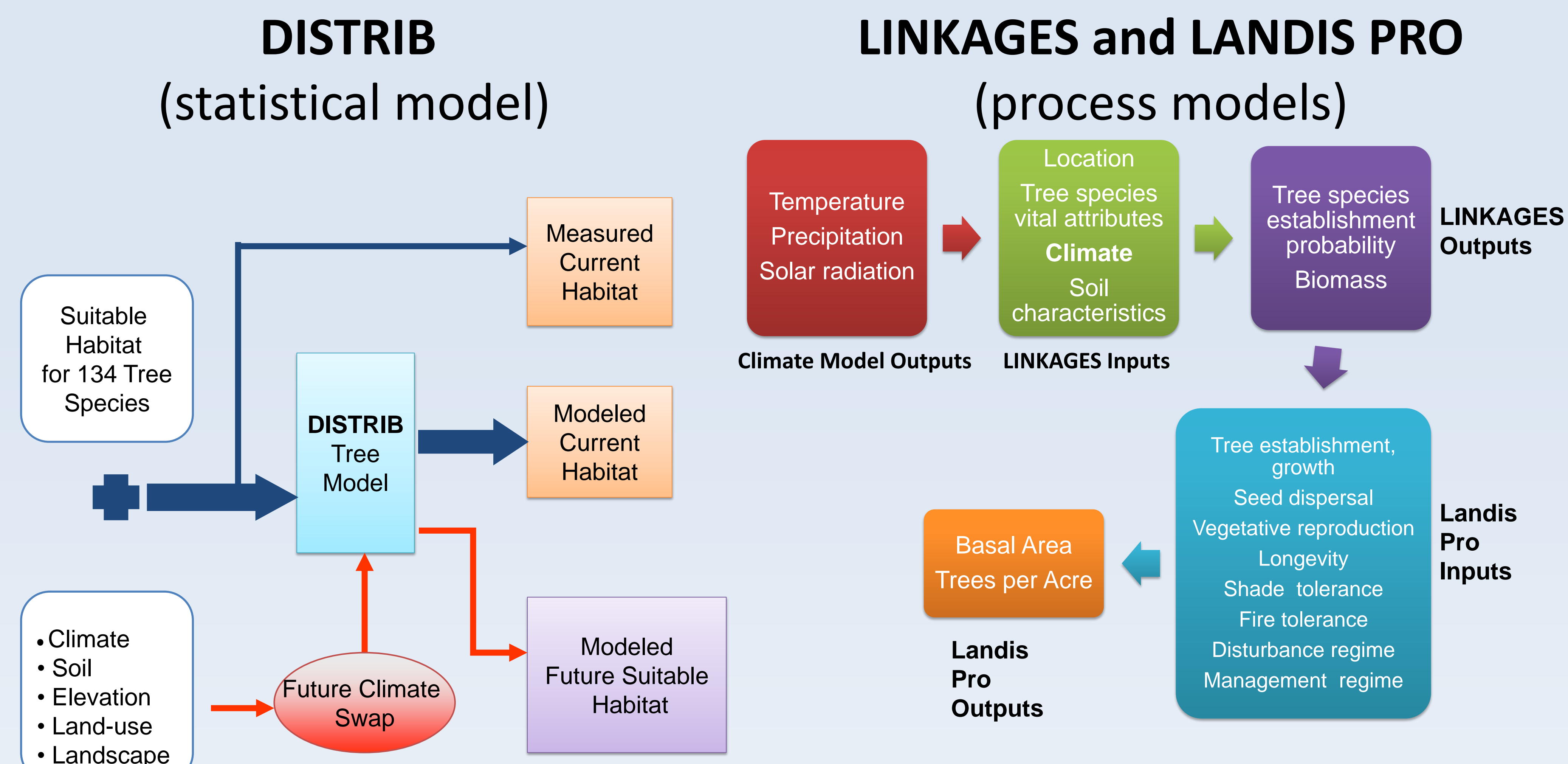
What are forest impact models?

Impact models use future climate data to help us understand changes in forest composition.



Impact models can be divided into two main types:

- **Statistical models** that use relationships between observational data to project future values
- **Process models** that simulate physical and biological processes over time using mathematical representations



- Can model habitat for many species over a large area (134 species across the Eastern US).
- Does not directly account for species migration or response to disturbance.
- Can simulate dispersal, competition, disturbance, and management at very fine resolutions.
- Computationally expensive: only can be done for a few species (19).

What are the strengths and weaknesses of these models?

Strengths:

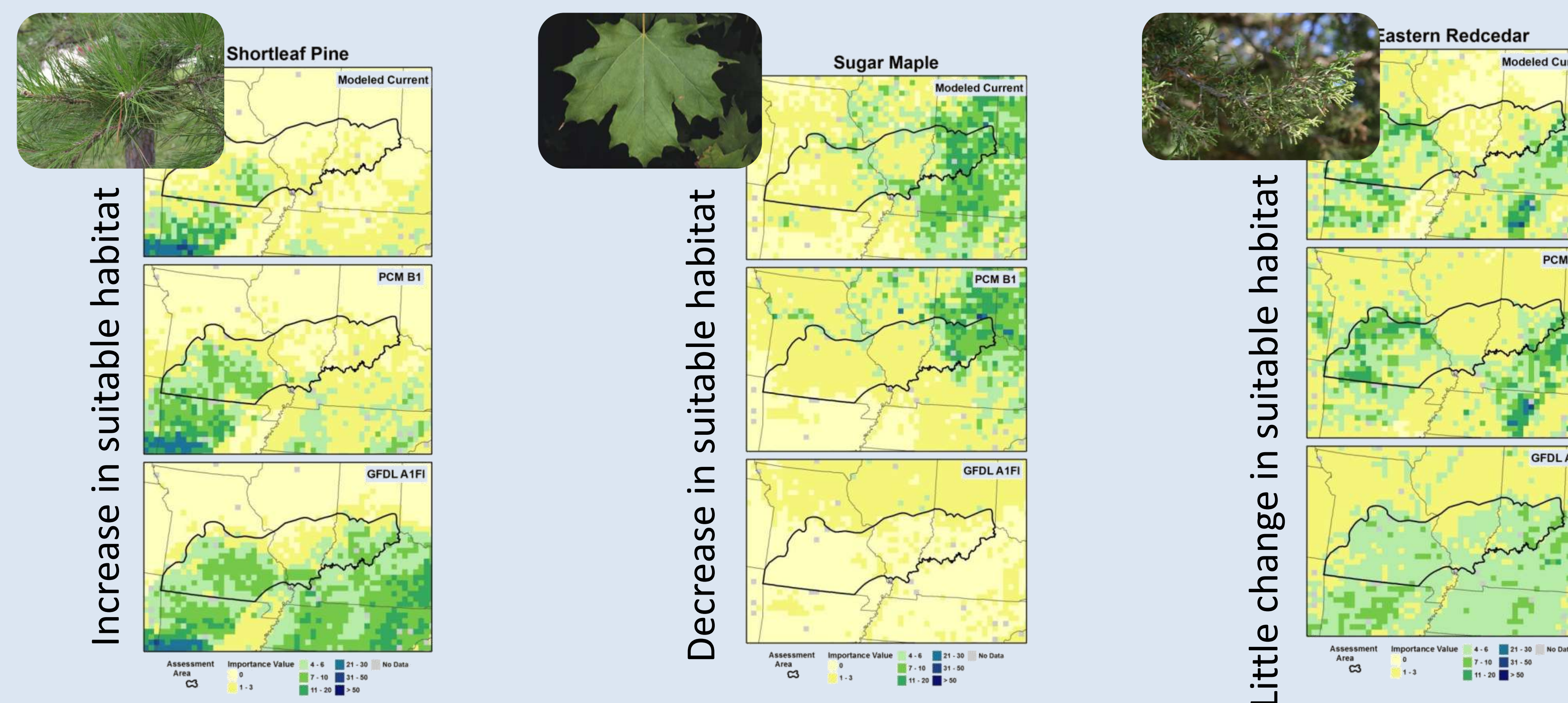
- Both can help us understand how particular species may respond to climate change.
- Both can be useful in helping to make decisions about forest management.

Weaknesses:

- Neither accounts for direct changes in carbon dioxide.
- Neither can simulate all possible interactions between climate and other physical and biological processes, such as changes in forest management, fire, interactions with invasive species, or the impacts of disease.

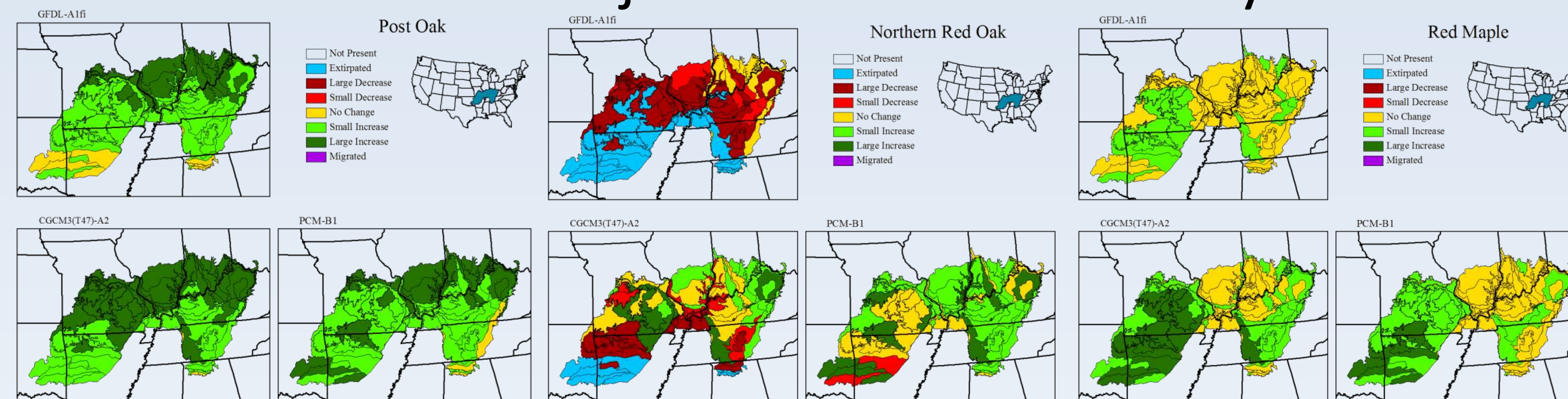
What do the models say about changes in forests in southern Illinois?

DISTRIB Projections: End of Century



Above is just a subset of results from the DISTRIB model. In southern Illinois, suitable habitat was projected to decrease for 12 species, increase for 18 species, and remain stable for 12 species currently on the landscape under both the high and low emissions scenarios. In addition, four species not currently present were projected to have newly suitable habitat. There was disagreement among climate models for 29 species, usually due to one projecting no change and the other projecting a small increase or decrease.

LINKAGES Projections: End of Century



Above is a subset of preliminary results showing potential changes in biomass from the LINKAGES model. The maps show simulated changes in biomass for three model-scenario combinations. The CGCM3(T47)-A2 combination is considered a mid-range scenario between the GFDL A1FI and PCM B1 scenarios. Note that these results are still preliminary. Classes are based on the ratio of (biomass from climate models divided by the biomass from current conditions). For ratio values: <0.4: Large decline; >=0.4 and <0.8: Small decline; >=0.8 and <1.2: No change; >=1.2 and <2.0: Small increase; >=2.0: Large increase; If current condition biomass = 0 and model biomass >0: Migrated; If current condition biomass > 0 and model biomass =0: Extirpated; If current condition biomass = 0 and model biomass = 0: Not present. LANDIS modeling results are still forthcoming.

How readily can species adapt to change?

	Species	Factors that affect rating
highest adaptive capacity	1. red maple	high probability of seedling establishment, wide range of habitats, shade-tolerant, high dispersal ability
	2. boxelder	high probability of seedling establishment, shade-tolerant, high dispersal ability, wide range of temperature tolerances, drought-tolerant
	3. sourwood	shade-tolerant, wide range of habitats
	4. Nuttall oak	wide range of habitats
	5. bur oak	drought-tolerant, fire-tolerant
lowest adaptive capacity	1. pecan	fire-intolerant, susceptibility to insect pests, shade-intolerant
	2. butternut	shade-intolerant, drought intolerant, butternut canker, susceptible to fire topkill
	3. white ash	emerald ash borer, drought-intolerant, susceptible to fire topkill
	4. blue ash	emerald ash borer, drought-intolerant, susceptible to fire topkill, shade-intolerant, narrow habitat range
	5. swamp tupelo	drought-intolerant, susceptible to fire topkill, shade-intolerant, narrow habitat range

Some species have characteristics that will allow them to more readily adapt to changes in climate, such as high dispersal ability, tolerance of disturbances such as drought and flooding, or a lack of specific habitat requirements. These species are said to have a high adaptive capacity.

Other species are relatively intolerant of disturbances or are particularly vulnerable to disease or insect outbreaks. Many of these may also have a narrow range of habitat requirements. These species are said to have a low adaptive capacity.

Find Out More

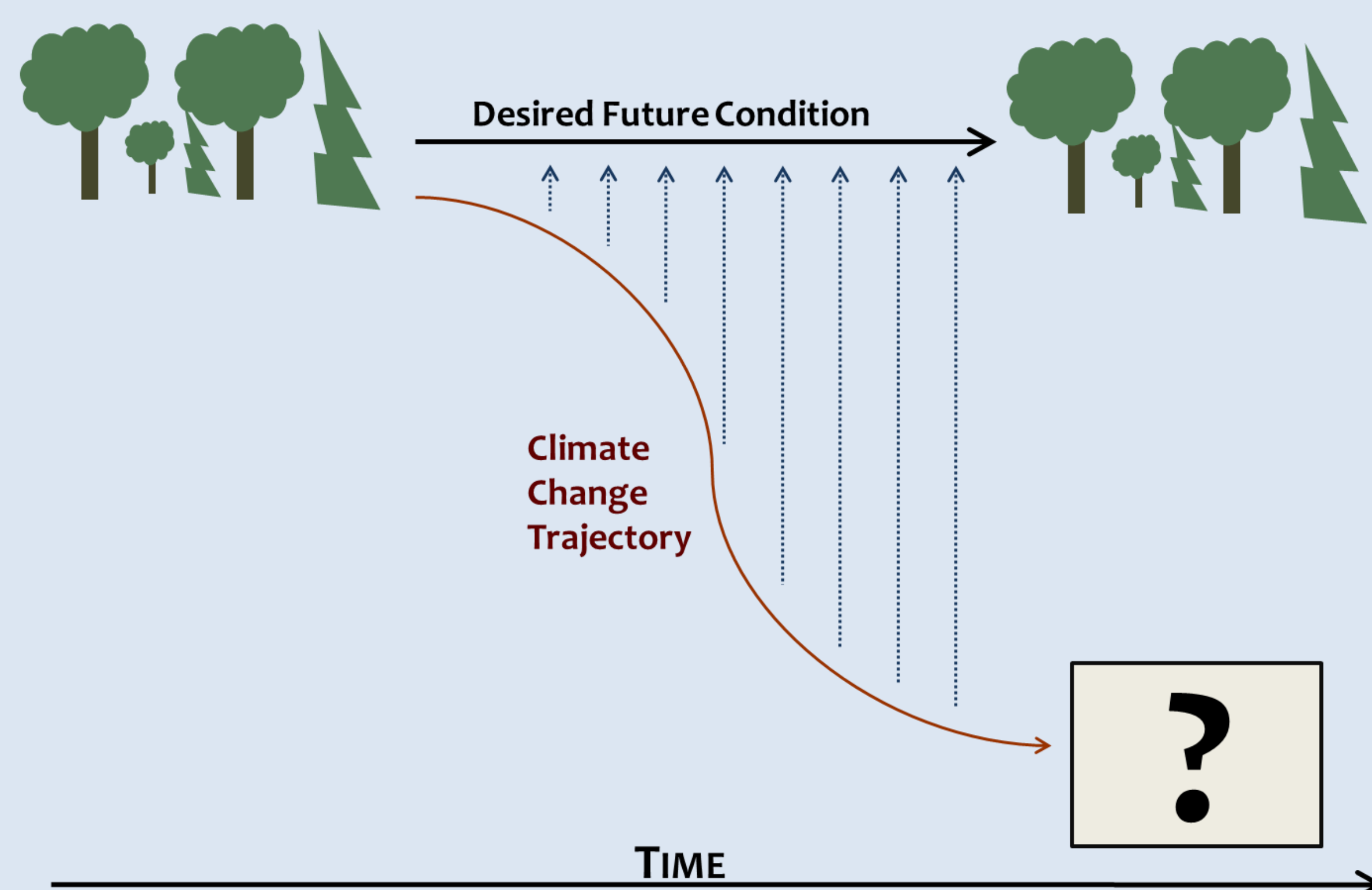
For more information on the DISTRIB results and the factors that contribute to adaptive capacity, visit the Climate Change Atlas: nrs.fs.fed.us/atlas

More information on the ongoing effort using LINKAGES and LANDIS PRO can be found here: nrs.fs.fed.us/disturbance/climate_change/climate_adaptation_strategies

Adapting Forests to Climate Change

Adaptation is the adjustment of human or natural systems in response to climate change. Adaptation actions can be used to reduce or avoid loss of forest cover, declines in forest productivity, alterations to ecosystem processes, reductions in the environmental benefits that forests provide to people (such as wildlife, recreation, and wood products), and many other potential impacts on forests. There are three broad categories of actions:

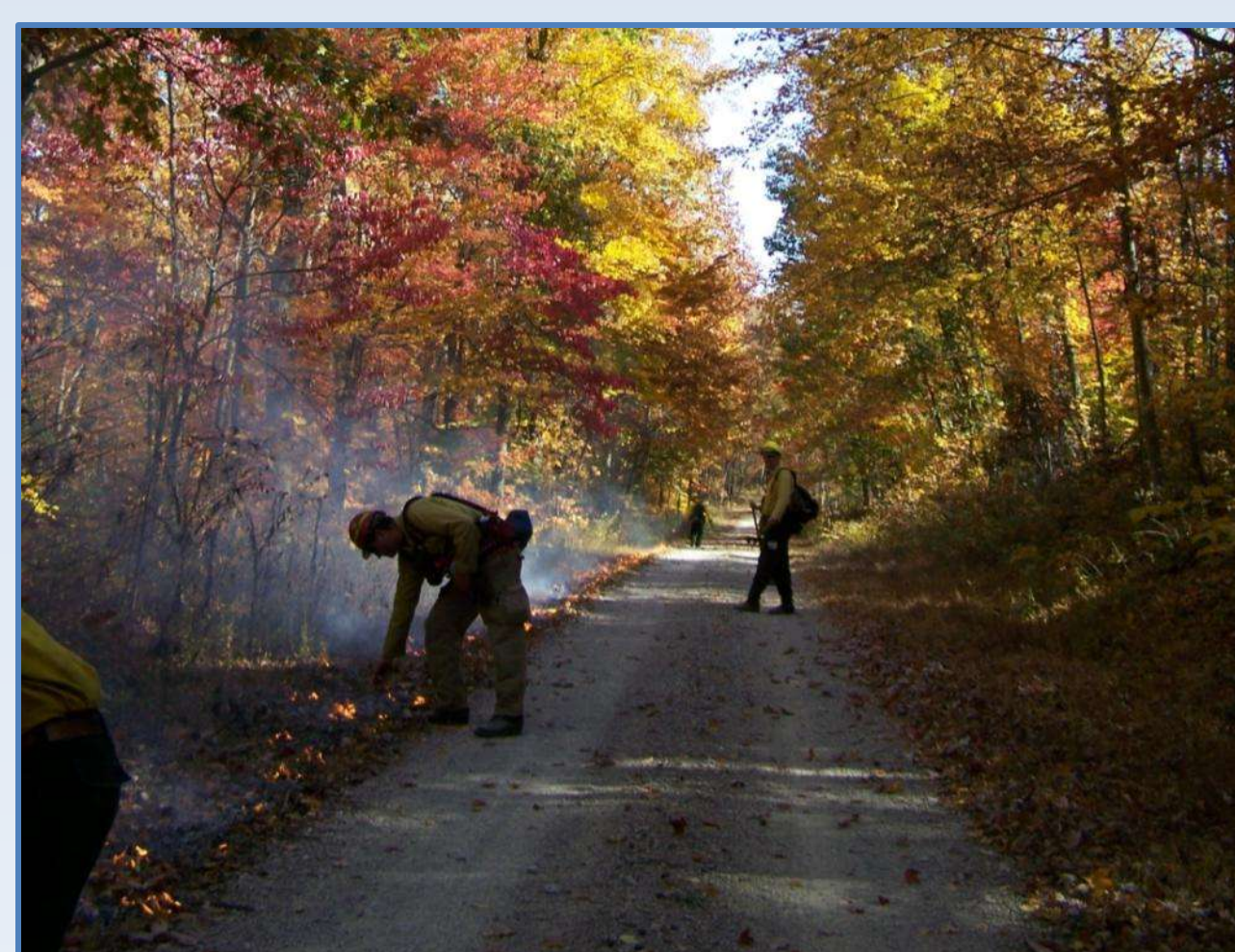
Resistance



Improve the defenses of the forest against effects of change.

Examples

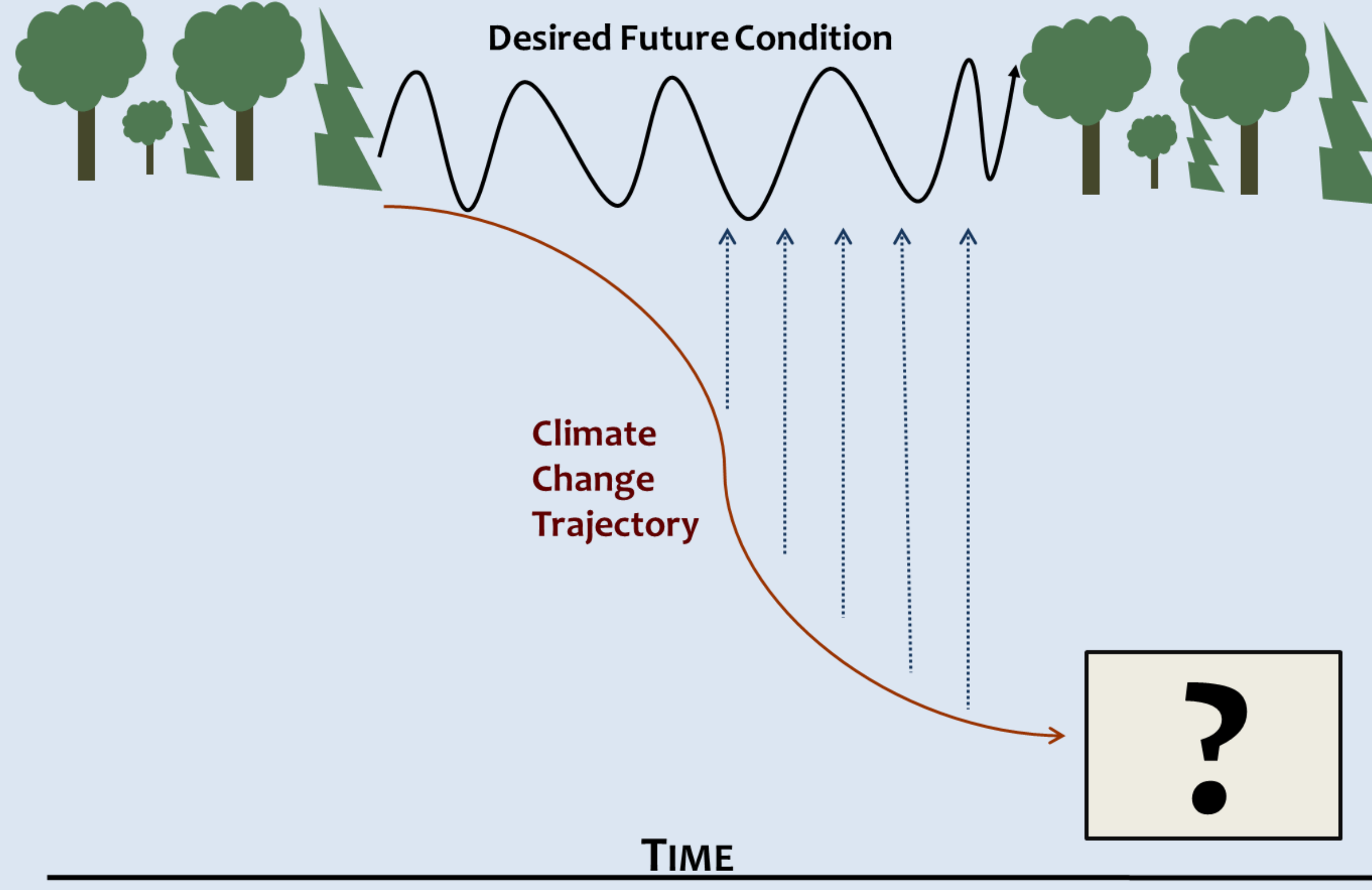
Installing fuelbreaks to prevent the spread of fire.



Preventing the spread of invasive species, pests, diseases.



Resilience



Accommodate gradual change, usually returning to a prior condition after disturbance.

Examples

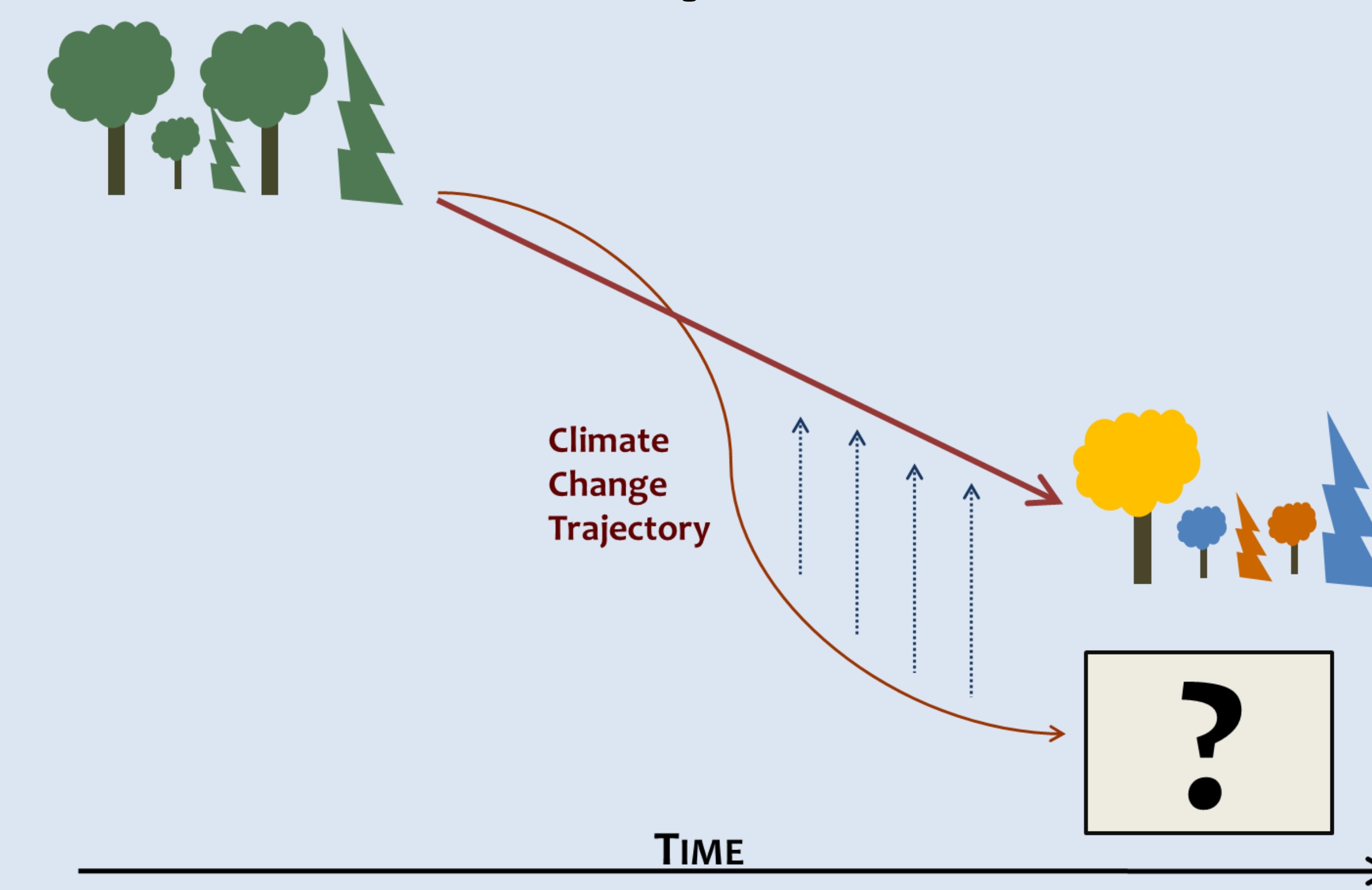
Conducting prescribed burns and thinning.



Removing dead/dying trees following a pest outbreak.



Response



Intentionally accommodate change, enabling ecosystems to adaptively respond

Examples

Planting a mix of species that are most likely to do well under projected change.

Planting seeds/seedlings of genotypes from one seed zone south.

Planting /relocating species that currently reside south of the area (CAUTION).



Increasing connectivity for migration.

Find out more

Basics of forest adaptation:

- Climate Change Response Framework (forestadaptation.org/our-approach/what-is-adaptation)
- Climate Change Resource Center (fs.fed.us/ccrc/mgmt_options)
- EPA Impacts and Adaptation (epa.gov/climatechange/impacts-adaptation/forests.html#adapt)

Tools to aid in forest adaptation decisions:

- Forest adaptation resources: Climate change tools and approaches for land managers (treesearch.fs.fed.us/pubs/40543)
- Seedlot selection tool (sst.forestry.oregonstate.edu)
- TACCIMO: Template for Assessing Climate Change Impacts and Management Options (sgcp.ncsu.edu:8090)

Reducing Our Carbon Footprint

The average person in the United States releases the equivalent of about 17 metric tons of carbon dioxide into the atmosphere each year

(source: Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory,).

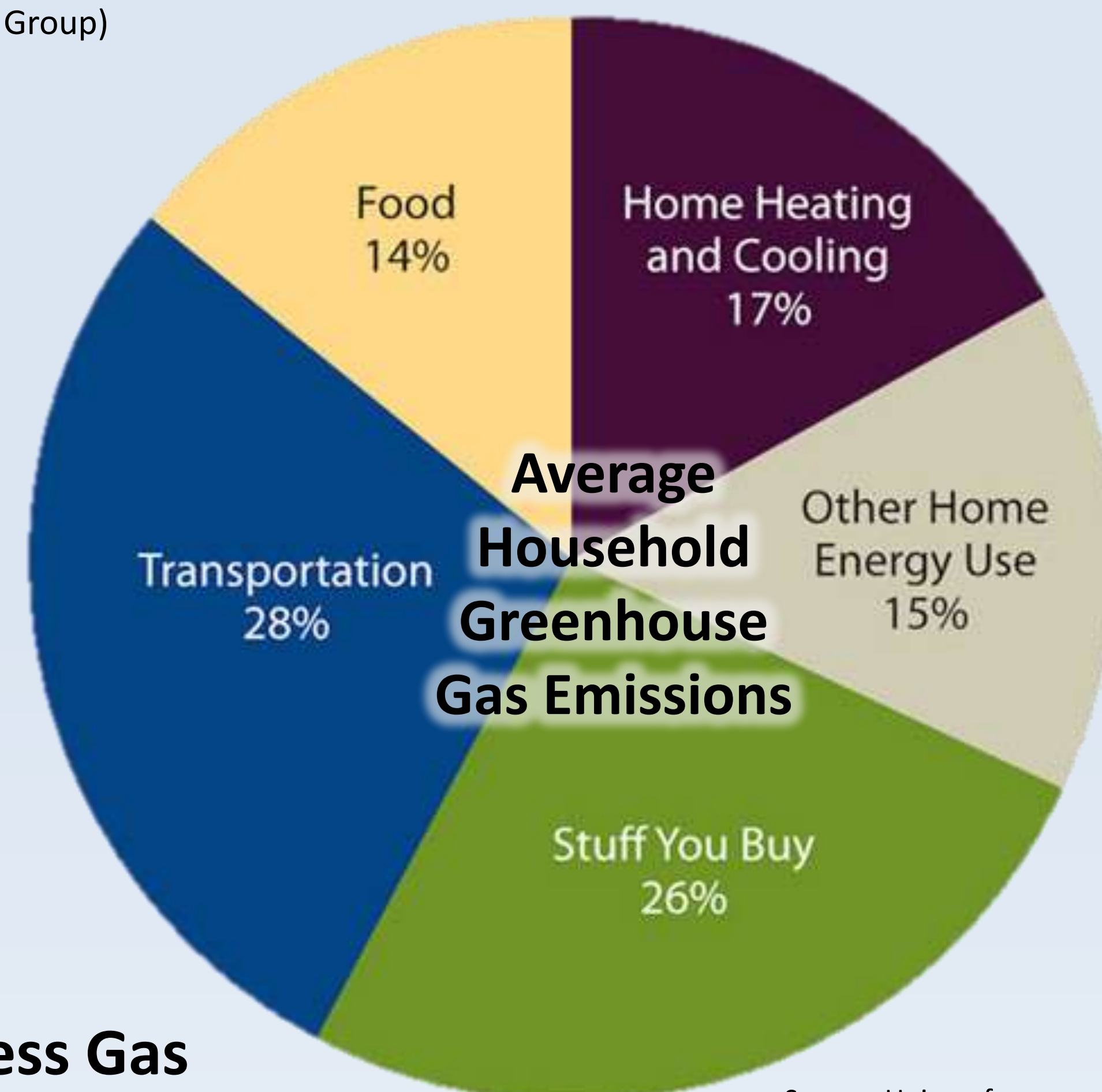
What Can You Do?

Eat Less Meat and Cheese

You don't need to be a vegetarian, but consider cutting back on some of the most energy-intensive foods, such as lamb, beef, and cheese. If a four-person family skips meat and cheese one day a week, it's like taking your car off the road for five weeks. (Source: Environmental Working Group)

Get a Home Energy Audit

A professional energy audit gives you a thorough picture of where your home is losing energy and what you can do to save money, and thus greenhouse gas emissions. You can save 5%-30% on your energy bill by making upgrades following a home energy assessment. (Source: US Dept. of Energy)



Use Less Gas

Cut back on vehicle use by biking, carpooling, and making fewer trips whenever possible. If you must drive, make sure your vehicle is in good conditions and your tires are properly inflated and consider buying a more fuel-efficient vehicle for your next purchase.

Source: Union of Concerned Scientists

Use Energy-efficient Lighting

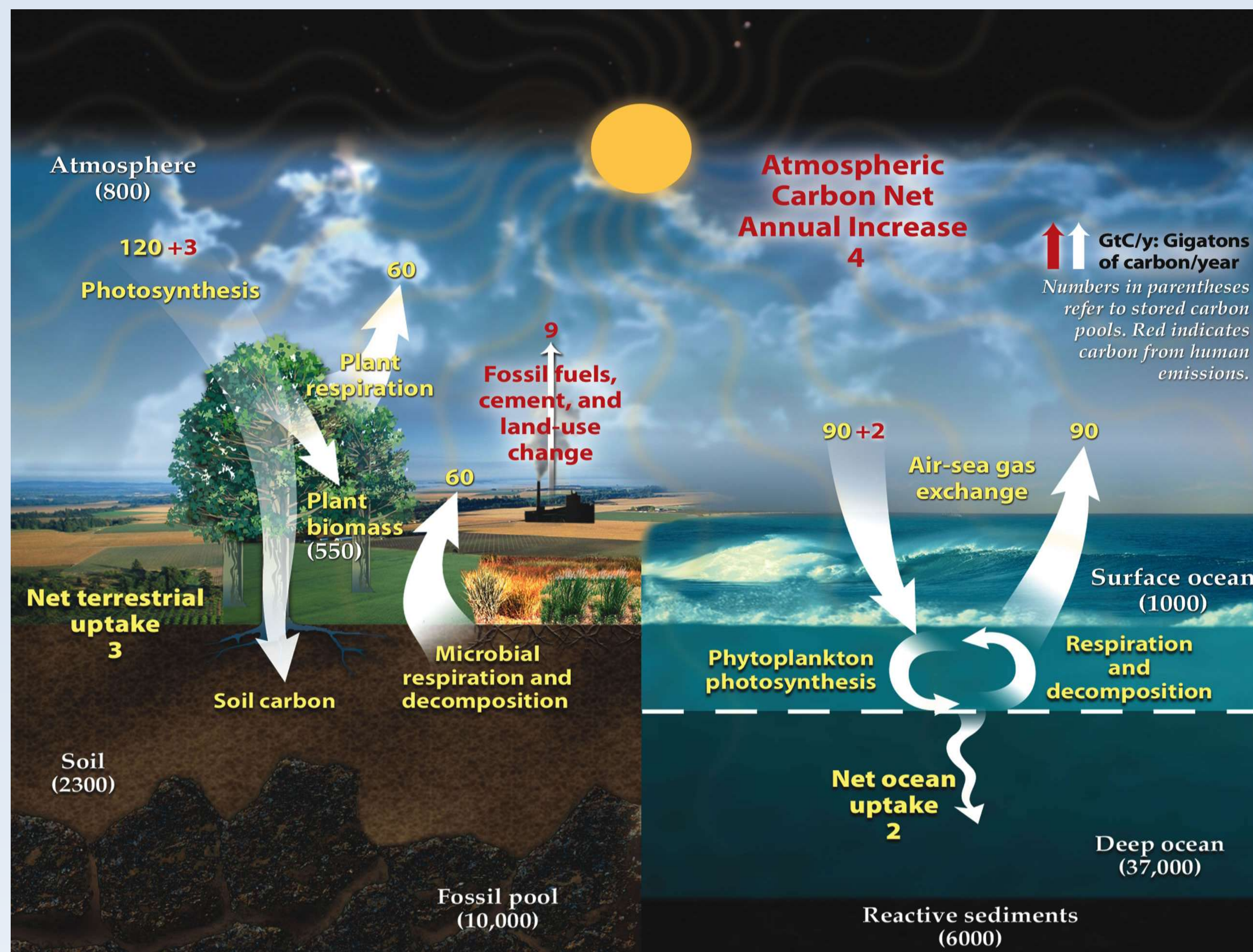
If every American home replaced just one light bulb with a light bulb that's earned the ENERGY STAR, we would save about \$600 million in annual energy costs, and prevent 9 billion pounds of greenhouse gas emissions per year, equivalent to those from about 800,000 cars. (Source: US EPA)

Reduce, Reuse, Recycle

Reducing, reusing, and recycling in your home helps conserve energy and reduces pollution and greenhouse gas emissions from resource extraction, manufacturing, and disposal. If there is a recycling program in your community, recycle your newspapers, beverage containers, paper, and other goods. Also, composting your food and yard waste reduces the amount of garbage that you send to landfills and reduces greenhouse gas emissions.

The Carbon Cycle

Carbon dioxide (CO₂) accounts for about 84% of all U.S. greenhouse gas emissions from human activities. Carbon dioxide is naturally present in the atmosphere as part of the Earth's carbon cycle. Human activities are altering the carbon cycle—both by adding more CO₂ to the atmosphere and by influencing the ability of natural sinks, like forests, to remove CO₂ from the atmosphere.



U.S. DOE. 2008. Carbon Cycling and Biosequestration: Integrating Biology and Climate Through Systems Science; Report from the March 2008 Workshop, DOE/SC-108, U.S. Department of Energy Office of Science (genomicscience.energy.gov/carboncycle/).

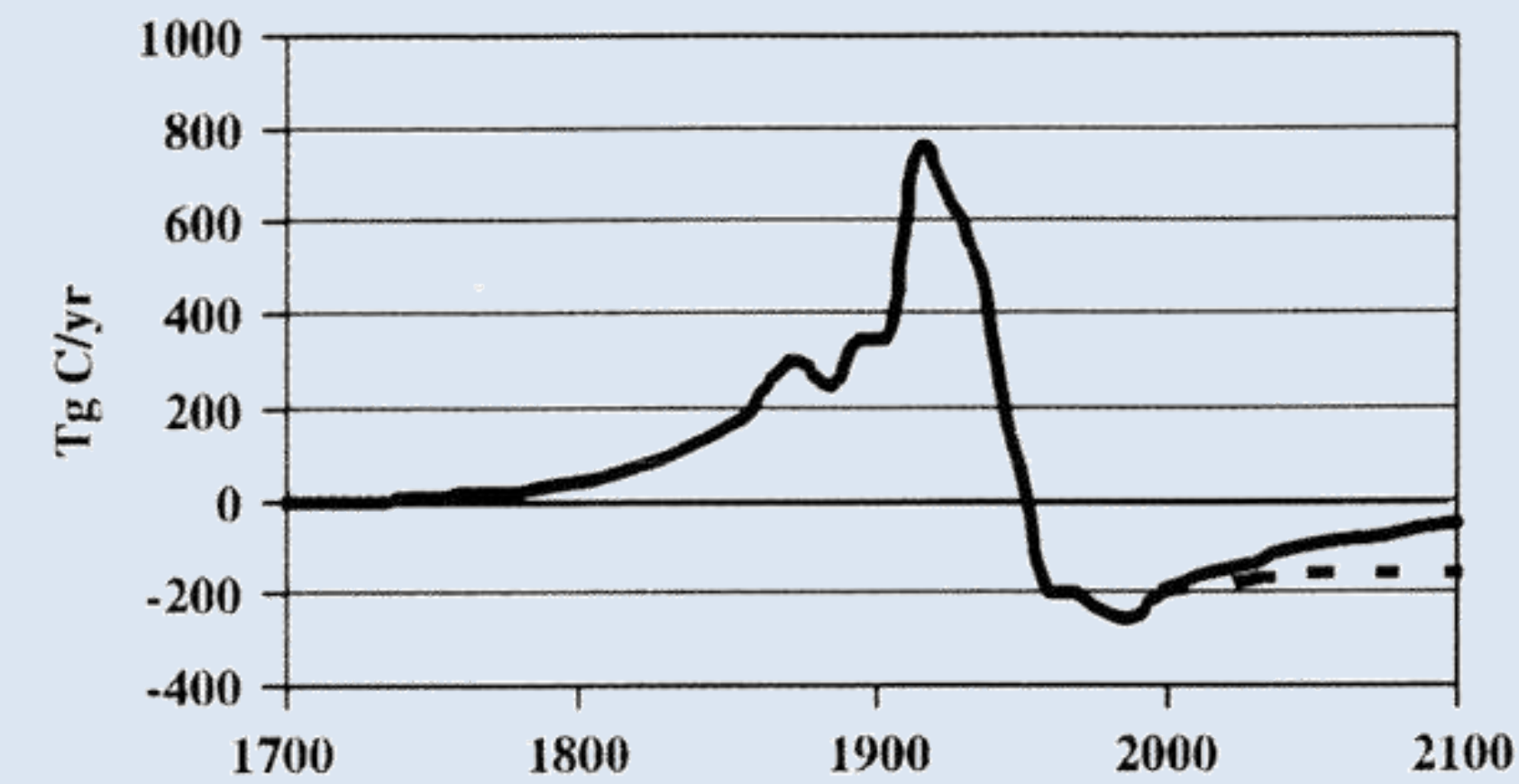
What Role Do Forests Play?

Forests in the U.S. currently offset approximately 16% of U.S. emissions from burning fossil fuels.

While individual trees or tracts release some or all of their carbon if harvested, burned, or otherwise disturbed, subsequent forest regrowth will take in carbon from the atmosphere.

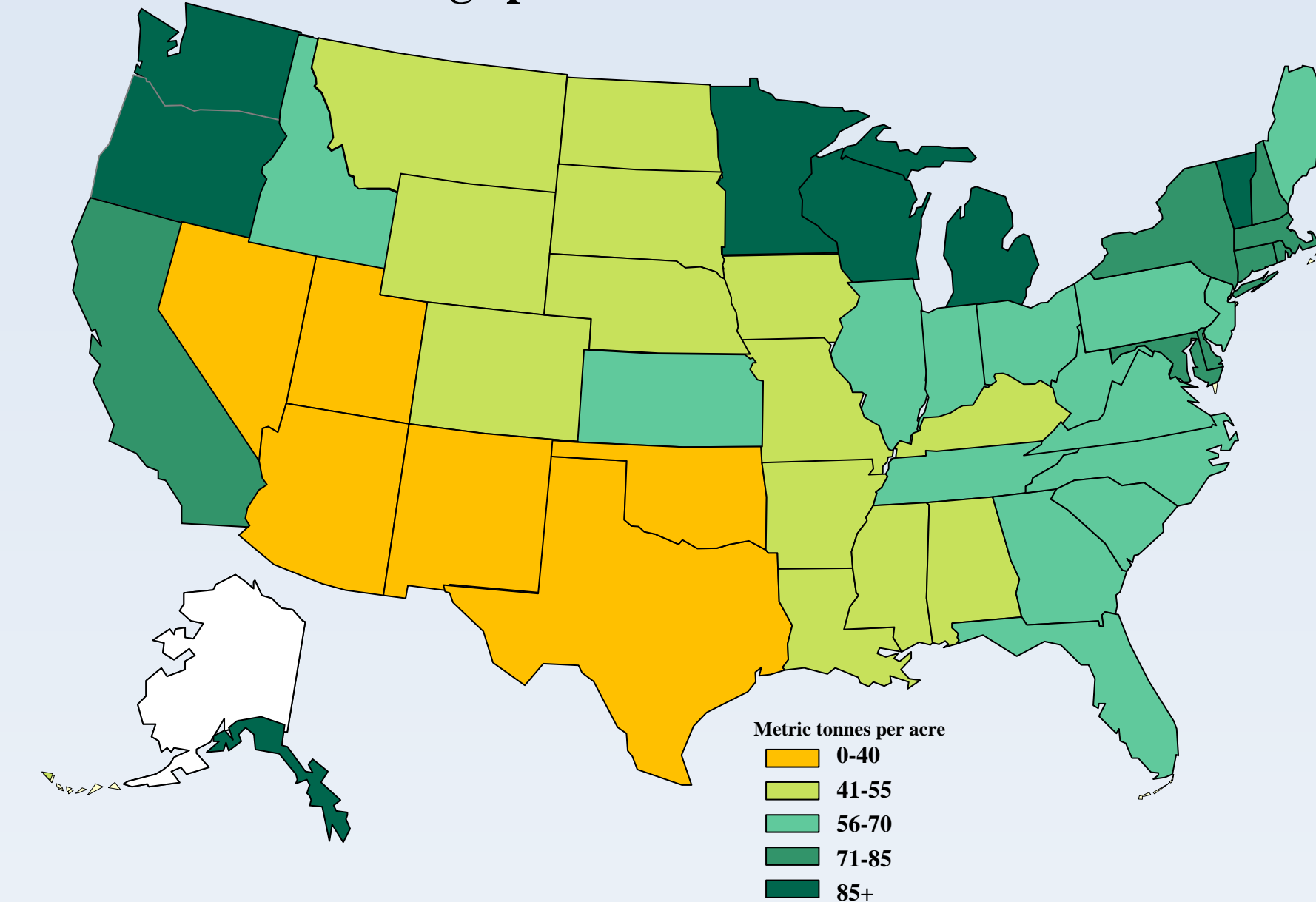
Forested landscapes tend to include a mix of disturbed and re-growing forest stands, and have a carbon balance of near zero over the medium and longer term.

Our large carbon "sink" today is a legacy of harvesting and forest conversion that took place in the past. These disturbances released CO₂ into the atmosphere decades ago, and the re-growing forests are recovering some of that released CO₂ on land that has not been permanently converted to non-forest cover.



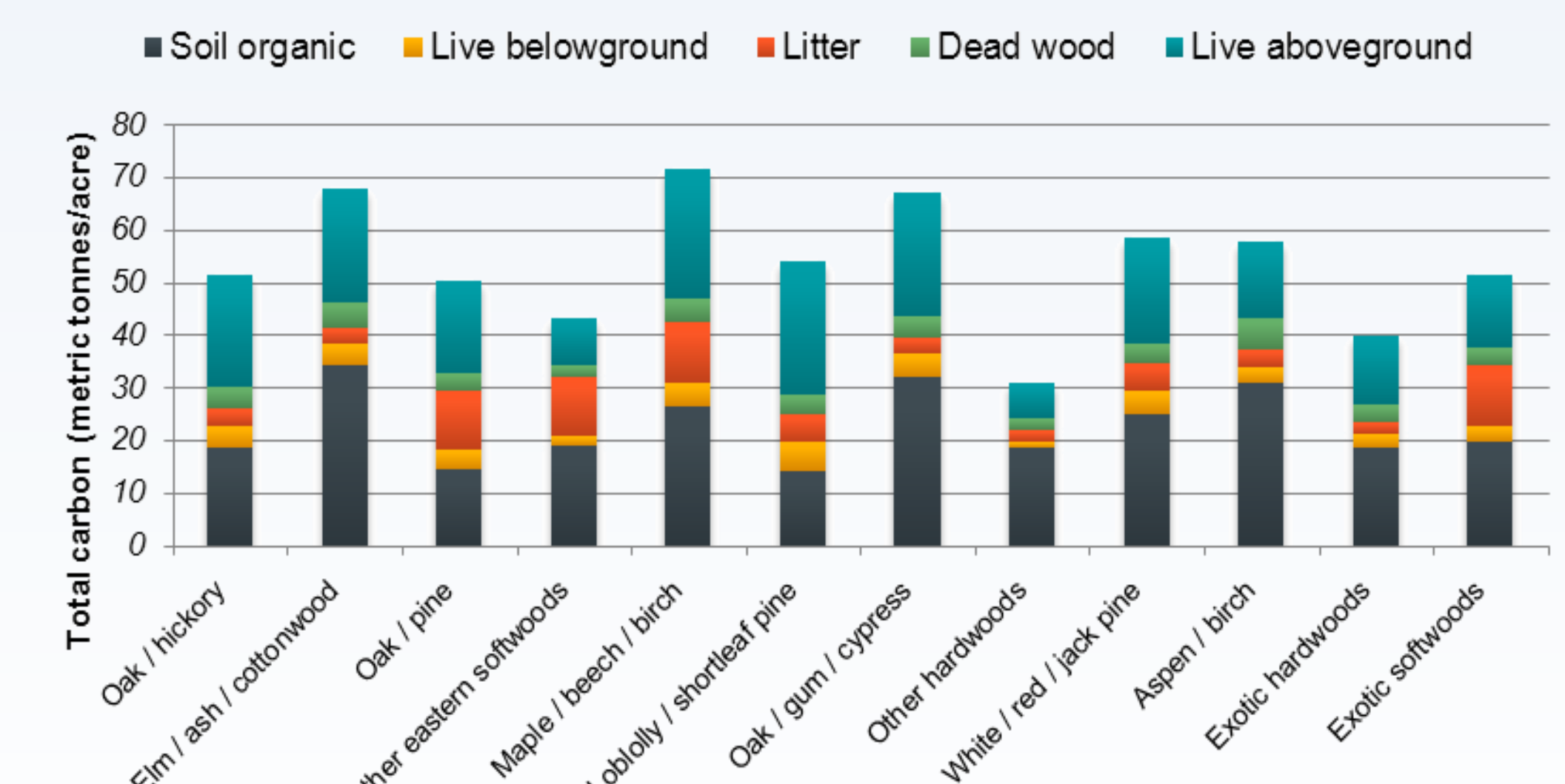
Carbon balance of a U.S. forest sector in millions of metric tons of carbon per year. The solid line represents a continuation of current trends. The dashed line represents the potential for storage if dramatic changes in policy are made (From Birdsey et al, 2006).

Average per acre carbon in forests in the U.S.



Forests across the United States vary in how much carbon they store per unit area (i.e. their "carbon density"). In general, forests in the Pacific Northwest and the Northern Great Lakes are the most carbon-dense.

Forests in southern Illinois and the surrounding Central Hardwoods region store on average 30-70 metric tonnes of carbon per acre. This varies by forest type, forest age, and other factors. Oak-hickory forests, which make up the majority of forest land in the area, store a little over 50 metric tonnes per acre. Forests vary in where the carbon is stored, with some storing more in soil and some more in aboveground biomass (stems, trunks, leaves).



Find Out More

Free Carbon Footprint Calculators:

- www.nature.org/greenliving/carboncalculator
- www.epa.gov/climatechange/ghgemissions/ind-calculator.html

More about Carbon and Forests:

- www.fs.fed.us/ccrc/topics/forests-carbon
- www.esa.org/science_resources/issues/FileEnglish/issue13.pdf