CARBON AND CLIMATE CHANGE

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WEATHER VS. CLIMATE

Weather – state of the atmosphere **with respect to heat or cold, wetness or dryness, calm or storm, clearness or cloudiness;** short-term

Climate – statistical collection of weather conditions **at a place over a period of years;** long-term

"Climate is what you expect. Weather is what you get."

CLIMATE

- Cordova, AK
- Average January high = 26°F

- Miami, FL
- Average January high = 76°F

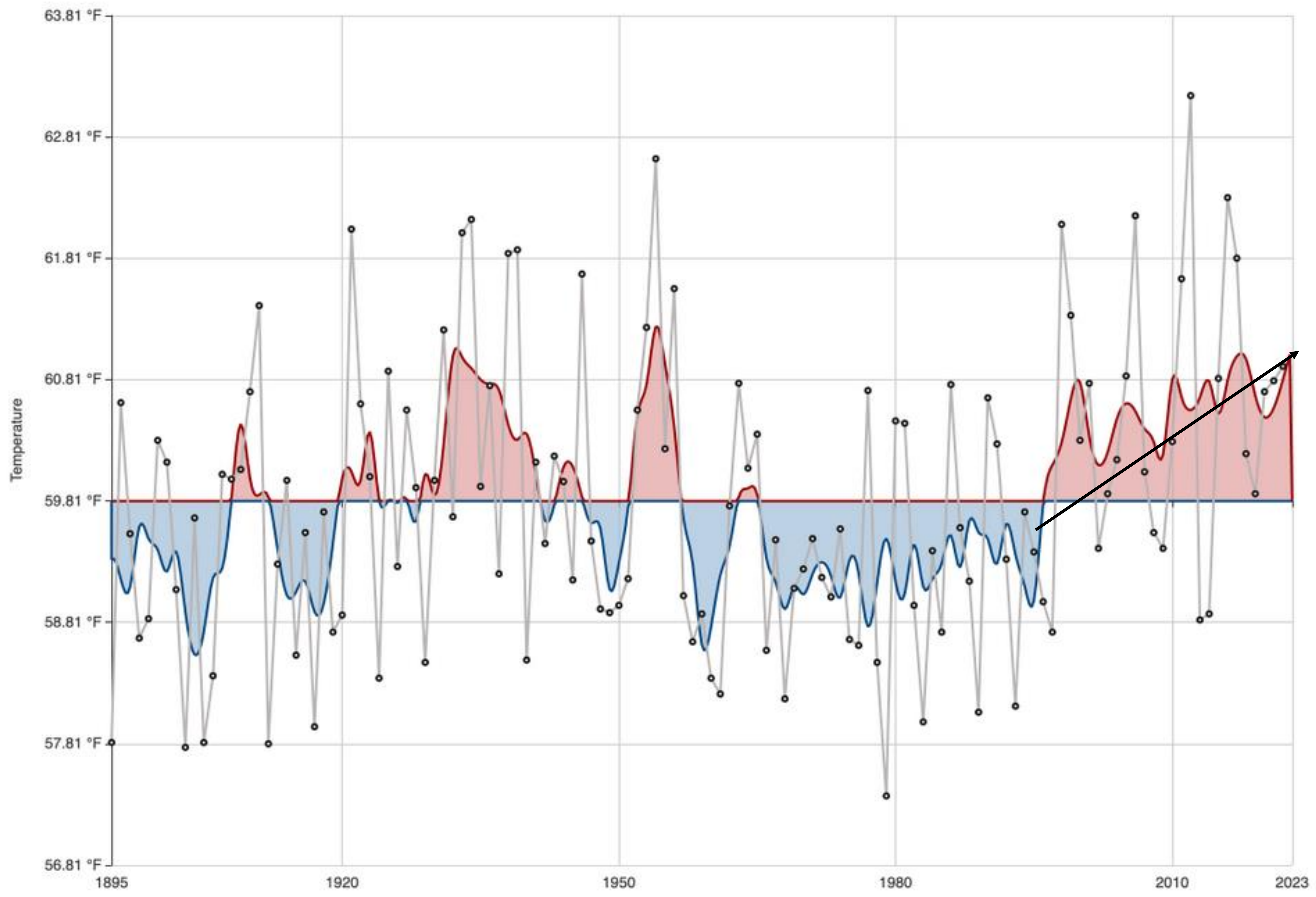
CLIMATE VARIABILITY

- Variations around a mean (average, normal)
- Day-to-Day changes (weather)
- Seasonal changes
- Year-to-Year Changes

➢ Over time these average out to something about the middle, which we call climate

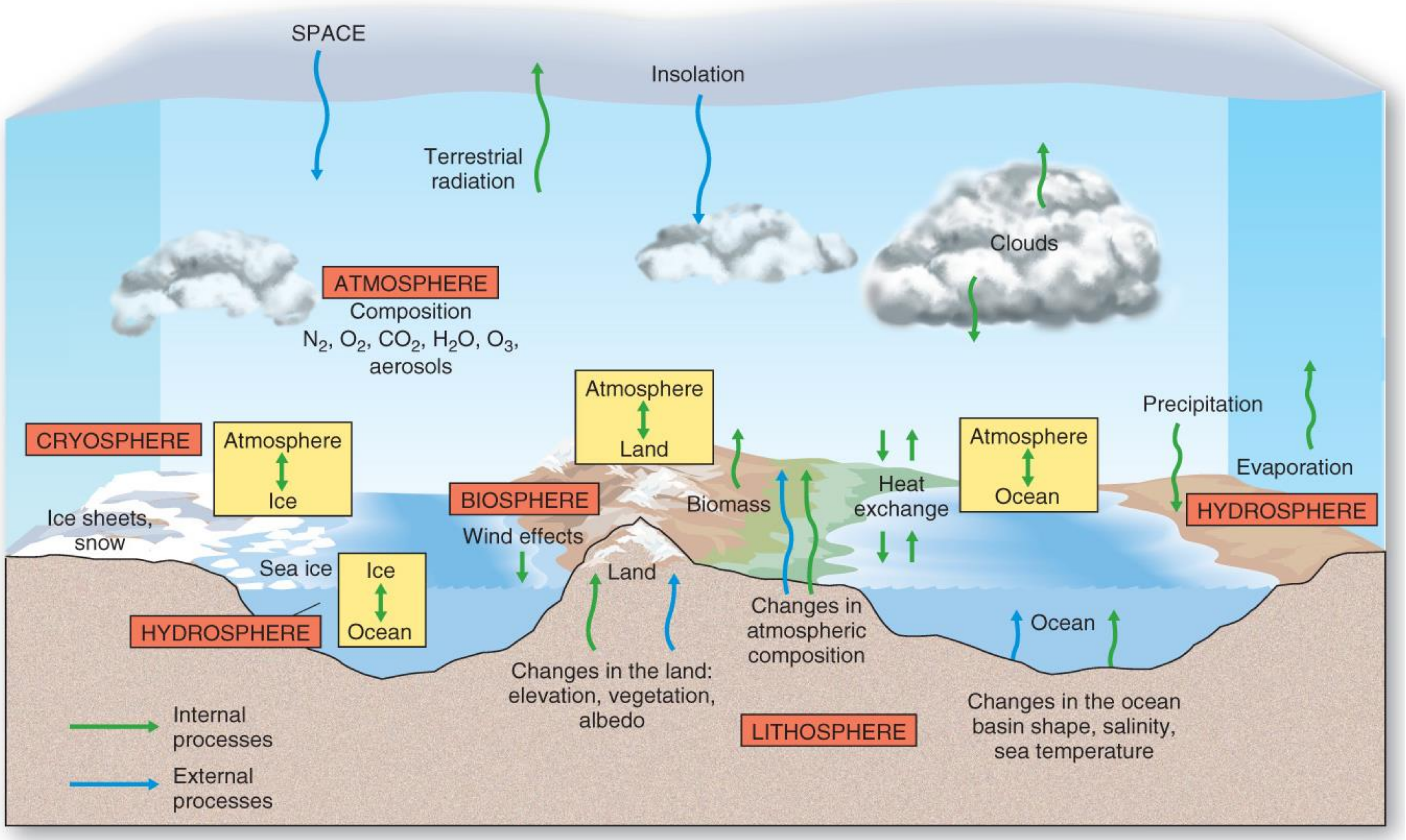
  - Average all the October 18th's together and you come up with a high of 73 degrees

OKLAHOMA ANNUAL TEMPERATURE (1895 -2022)



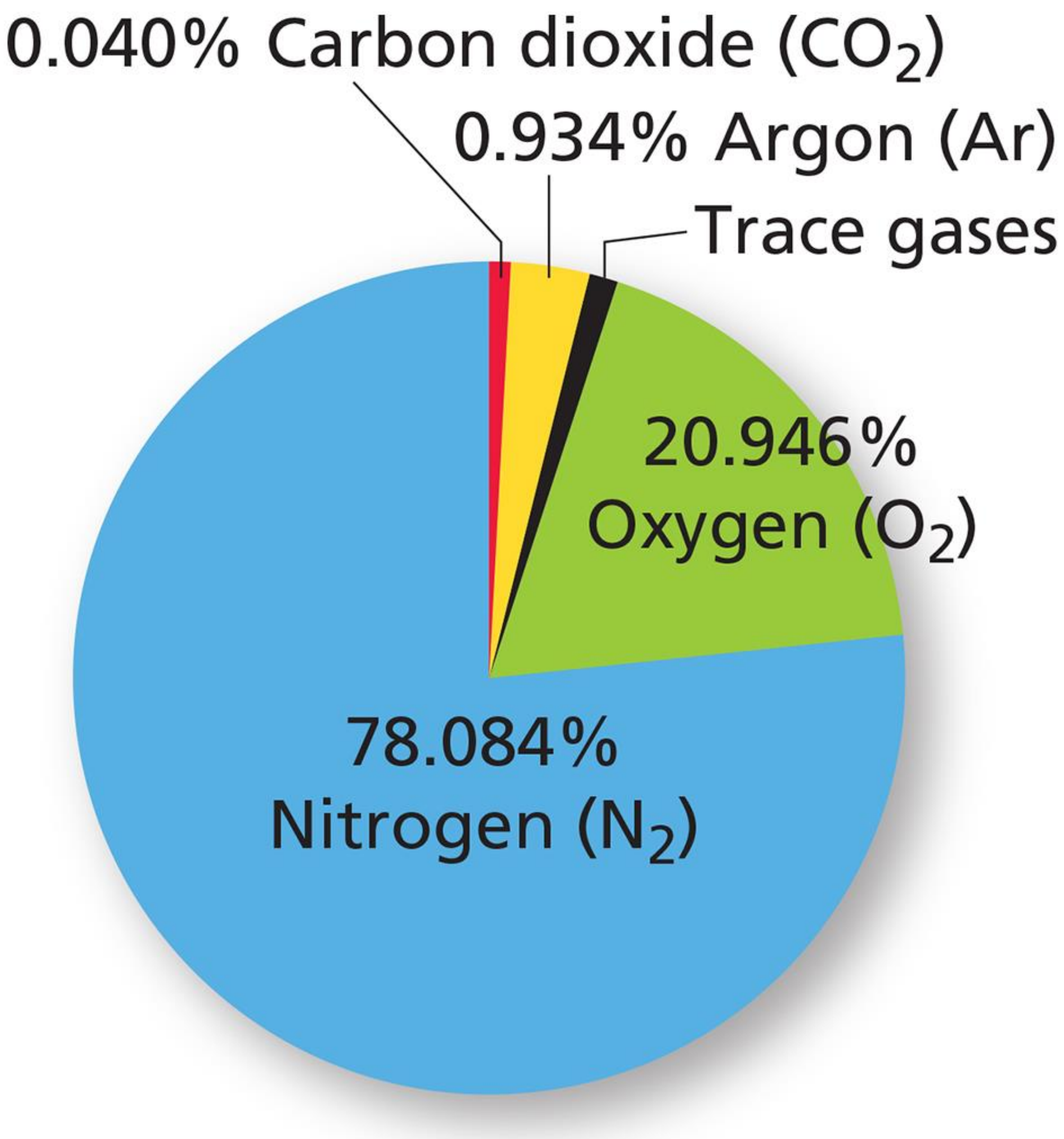
- Climate is still variable – the same ups and downs around the average
- But the average changes over time
- Charts show a slope from left-to-right
- It's often very difficult to detect changes, especially over short times
- It's very difficult to attribute events to climate change, especially in places of high variability
- Even identifying a change does not tell you the causes

EARTH’S CLIMATE SYSTEM



GASES OF OUR ATMOSPHERE

Gas	Symbol	Content
Nitrogen	N_2	78.084%
Oxygen	O_2	20.947%
Water Vapor	H_2O	0–4%
Argon	Ar	0.934%
Carbon Dioxide	CO_2	0.0360%
Neon	Ne	0.0018%
Helium	He	0.0005%
Methane	CH_4	0.00017%
Hydrogen	H_2	0.00005%
Nitrous Oxide	N_2O	0.00003%
Ozone	O_3	0.000004%



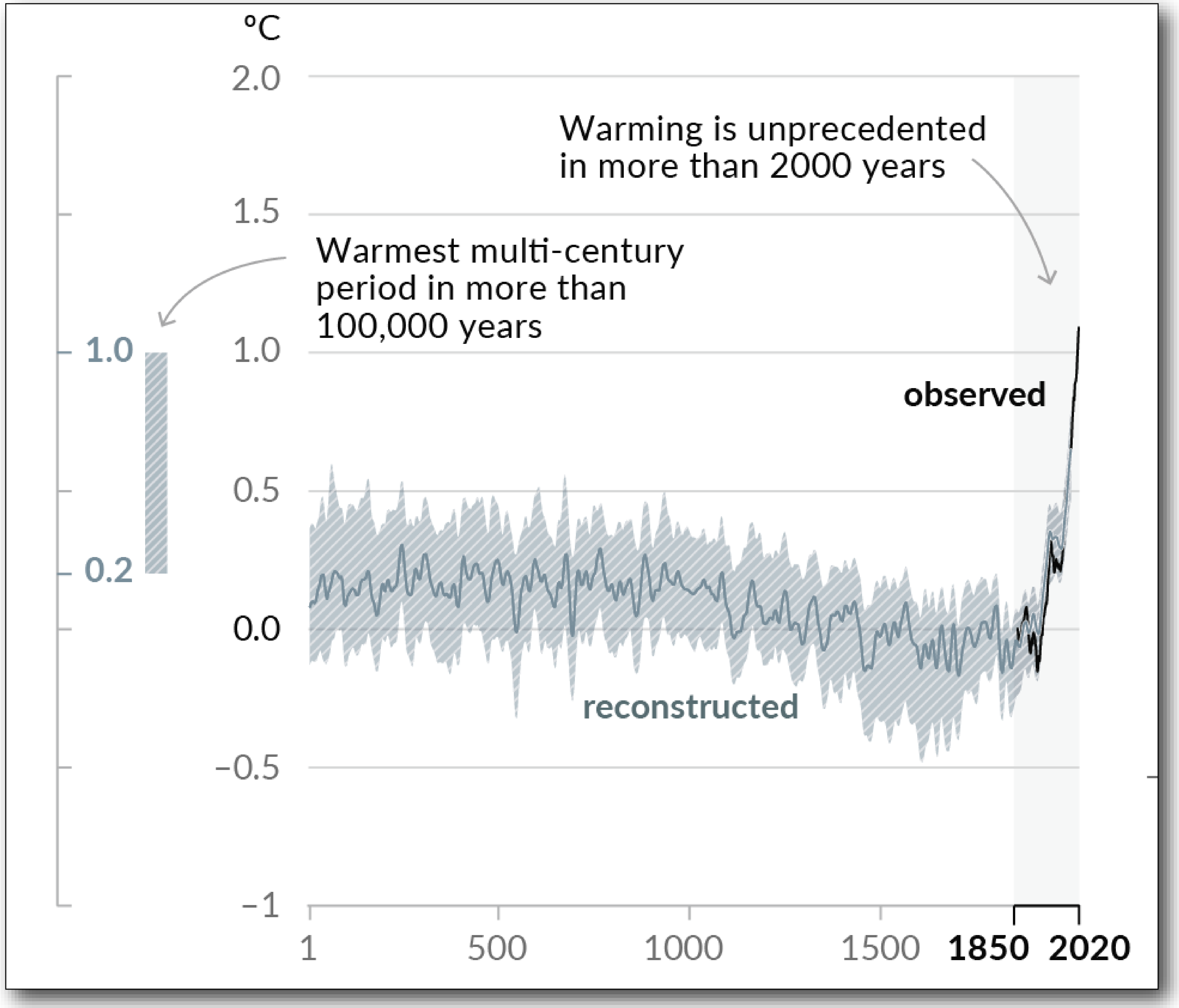
KEY POINTS

The global climate system is complex and interconnected. What happens in one part of the world eventually affects other areas.

Although we must focus on our region for decision making, it's a good practice to remember the bigger picture from time to time, as changes elsewhere may ultimately have a great impact here.

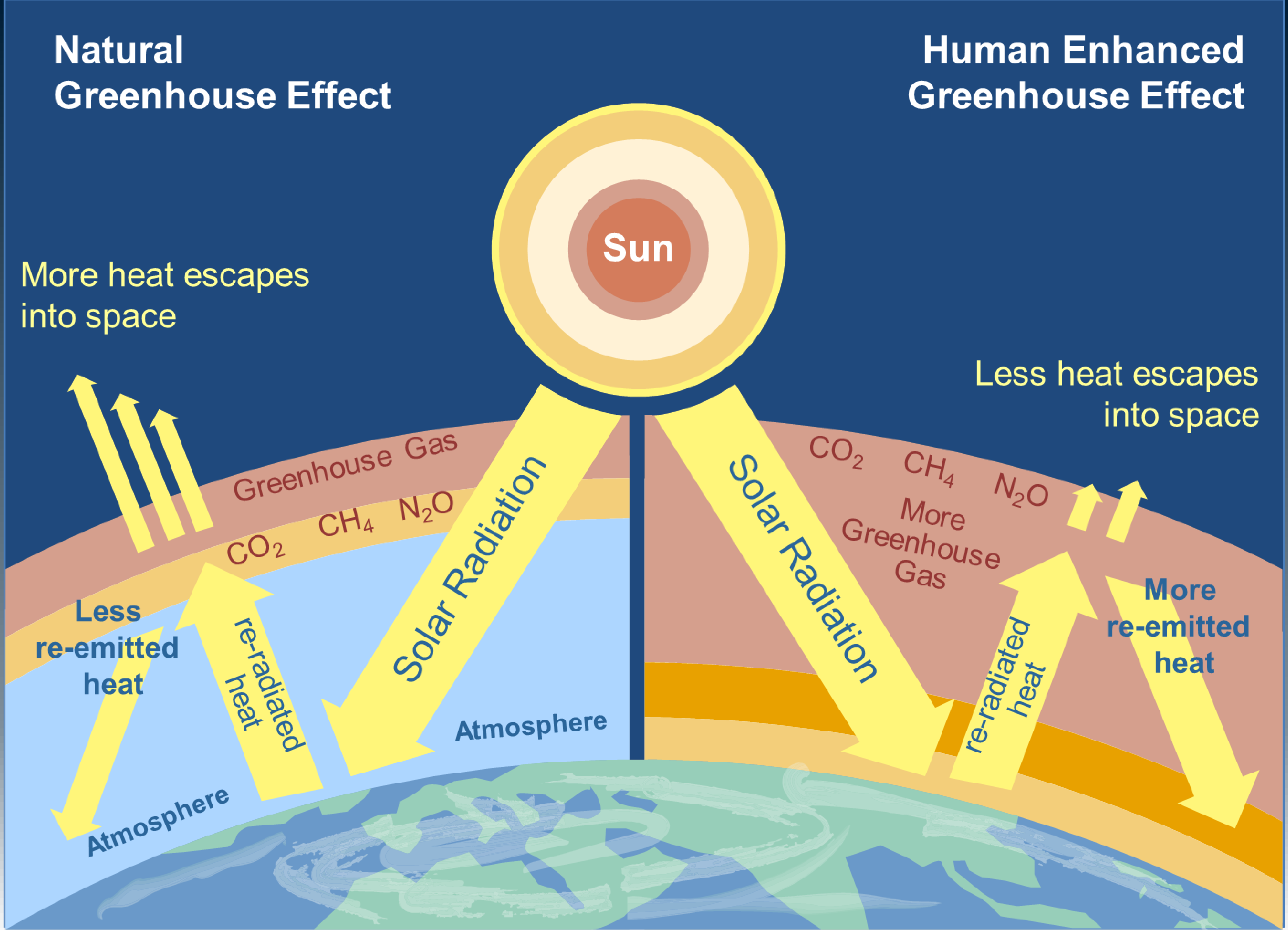
The South Central CASC and your state climate office can help you access and interpret climate information

CHANGE IN GLOBAL SURFACE TEMP.



Changes in global surface temperature reconstructed from paleoclimate archives (solid grey line, years 1–2000) **and from direct observations** (solid black line, 1850–2020), both **relative to 1850–1900 and decadally averaged**

Figure SPM.1 in IPCC, 2021: Summary for Policymakers. In: Climate Change 2021



Natural
Greenhouse Effect
Human Enhanced
Greenhouse Effect
Sun
More heat escapes
into space
Less heat escapes
into space
Greenhouse Gas
CO_2
CH_4
N_2O
Solar Radiation
Solar Radiation
CO_2
CH_4
N_2O
More
Greenhouse
Gas
Less
re-emitted
heat
re-radiated
heat
re-radiated
heat
More
re-emitted
heat
Atmosphere
Atmosphere

We’ve Known This Fact for More Than 150 Years

“… an atmosphere of that gas would give to our earth a high temperature ...”
— Eunice Newton Foote, 1856

ART. XXXI.—*Circumstances affecting the Heat of the Sun’s Rays;* by EUNICE FOOTE.

(Read before the American Association, August 23d, 1856.)

“Doubling of CO_2 would raise surface temperature by 5-6°C, or 9-11°F, above pre-industrial temperatures.”
— Svante Arrhenius,1896

“The atmosphere admits of the entrance of the solar heat, but checks its exit; and the **result is a tendency to accumulate heat at the surface of the planet.**”
— John Tyndall, 1859

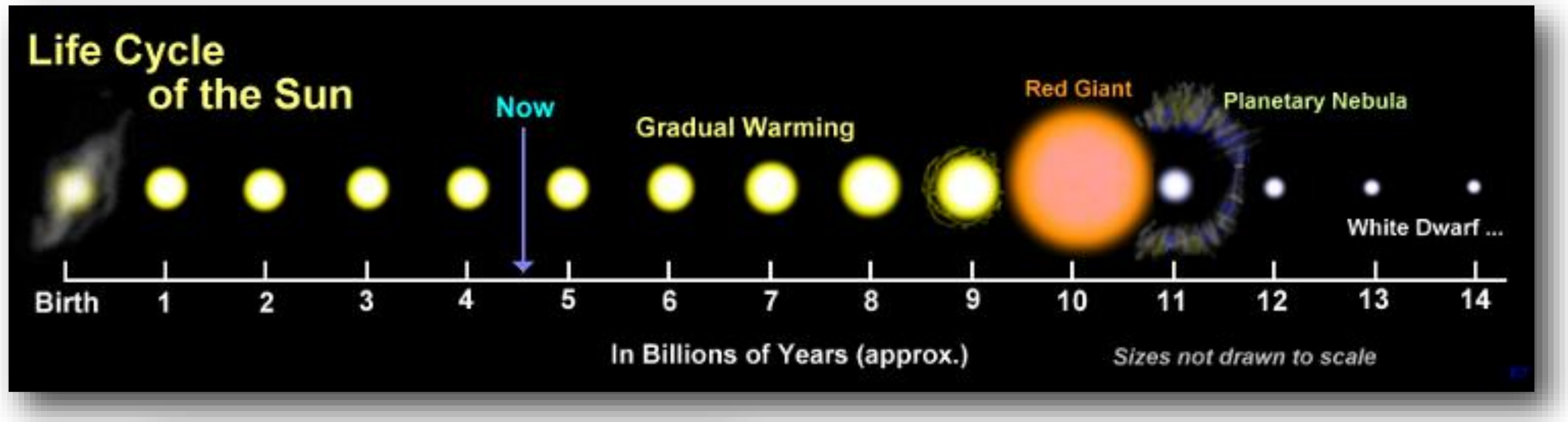
KEY POINT

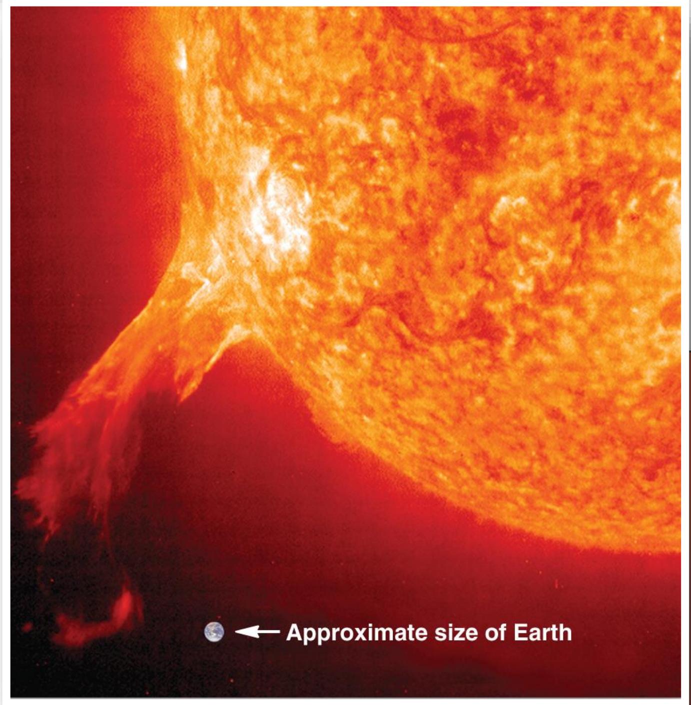
Greenhouse gases are necessary **for Earth to be livable,** but adding too much into the atmosphere will disrupt **the long-term energy balance,** increasing the thermal energy **in the atmosphere.**

CAUSES OF CLIMATE CHANGE

- Continental drift
- Changes in earth's orbit
- Solar variability
- Volcanoes
- Aerosols
- Increases in greenhouse gases (CO_2)

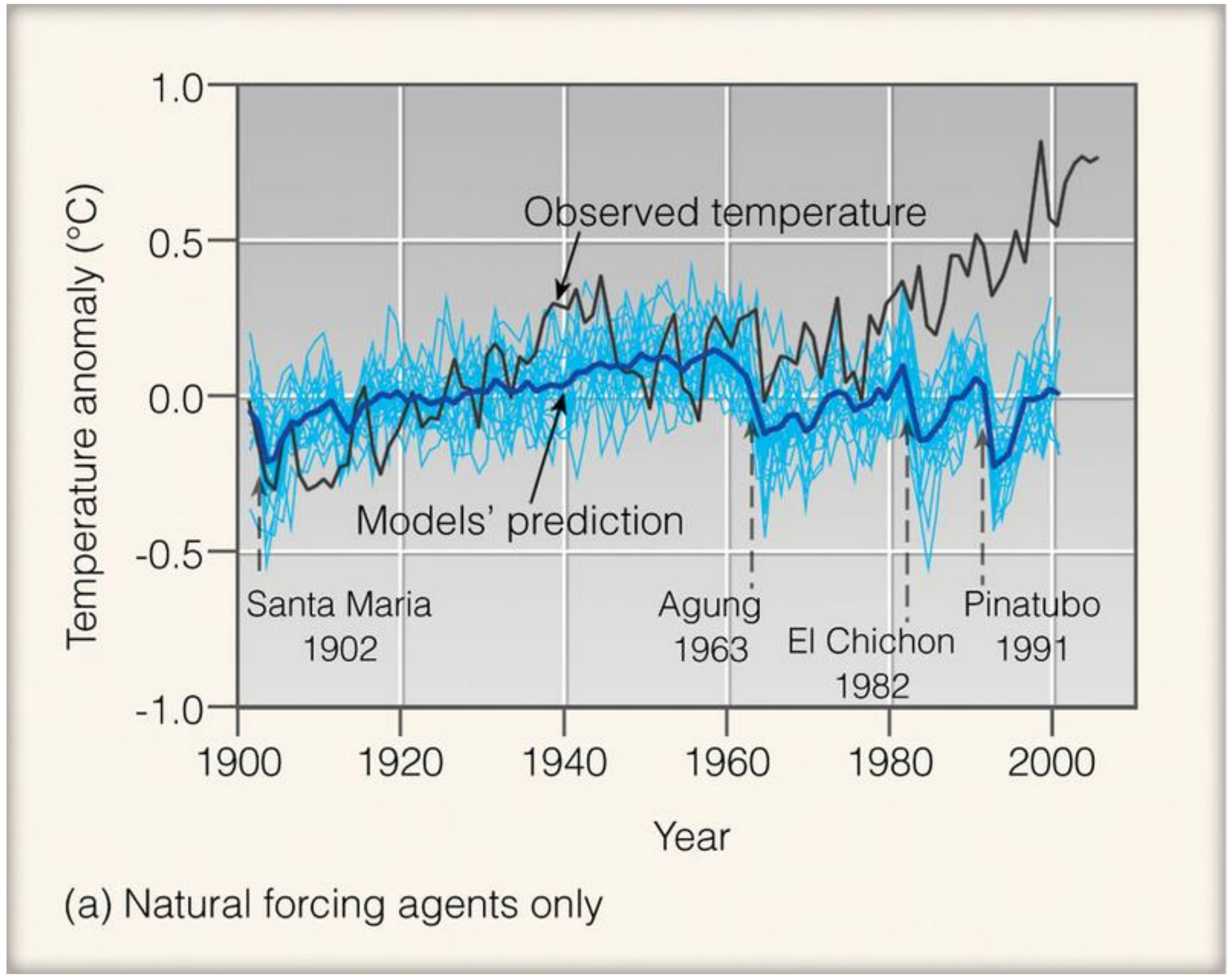
NATURAL VARIABILITY



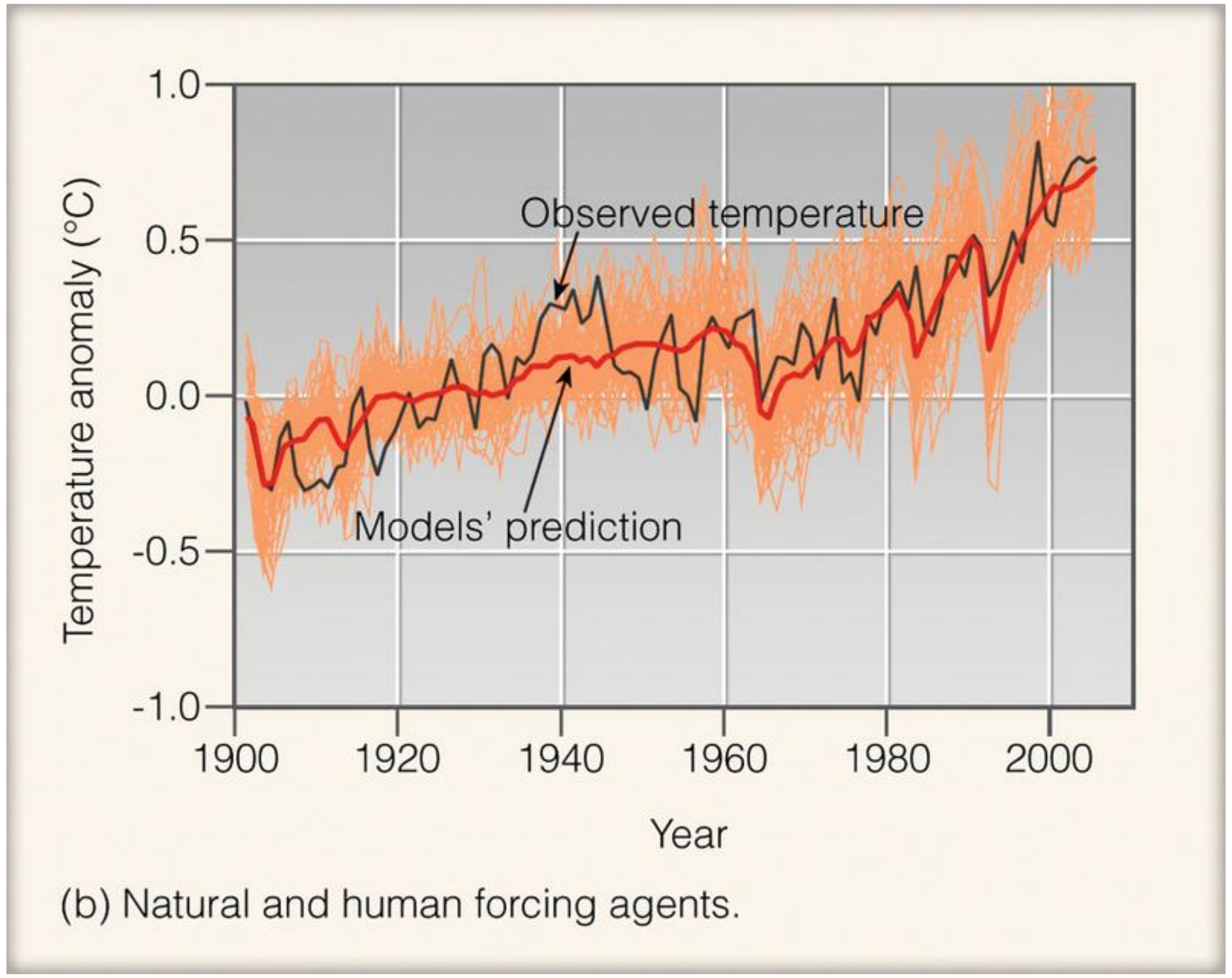


NATURAL OR ANTHROPOGENIC (human made)

REPLICATING PAST AND FUTURE CLIMATE



Climate models are unable to replicate recent warming with natural forcing agents alone



Climate models can replicate warming with natural and Anthropogenic forcing agents

CAUSES OF PRESENT CLIMATE CHANGE

Greenhouse gases

- Carbon dioxide

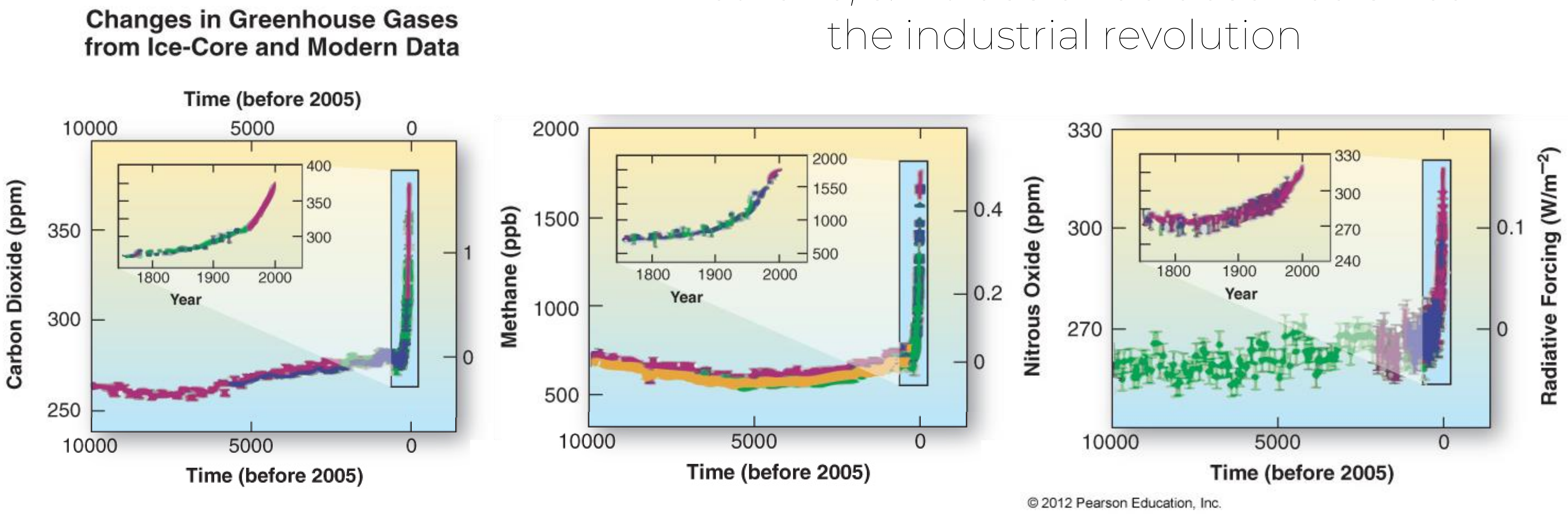
- Methane

- Nitrous oxide

- Halogenated gases

GREENHOUSE GASES INCREASING

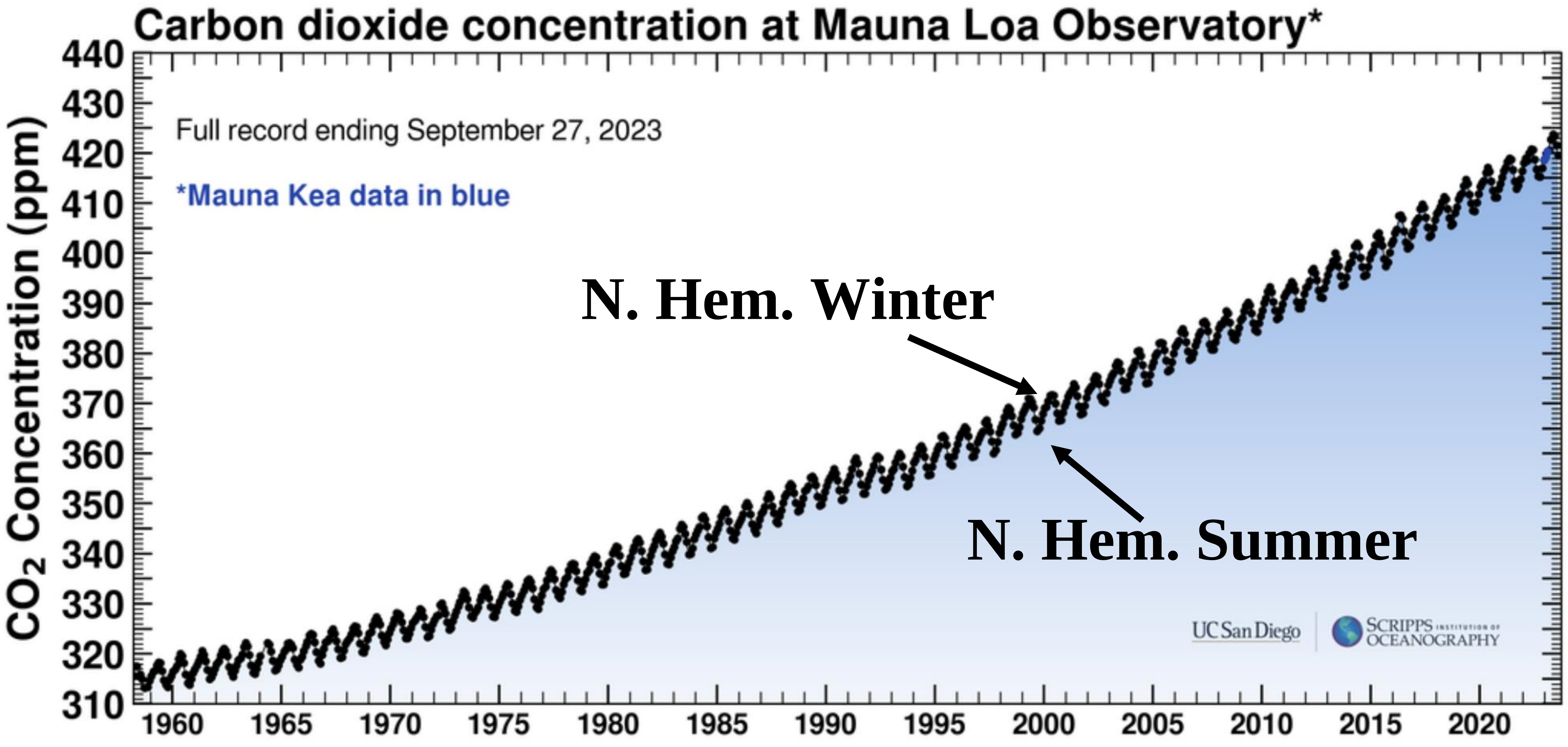
Significant increases in carbon dioxide, methane, & nitrous oxide observed since the industrial revolution



OBSERVATIONS OF CARBON DIOXIDE (CO_2)

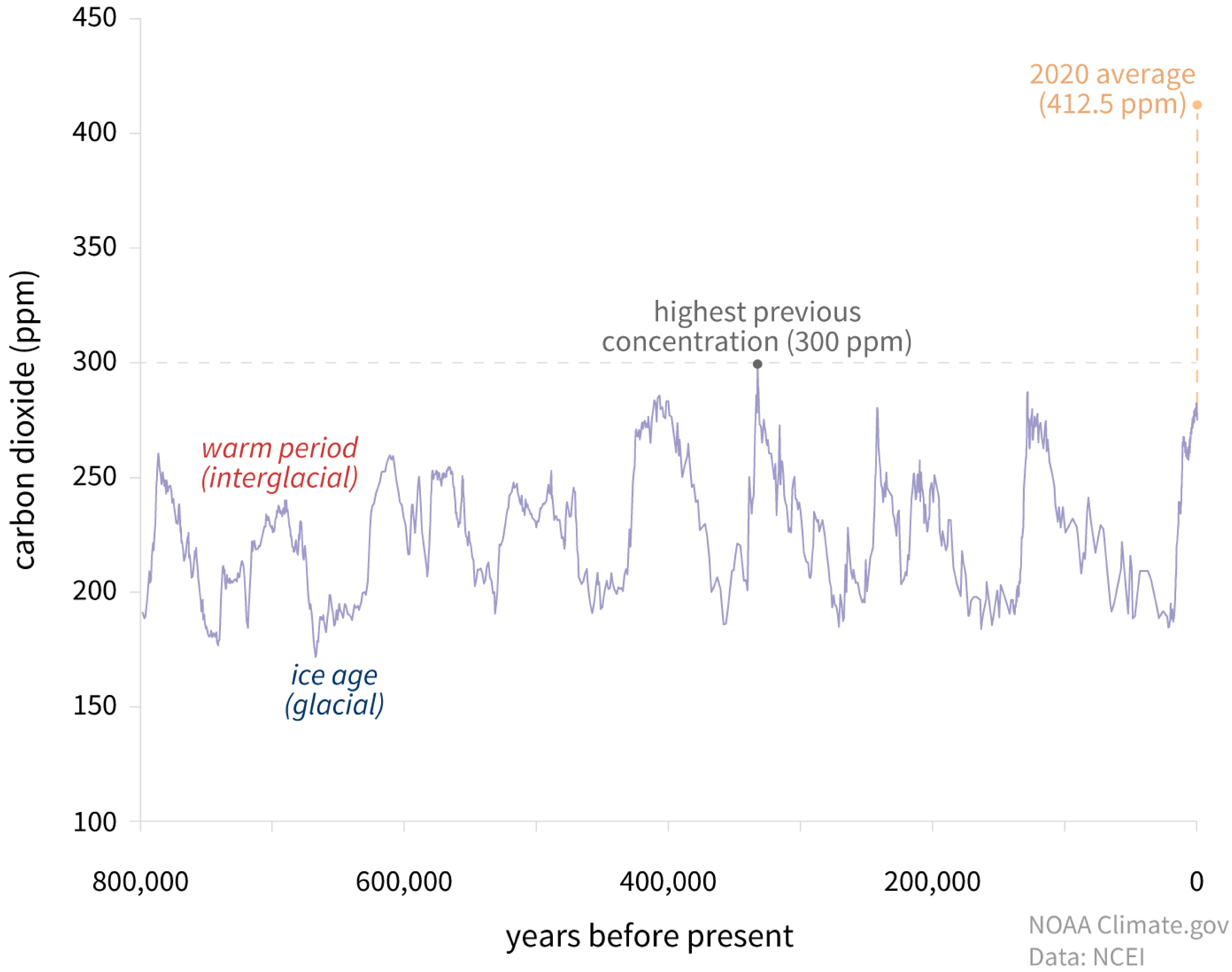
*Latest CO_2 reading: 417.95 ppm

Charles Keeling first measured CO_2 at the Mauna Loa Observatory**, leading scientific community to notice** human contribution to the greenhouse effect



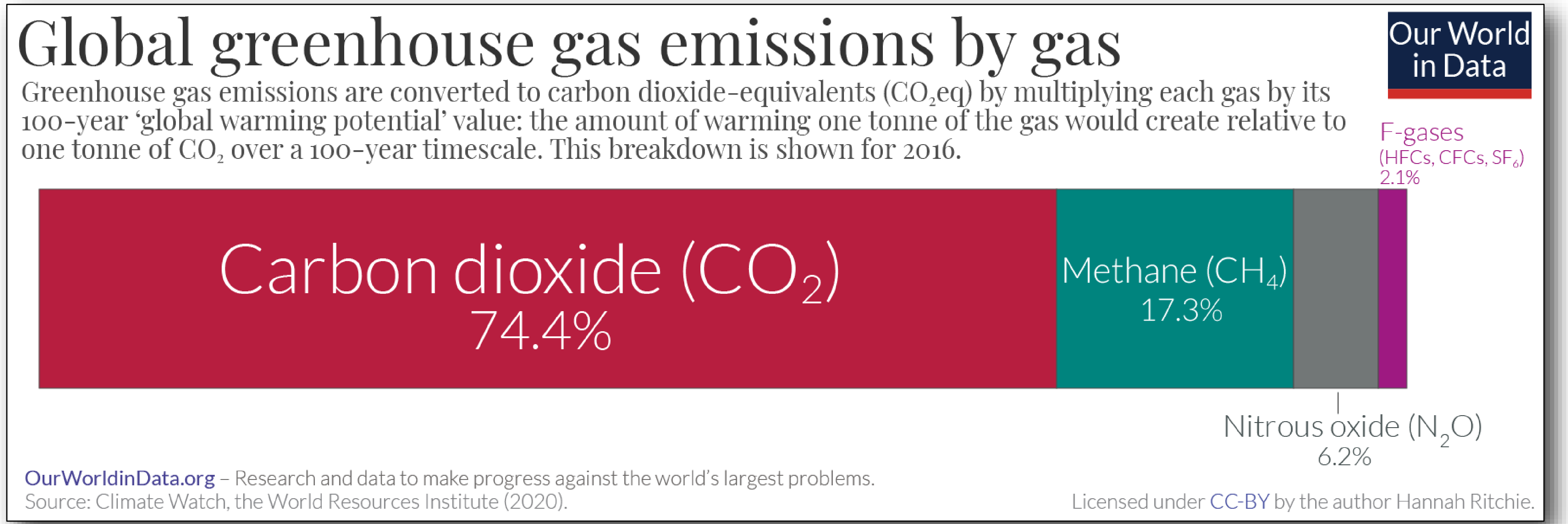
https://scripps.ucsd.edu/programs/keelingcurve/

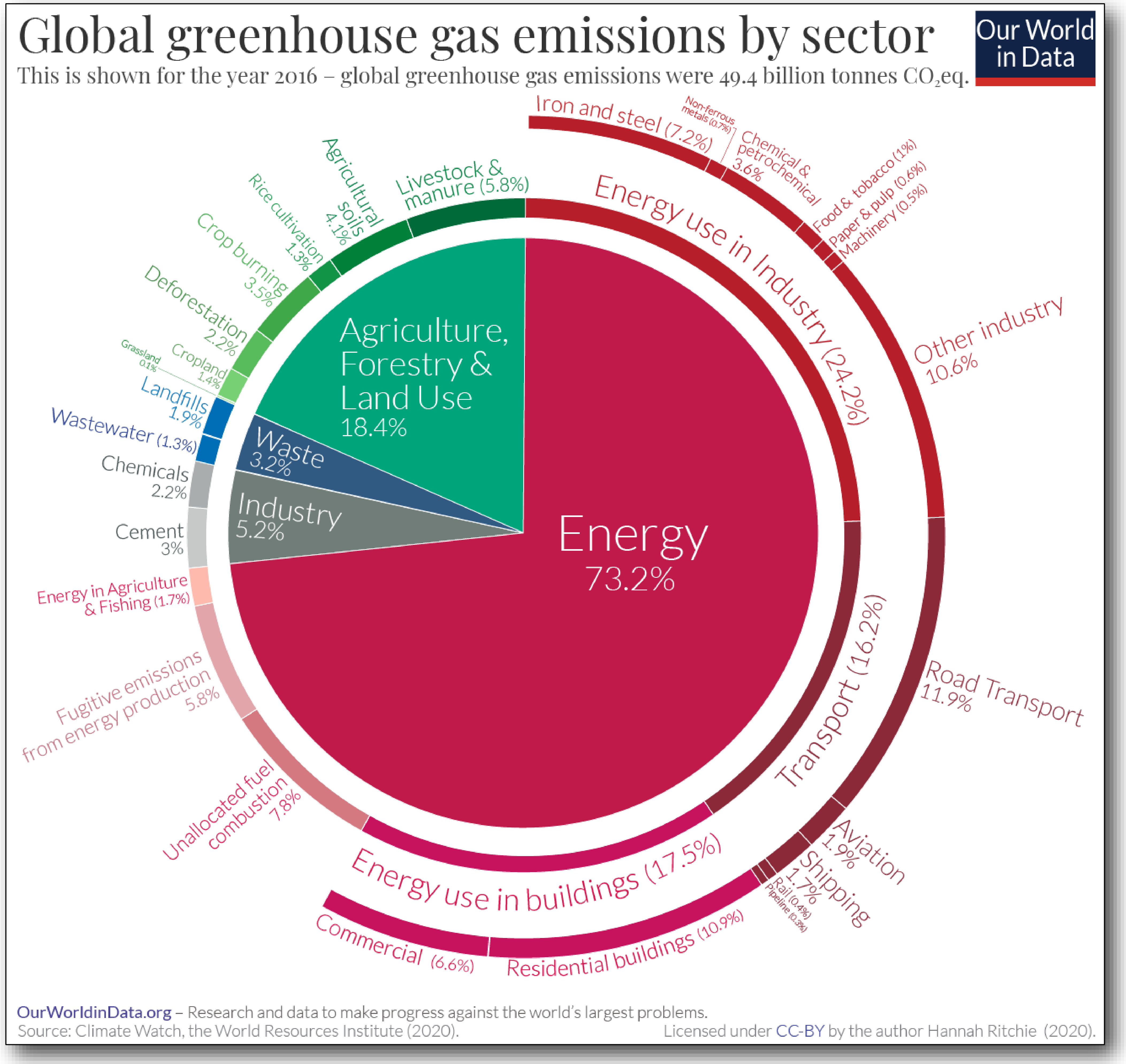
CARBON DIOXIDE OVER 800,000 YEARS



GREENHOUSE GAS EMISSIONS

Largest contributor is CO_2 from fossil fuel use





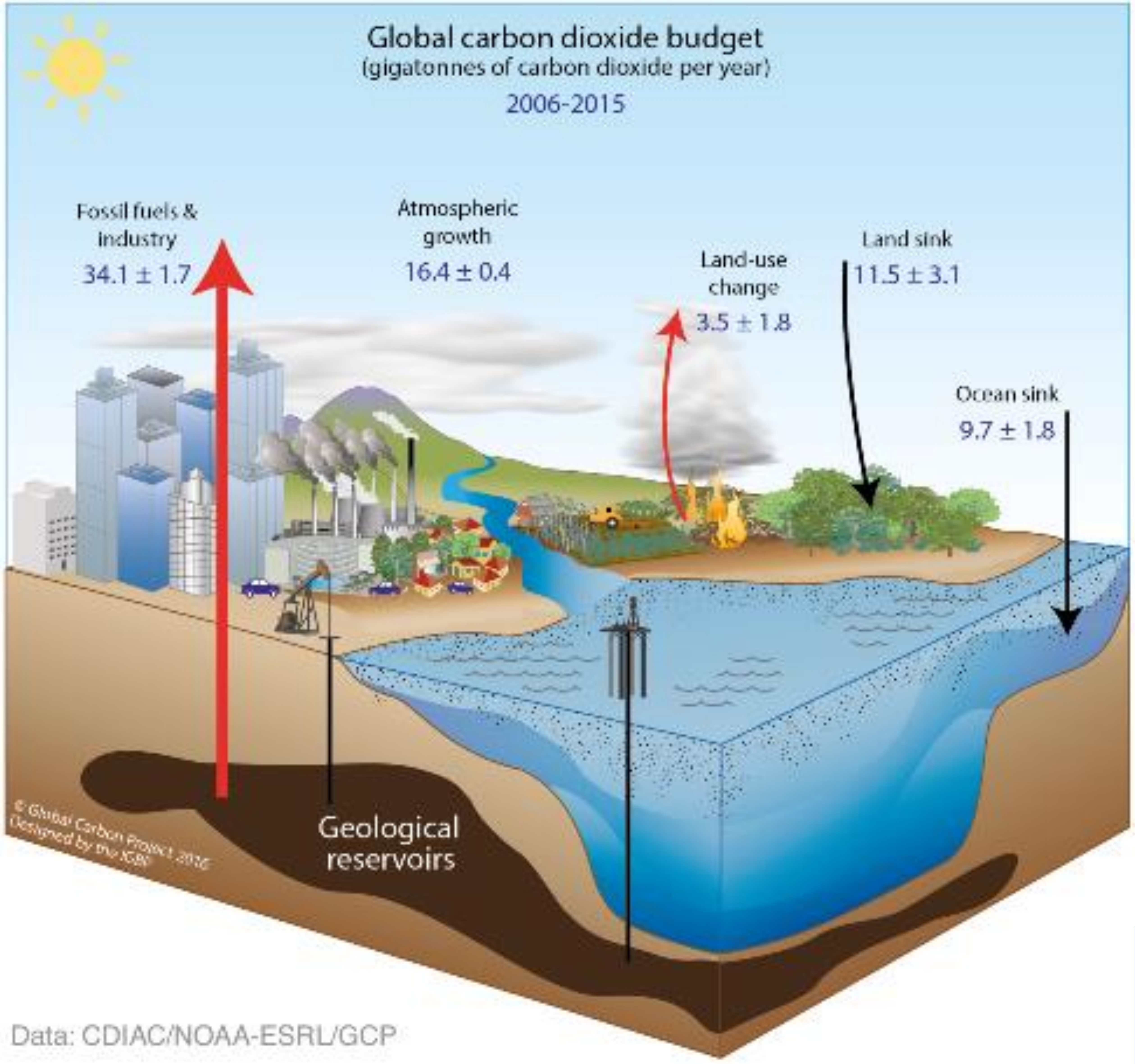
KEY POINTS

Historical observations demonstrate rapid (decadal) climate changes in surface temperature and other parts of our climate system.

These changes are all consistent with a warming planet resulting from increased greenhouse gases.

The changes are not consistent with long-term natural variations in our climate.

GLOBAL CARBON DIOXIDE BUDGET



FATE OF ANTHROPOGENIC CO_2 EMISSIONS (2012 – 2021)

Sources = Sinks

35.2 $GtCO_2$/yr

89%

11%

4.5 $GtCO_2$/yr

19.1 $GtCO_2$/yr

48%

29%

11.4 $GtCO_2$/yr

26%

10.5 $GtCO_2$/yr

Budget Imbalance:
(the difference between estimated sources & sinks)

3%
-1.2 $GtCO_2$/yr

Source: Friedlingstein et al 2022; Global Carbon Project 2022

RECAP

- The earth has warmed about 1°C (2°F) over the last 100 years
- Increased greenhouse gas concentrations
- Warming has not been uniform in space or time
- Need to predict future CO_2 emissions to predict future climates

CLIMATE MODELS AND PROJECTIONS

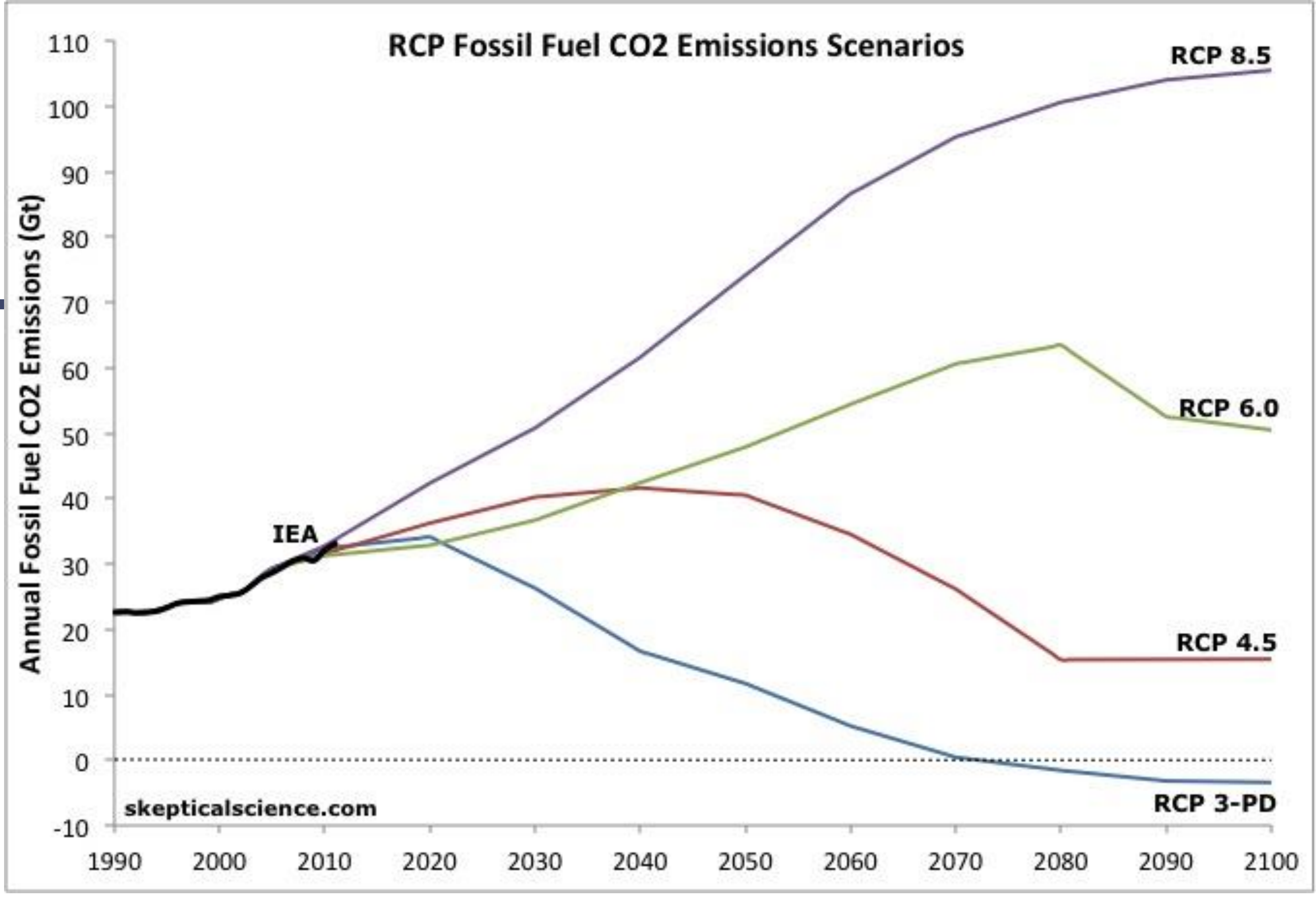
GCMs used to assess past climatic trends & forecast future climate changes

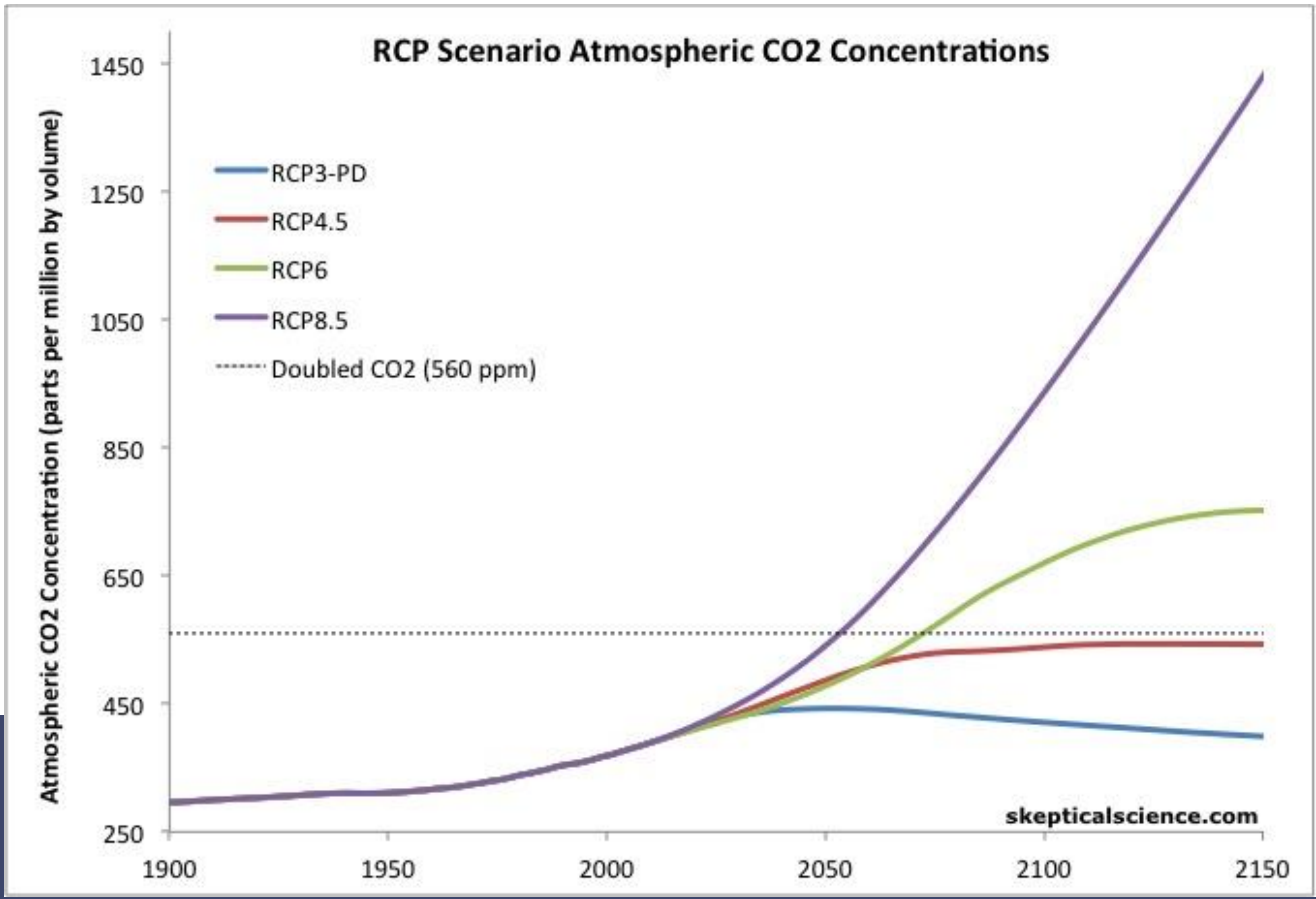
Used to determine the relative effects of various climate forcing on temperature

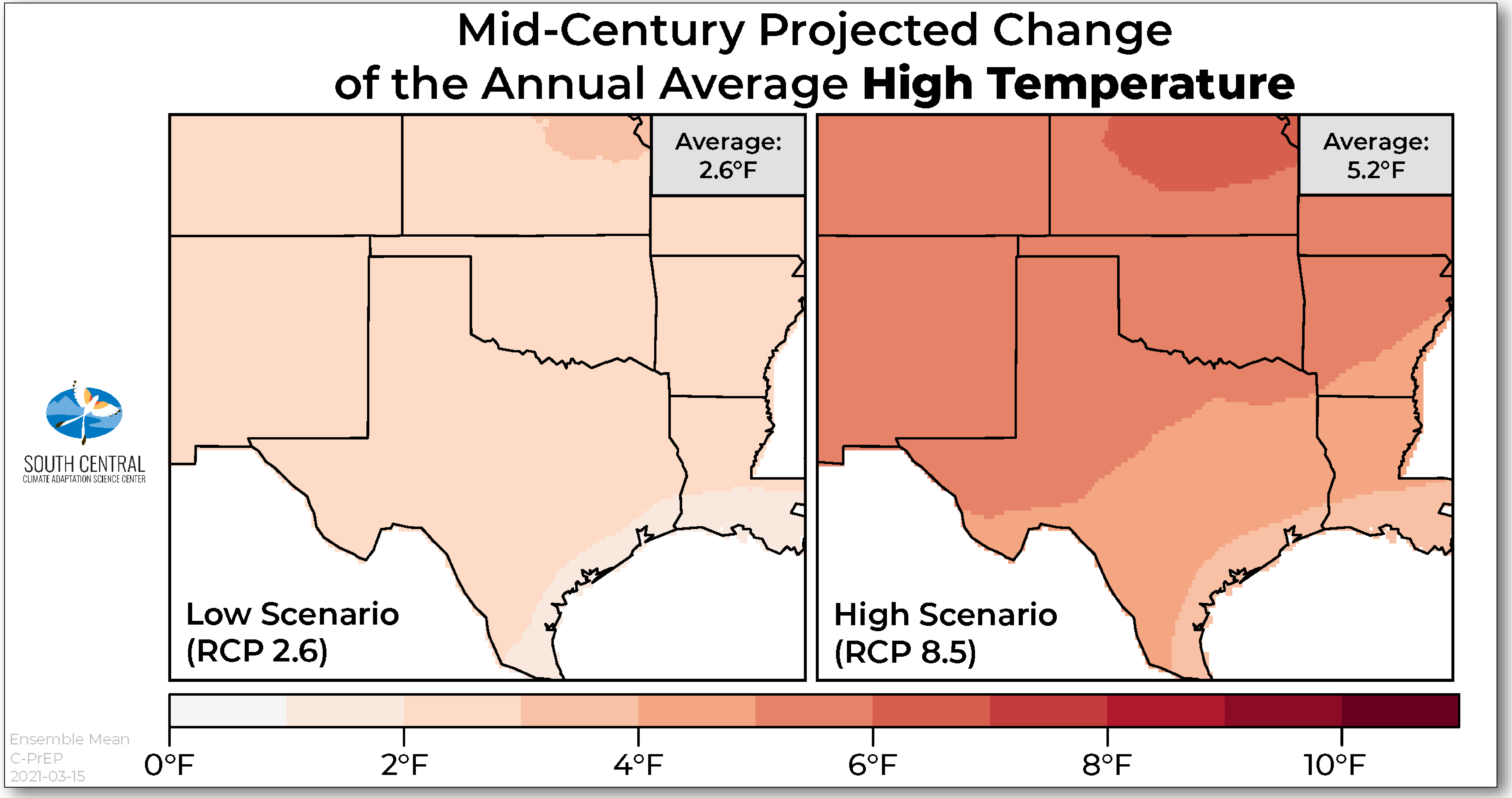
CO_2 EMISSIONS SCENARIOS

- How much CO_2 will we emit each year in the future?

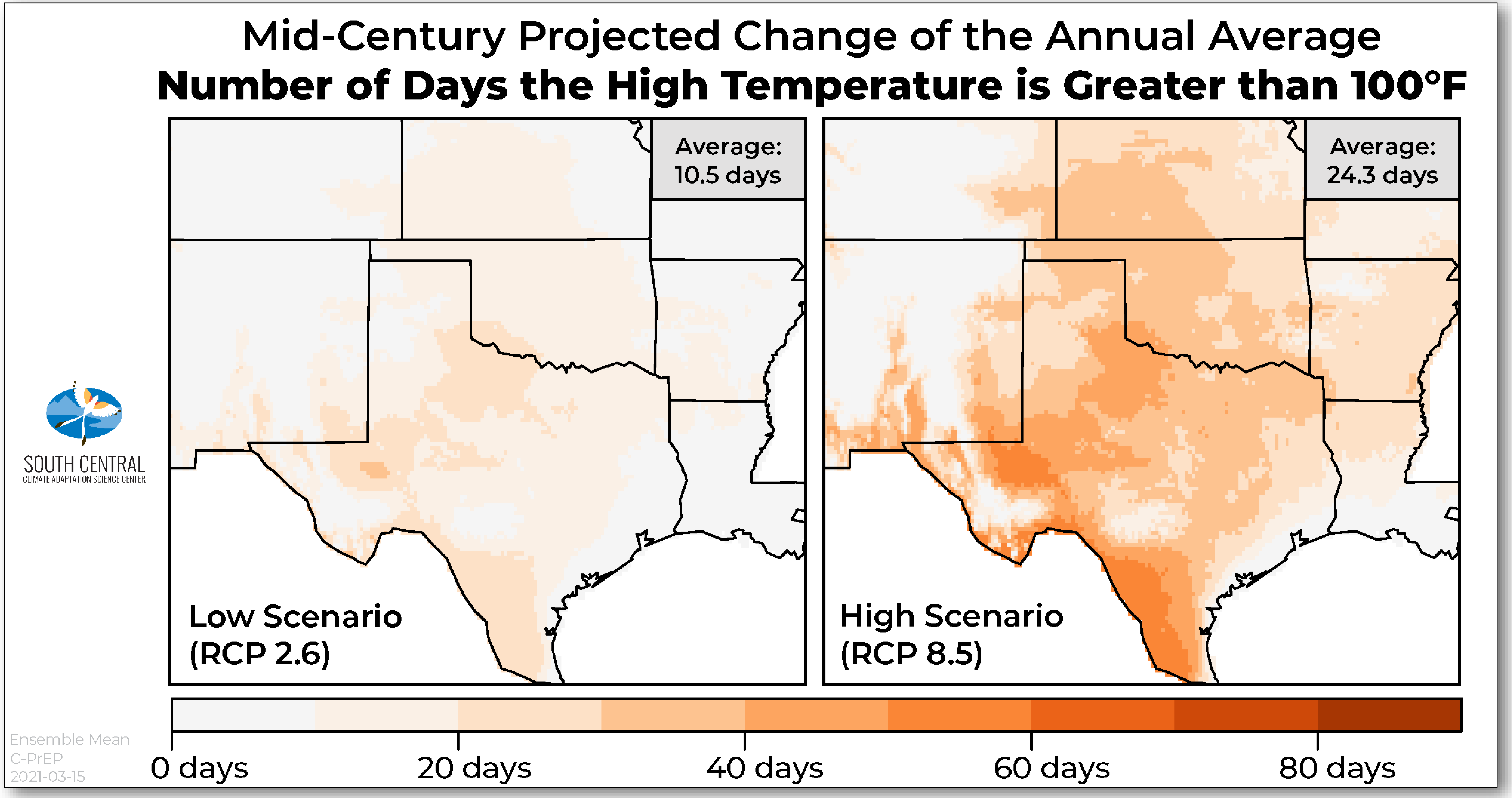
- Source of uncertainty in climate forecasts



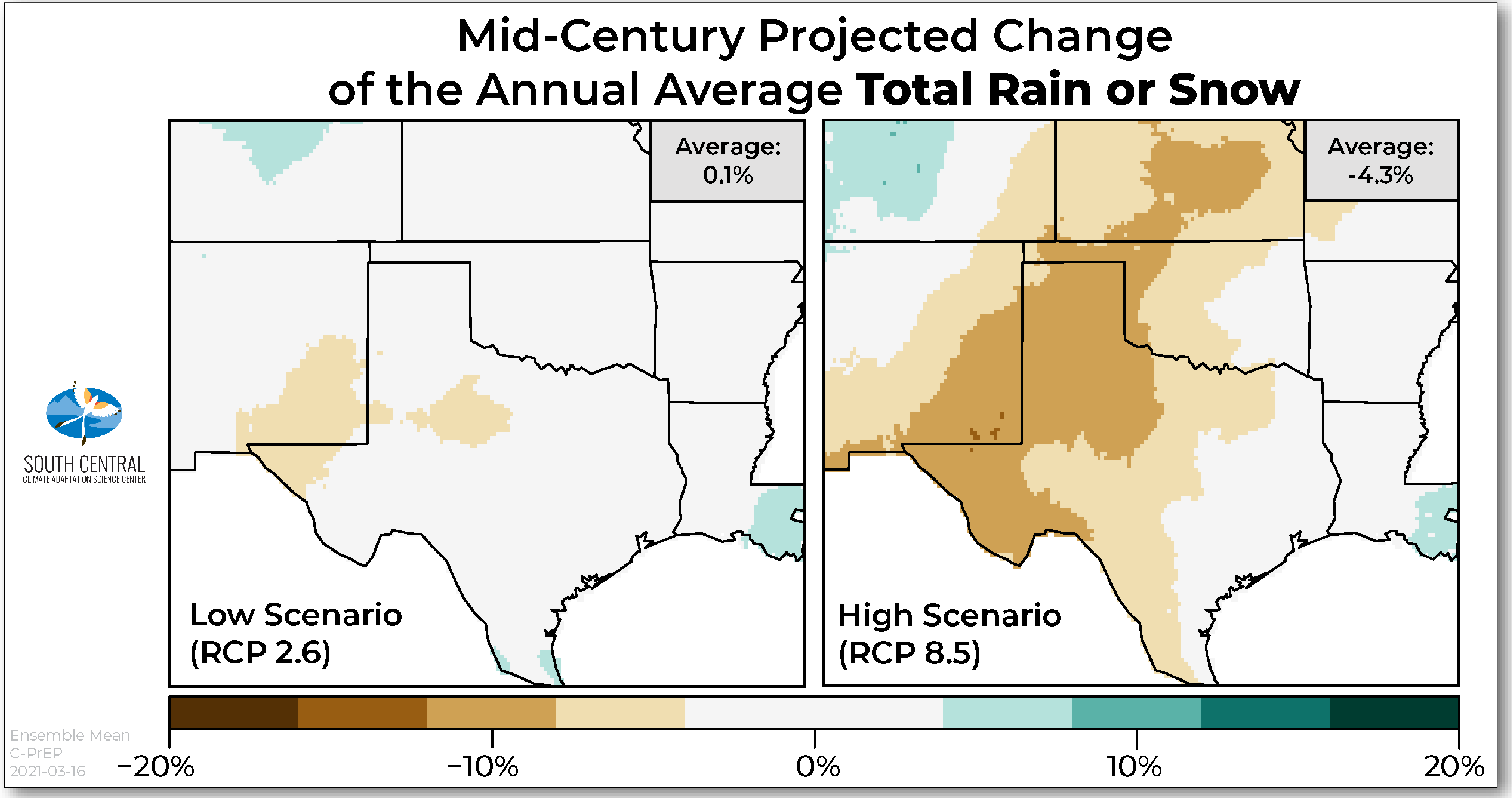




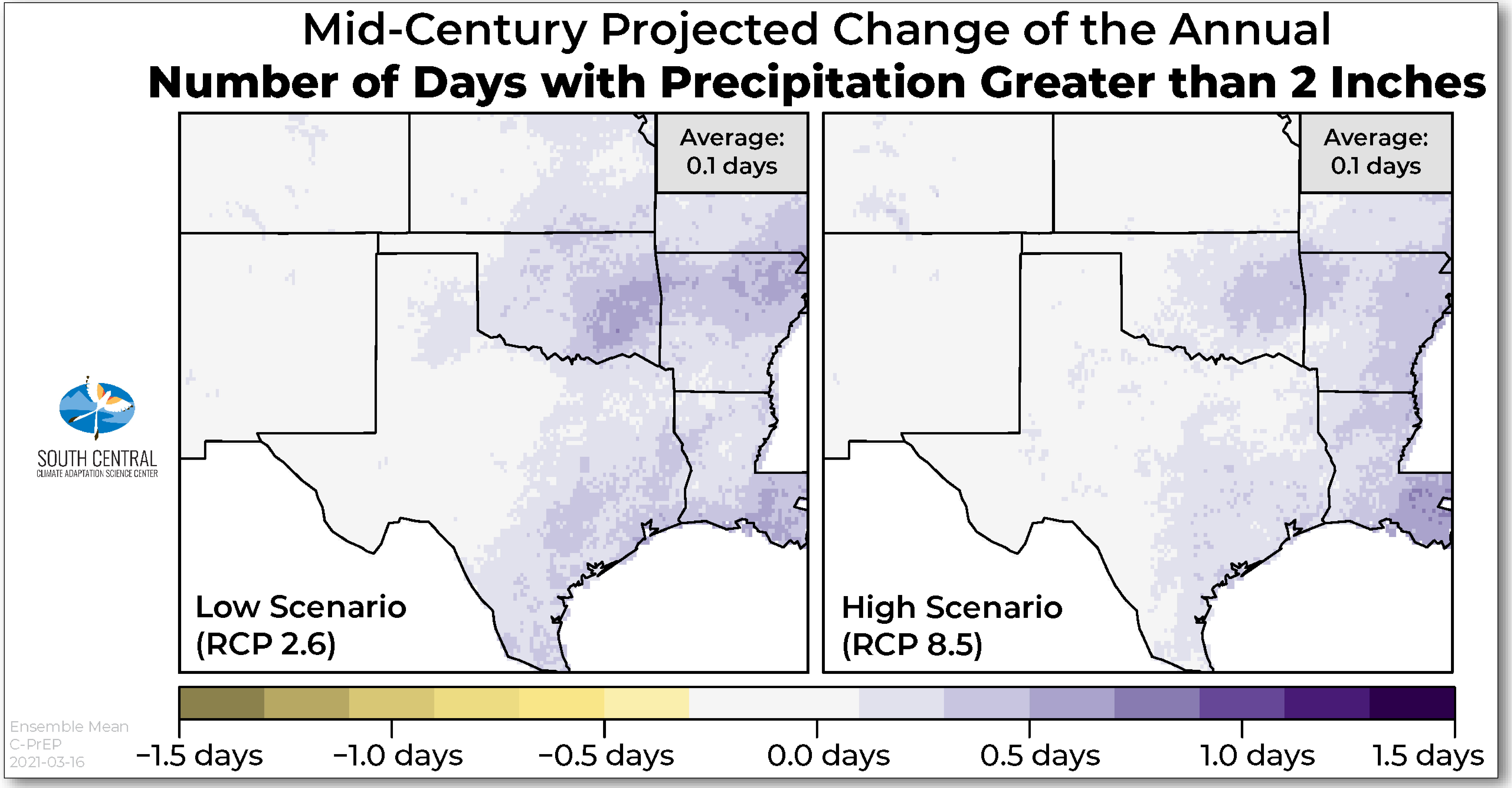
Daily high temperatures averaged for all days during the mid-century are projected to increase by 3 °F to 6 °F in Oklahoma



Across Oklahoma, the number of very hot days (>100 ˚ F) are projected to increase by 10-40 days by the mid-century



Average annual precipitation during the mid-century is projected to decrease by 2-10 percent in Oklahoma



The eastern half of the region is projected to have 1 more day at least every other year with more than 2 inches of rain

REMAINING CARBON BUDGET

Estimate	Warming to 0.97°C	Warming to 1.5°C	Warming to 2.0°C
Historical Carbon Emissions (1850–2017)	2,230 $GtCO_2$	—	—
Additional Carbon Emissions (2018–2100)	—	420 to 840 $GtCO_2$	1,170 to 2,030 $GtCO_2$

Excludes feedbacks resulting from permafrost thawing or methane released by wetlands (~100 $GtCO_2$)

1.5°C VERSUS 2°C IMPACTS

- **Estimated** 1.7 billion more people will suffer **from** severe heatwaves **at least once every 5 years** under 2°C vs. 1.5°C **of warming**
- 420 million more **exposed to** extreme heatwaves
- 65 million more **exposed to** exceptional heatwaves

1.5°C VERSUS 2°C IMPACTS

- **Under 2°C warming,** ~75 million more people affected by drought each month **as compared to 1.5°C**
- 184–270 million more **people exposed to new or enhanced** water scarcity **at 2°C of warming (vs. 1.5°C)**
- **Differences in aridity to cause** substantially more freshwater stress on small islands **at 2°C**

1.5°C VERSUS 2°C IMPACTS

- **By 2050,** 26–34 million more **people exposed to increased** river flooding **at 2°C of warming (vs. 1.5°C), with** 5.7% more fatalities
- 70% greater risk **of flooding at 2°C than 1.5°C, with** largest increases in flood risks in USA, Asia, & Europe

CLIMATE CHANGE IMPACTS TO…

Agriculture

Water

Ecosystems

Communities

Commerce

Coastal

Health

Infrastructure

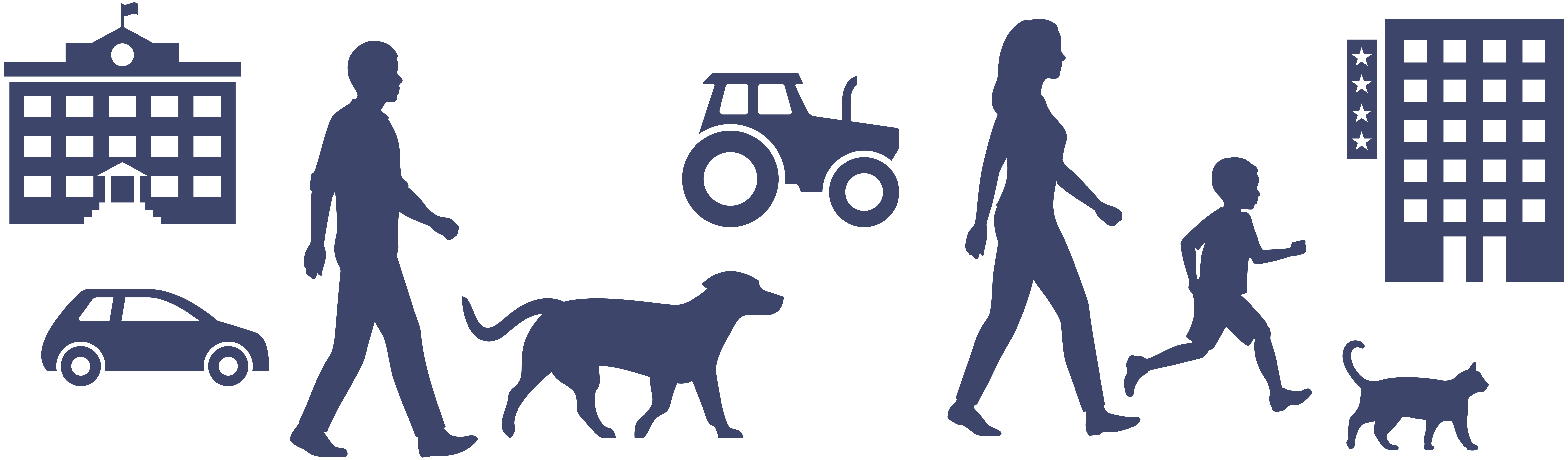
Energy

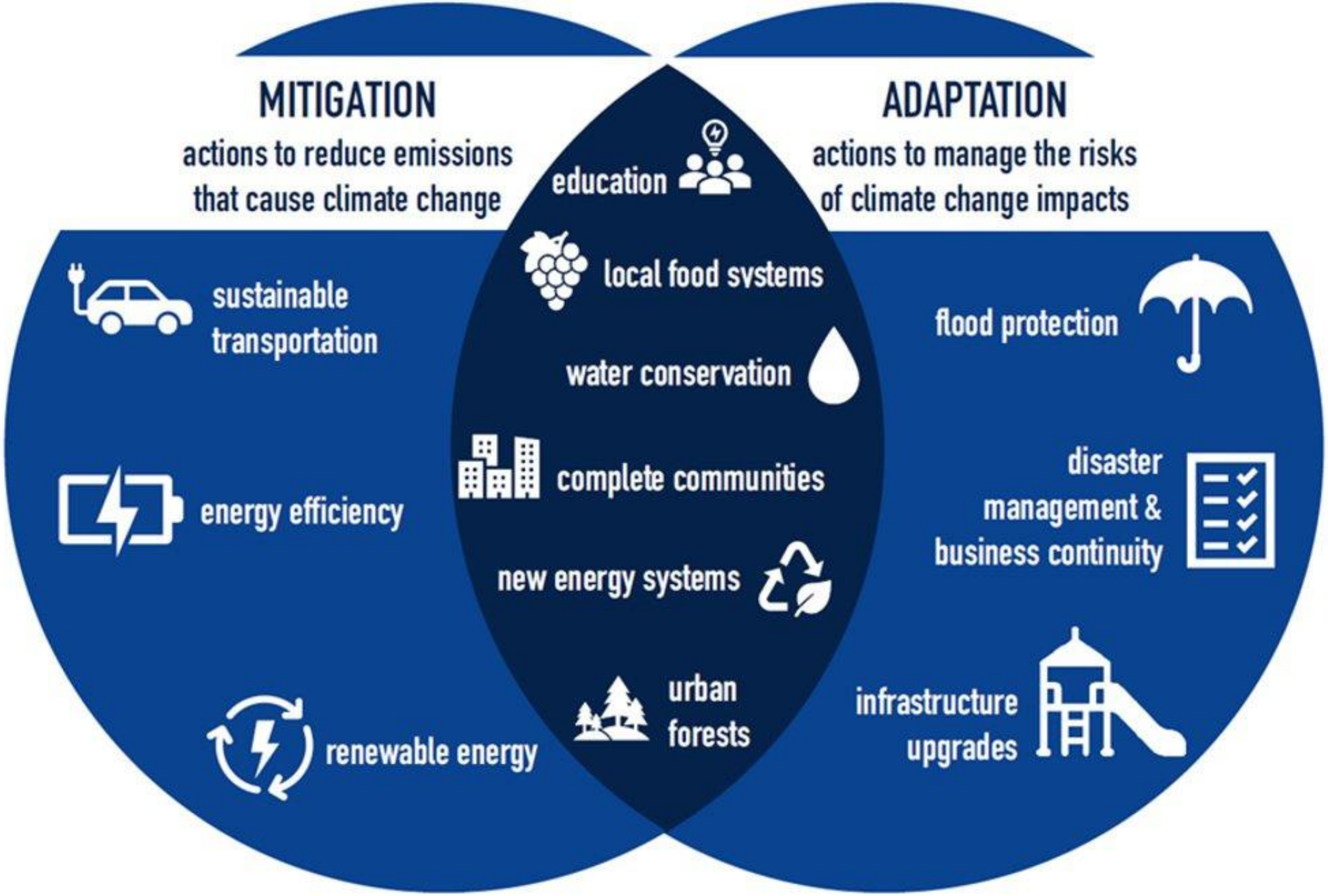
Forests

Carlye Calvin & Wikipedia photos

WHAT CAN BE DONE?

Everyone **(individuals, families, communities, businesses, schools, policymakers, & organizations)** can take part in reducing emissions & adapting **to the future climate**




MITIGATION
actions to reduce emissions that cause climate change
ADAPTATION
actions to manage the risks of climate change impacts
education
local food systems
water conservation
complete communities
new energy systems
urban forests
sustainable transportation
energy efficiency
renewable energy
flood protection
disaster management & business continuity
infrastructure upgrades

POSSIBLE PATHWAYS TO 1.5°C

- Few pathways to below 1.5°C exist; those that do require substantially lower energy demand, modestly larger share of energy from electricity, & huge shift to low-carbon sources of all energy (electricity & non-electricity)
- Options through 2030 must include renewables & nuclear energy as well as low-carbon fossil fuels with ***carbon capture/sequestration & storage*** technologies

MITIGATION – REDUCING THE CAUSES OF MANMADE CLIMATE CHANGE

- **Land sinks -** Forests and Growing trees
- **Renewable energy** – nuclear, solar, wind, & biofuels
- **Energy standards** – vehicle efficiency (60+ mpg), building efficiency, industrial heat recovery
- **Economic-based strategies** – "cap-and-trade" to limit emissions by allowing free market to reach goal
- **Geoengineering** – implement carbon scrubbers; place 1000s of mirrors in orbit to block incoming solar radiation; put powered limestone in ocean to reduce acidity; seed ocean with iron to encourage phytoplankton growth & remove carbon; spray seawater into sky to increase reflectivity of clouds

Connect with us with any questions

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