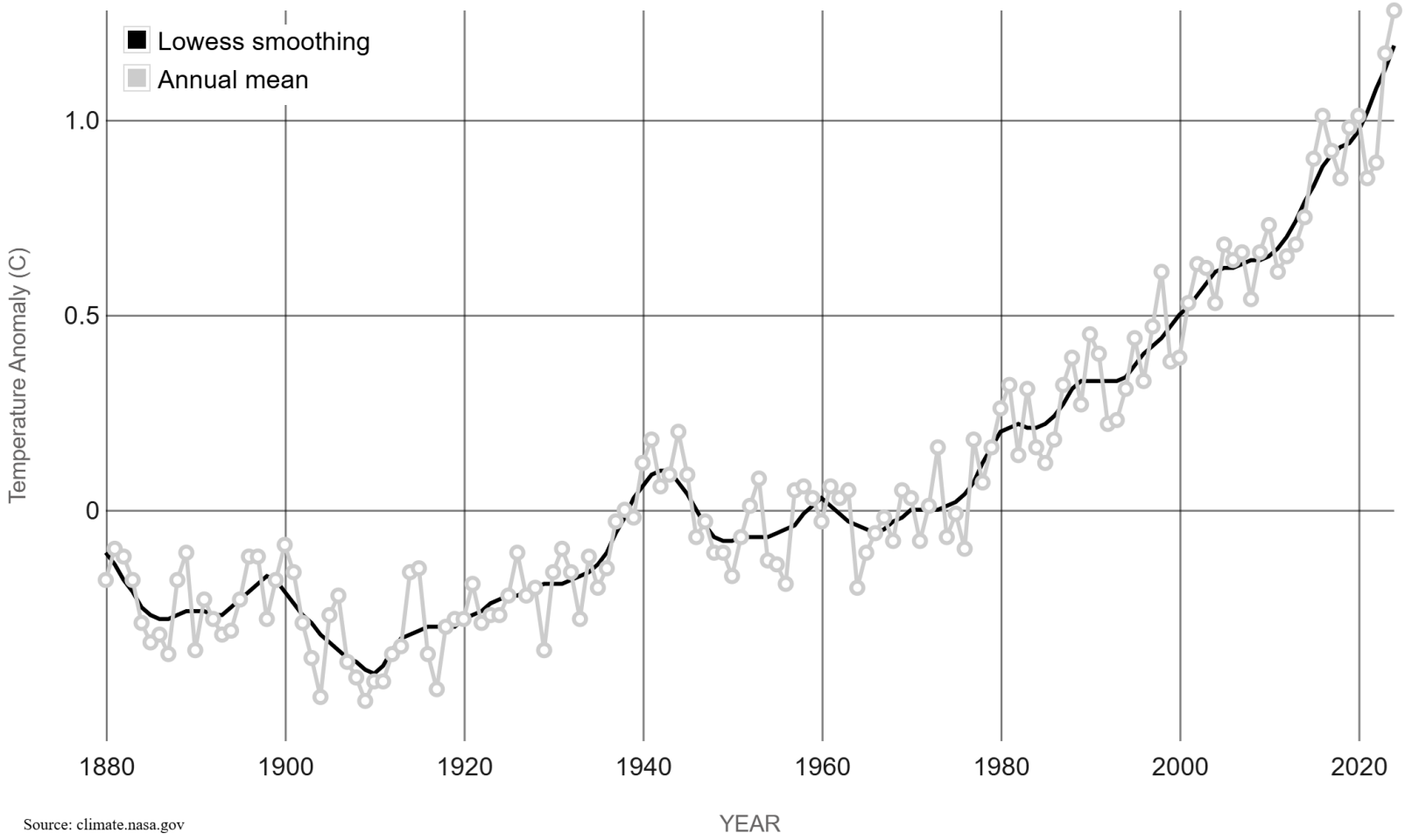
B.2

Climate Change

IB PHYSICS | ASTROPHYSICS

Temperature has been Rising

B.2

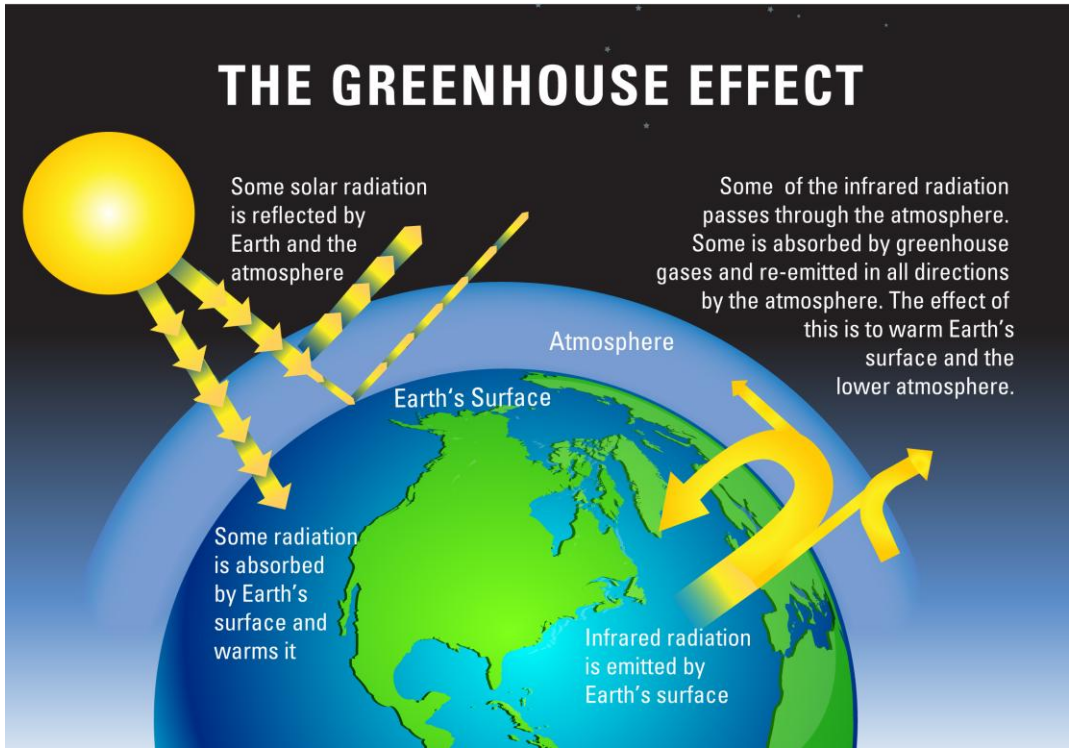


Source: climate.nasa.gov

B.2

Greenhouse Effect

If there was no atmosphere, the earth would experience a net loss of energy and reach equilibrium at an average temperature about 30°C colder than it is currently.

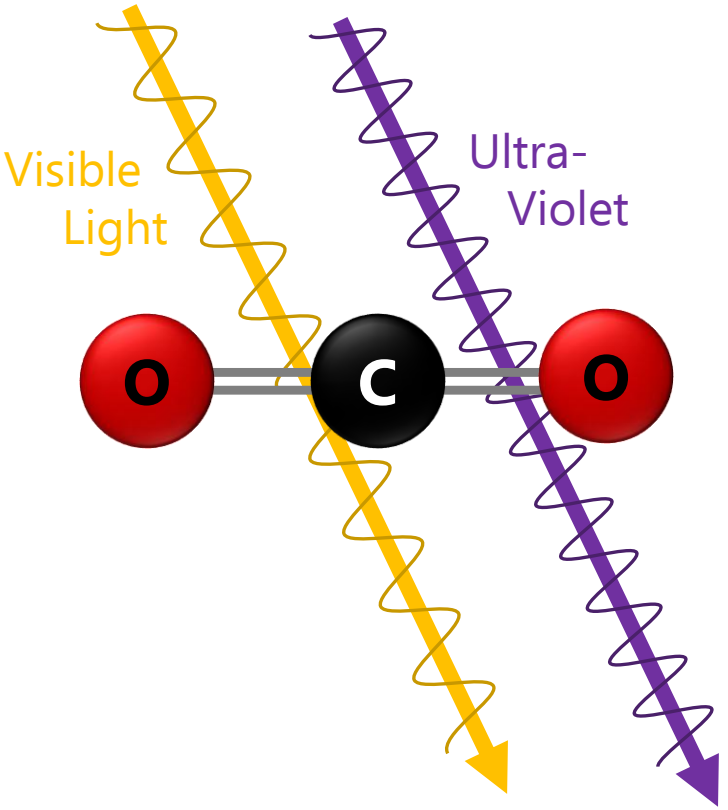


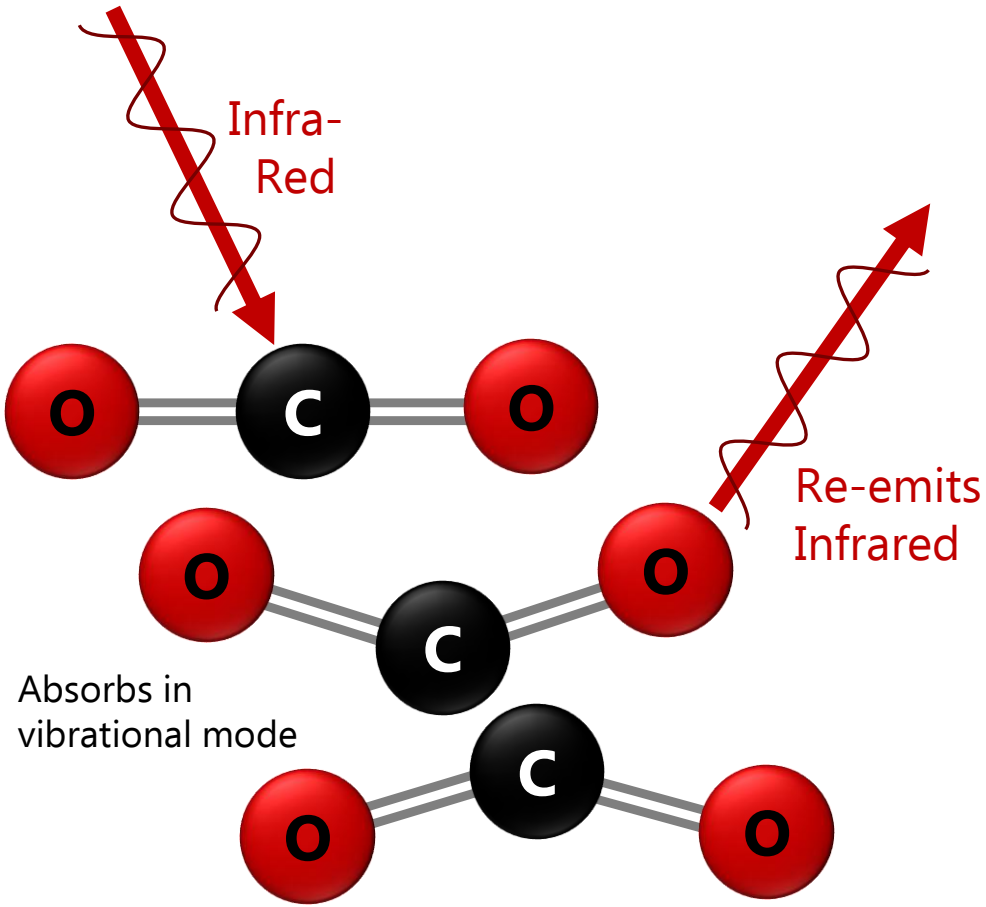
We see from the climate models that the concentration of greenhouse gases is the driving factor causing the climate to change

Enhanced Greenhouse Effect

Some Gases Absorb Light

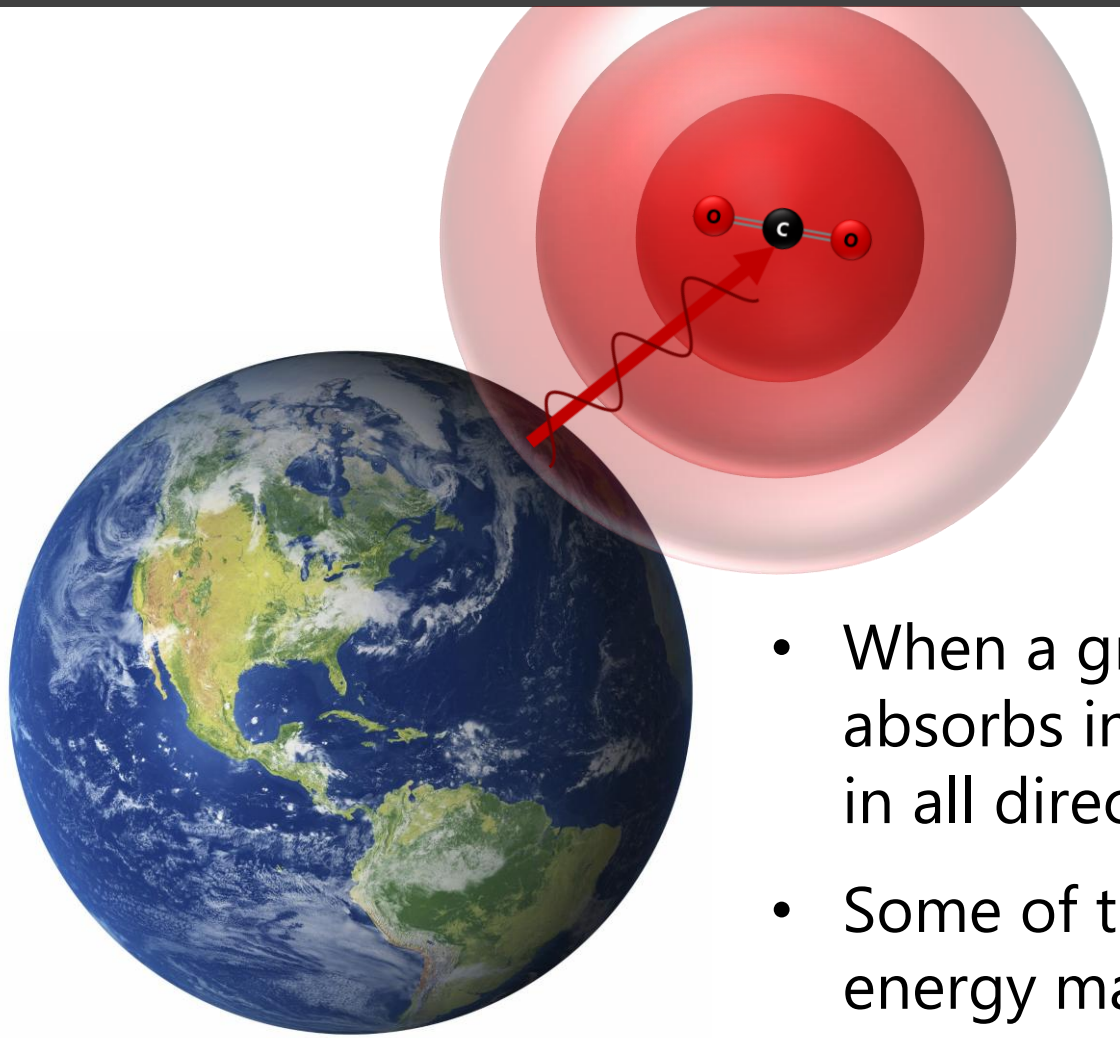
B.2





Energy is Re-emitted

B.2



- When a greenhouse gas absorbs infrared, it re-emits in all directions.
- Some of this re-emitted energy makes it back to earth

The Greenhouse Effect

B.2

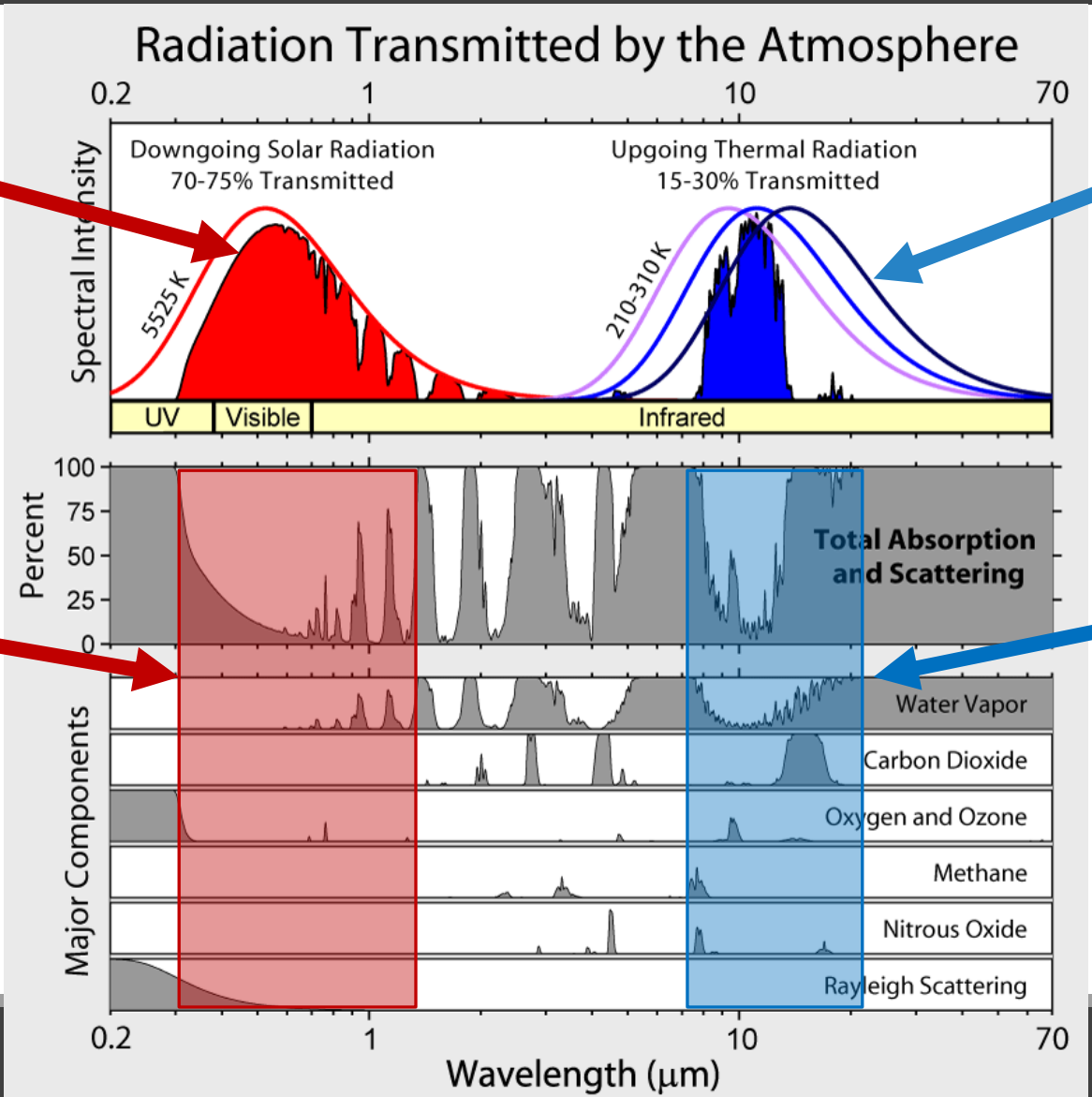
Gas molecules absorb and reemit infrared radiation

**This happens because the shape of these molecules means that they have natural vibration frequency that matches the frequency of infrared waves*

Role of the Atmosphere

Energy from the Sun

Energy from the Earth



Not affected by greenhouse gases

Absorbed by greenhouse gases

B.2

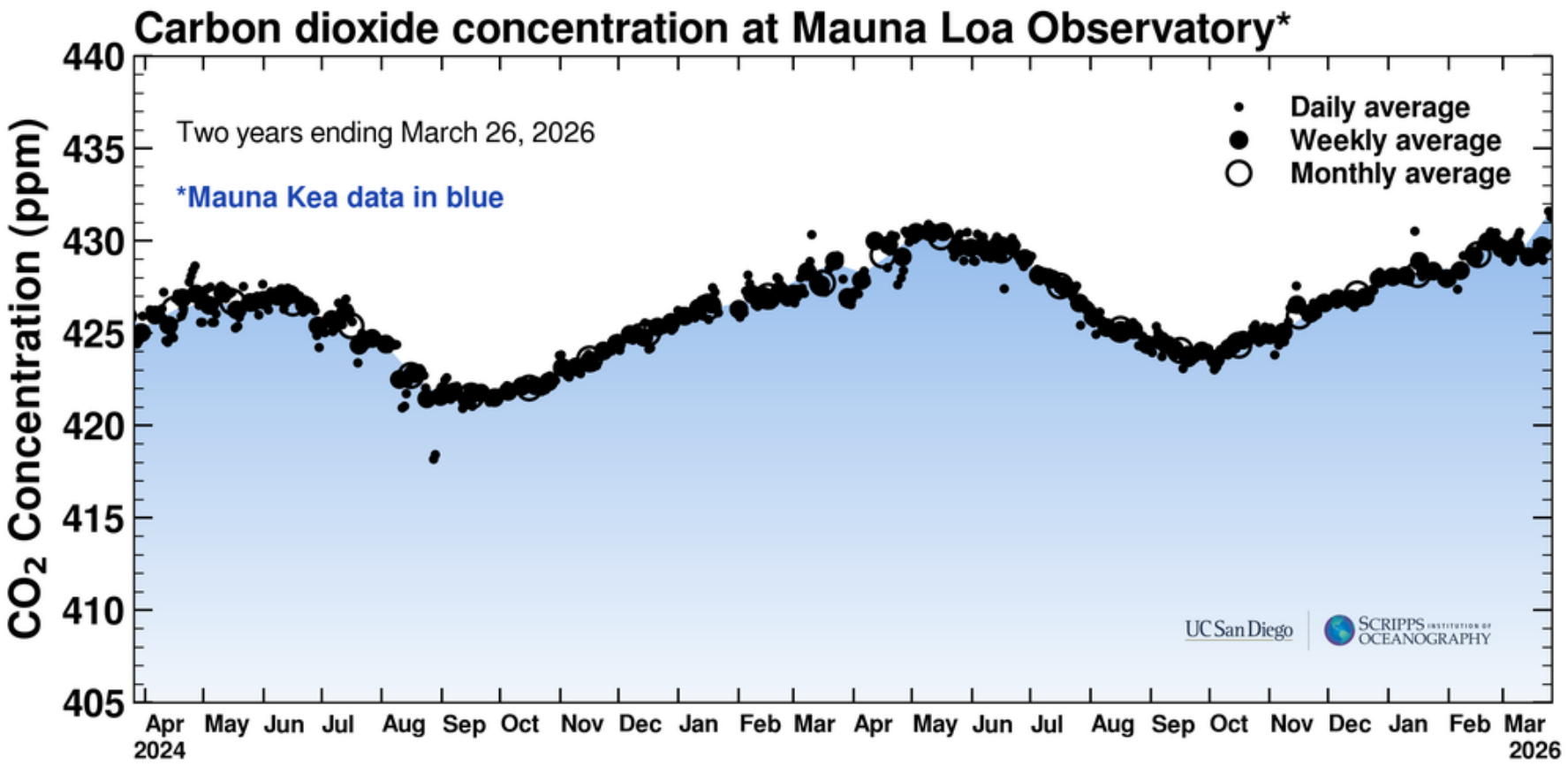
Where do they come from?

Greenhouse Gas	Natural	Human Activity
Water Vapor	• Water Cycle	• Hotter planet evaporates more water
Carbon Dioxide	• Carbon Cycle	• Fossil Fuel Combustion
Oxygen / Ozone	• Reaction in the presence of sunlight	• Emissions
Methane	• Termites • Melting Permafrost	• Leaks from natural gas • Raising of Livestock
Nitrous Oxide	• Nitrogen Cycle	• Agriculture • Wastewater management

CO_2 Concentration | 2 years

B.2

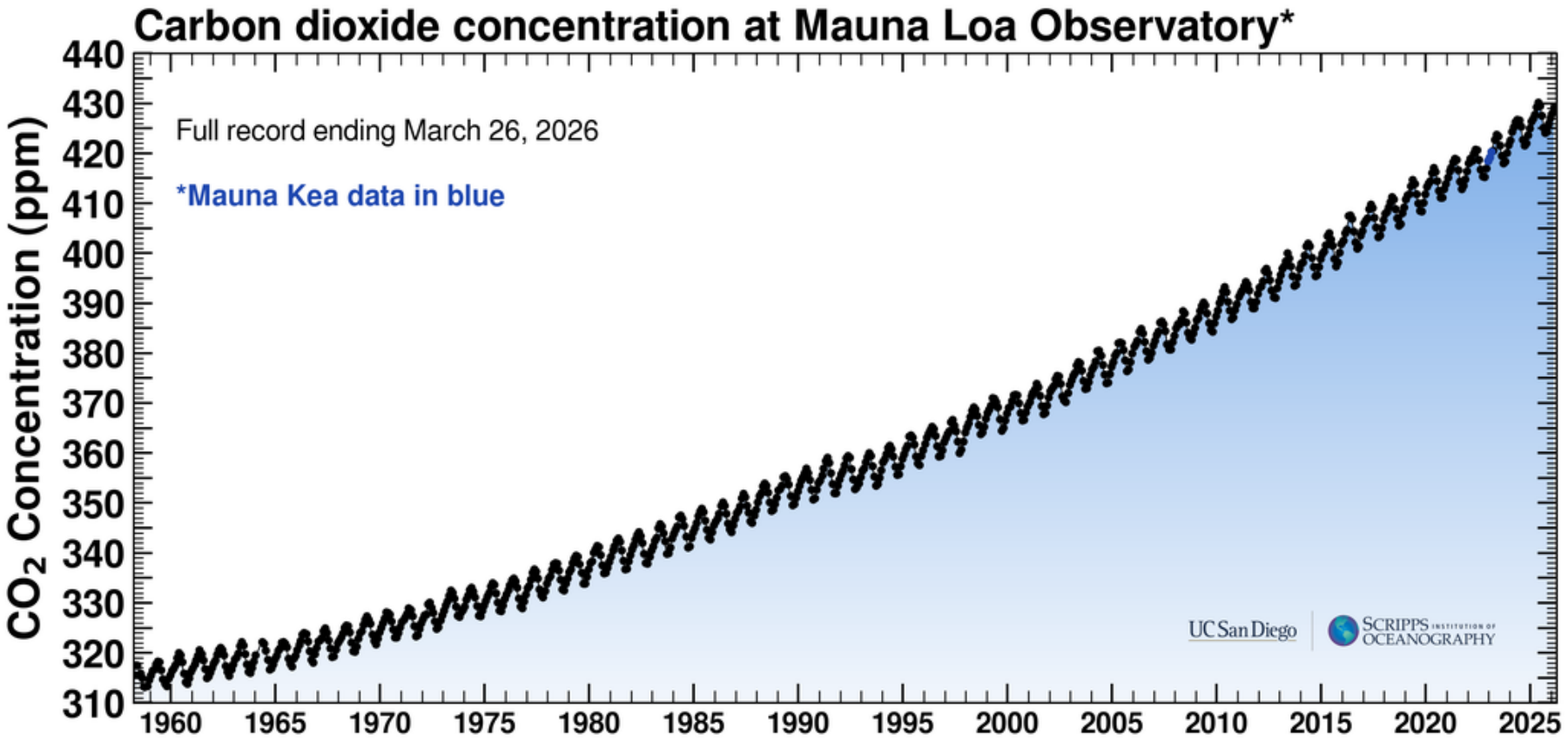
Latest CO_2 Reading: **431.28 ppm**



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

CO_2 Concentration | 63 years

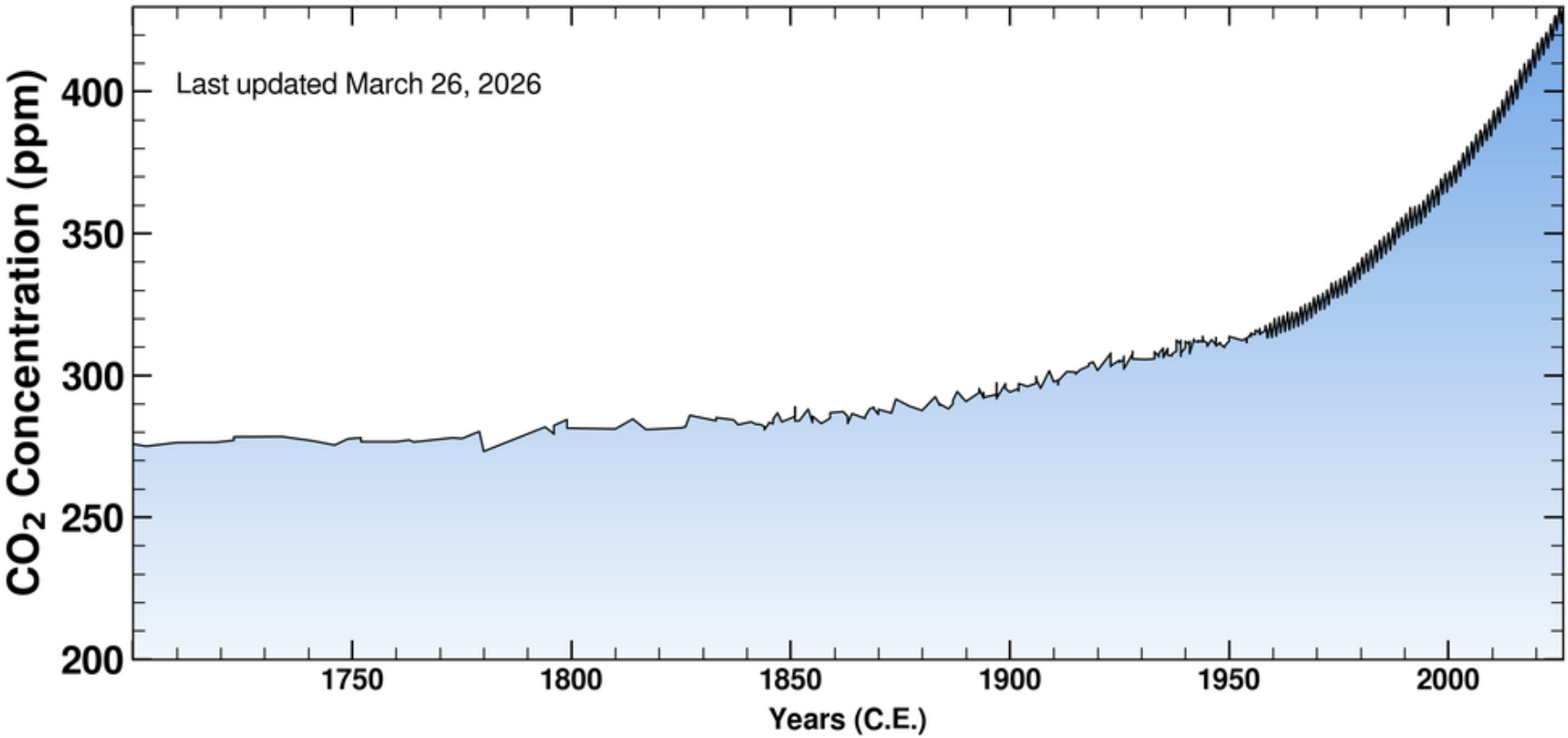
B.2



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

CO_2 Concentration | 300 years

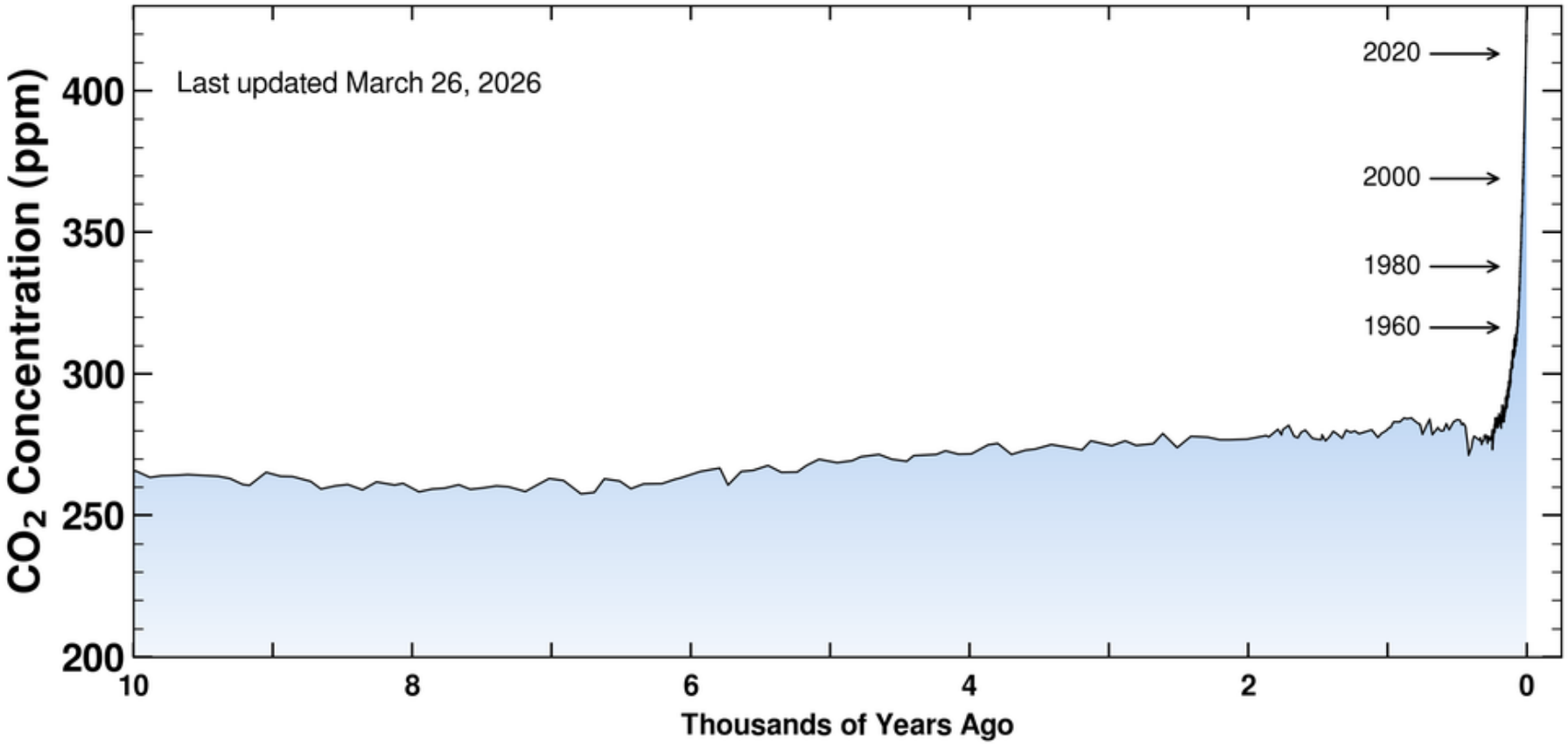
B.2



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

CO_2 Concentration | 10,000 years

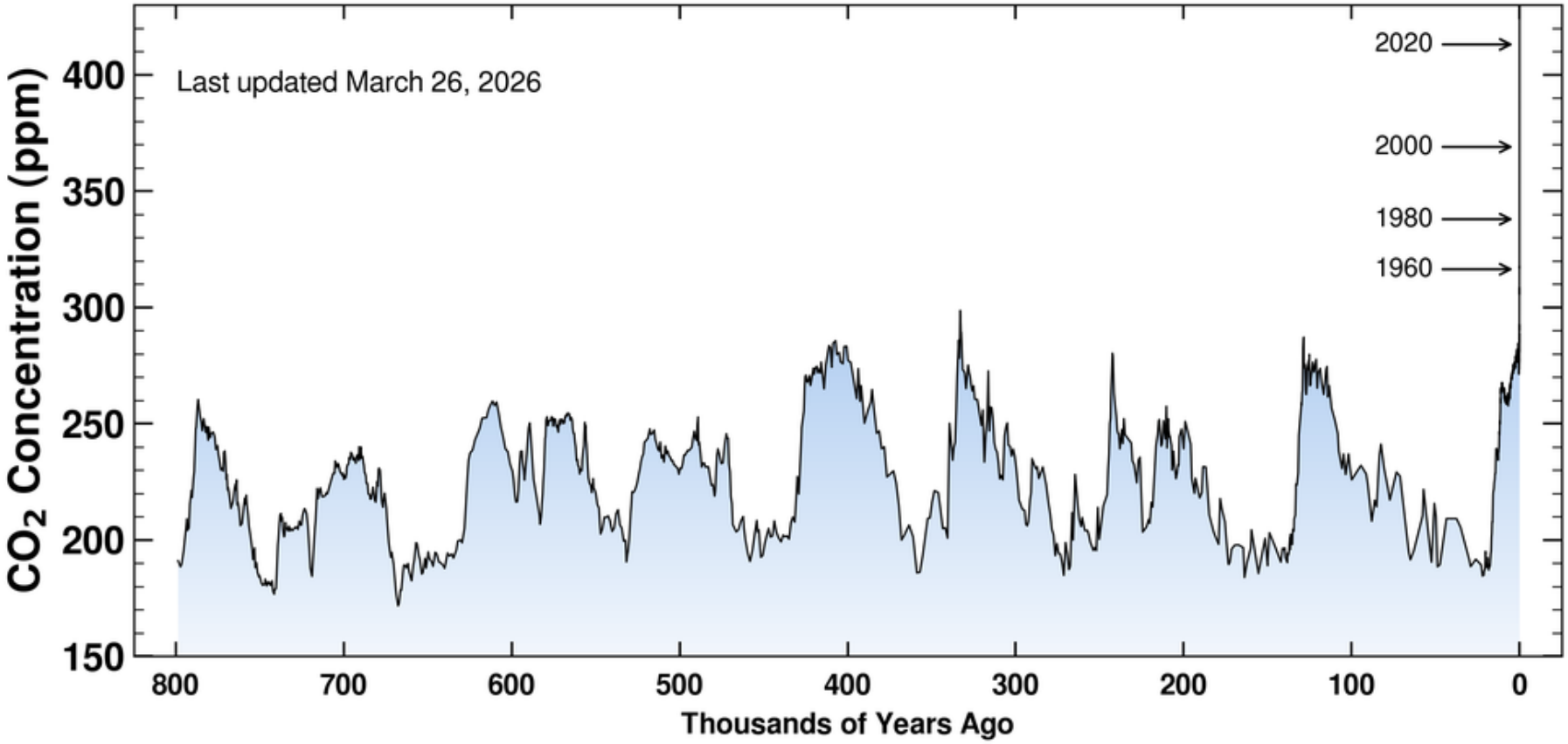
B.2



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

CO_2 Concentration | 800,000 years

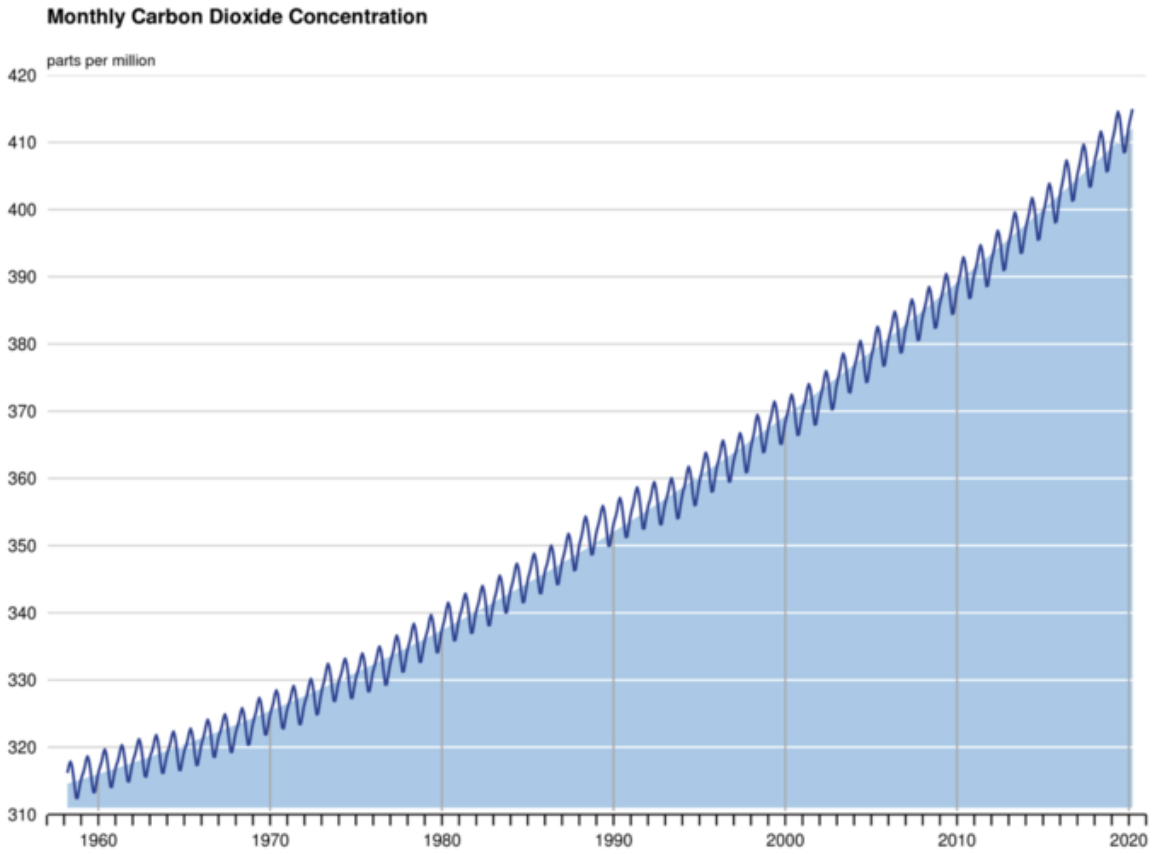
B.2



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

Why does the level fluctuate yearly?

B.2



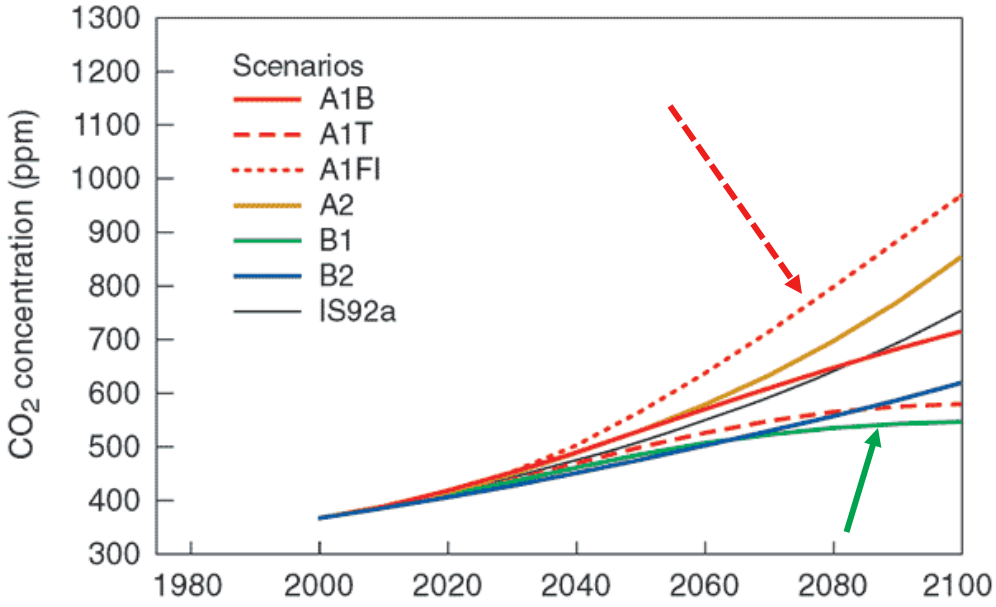
Seasons

**There are more land (plants) in the Northern Hemisphere that remove CO_2 from the atmosphere during the summer months*

B.2

What's Next?

The future of CO_2 depends on the global growth and energy choices



A1B: A world of rapid economic growth with a balanced use of fossil and non-fossil energy sources.

A1T: A rapidly growing world prioritizing non-fossil energy like renewables and nuclear.

A1FI: A rapidly growing world heavily reliant on fossil fuels

A2: A fragmented, self-reliant world with high population growth and slower technological development.

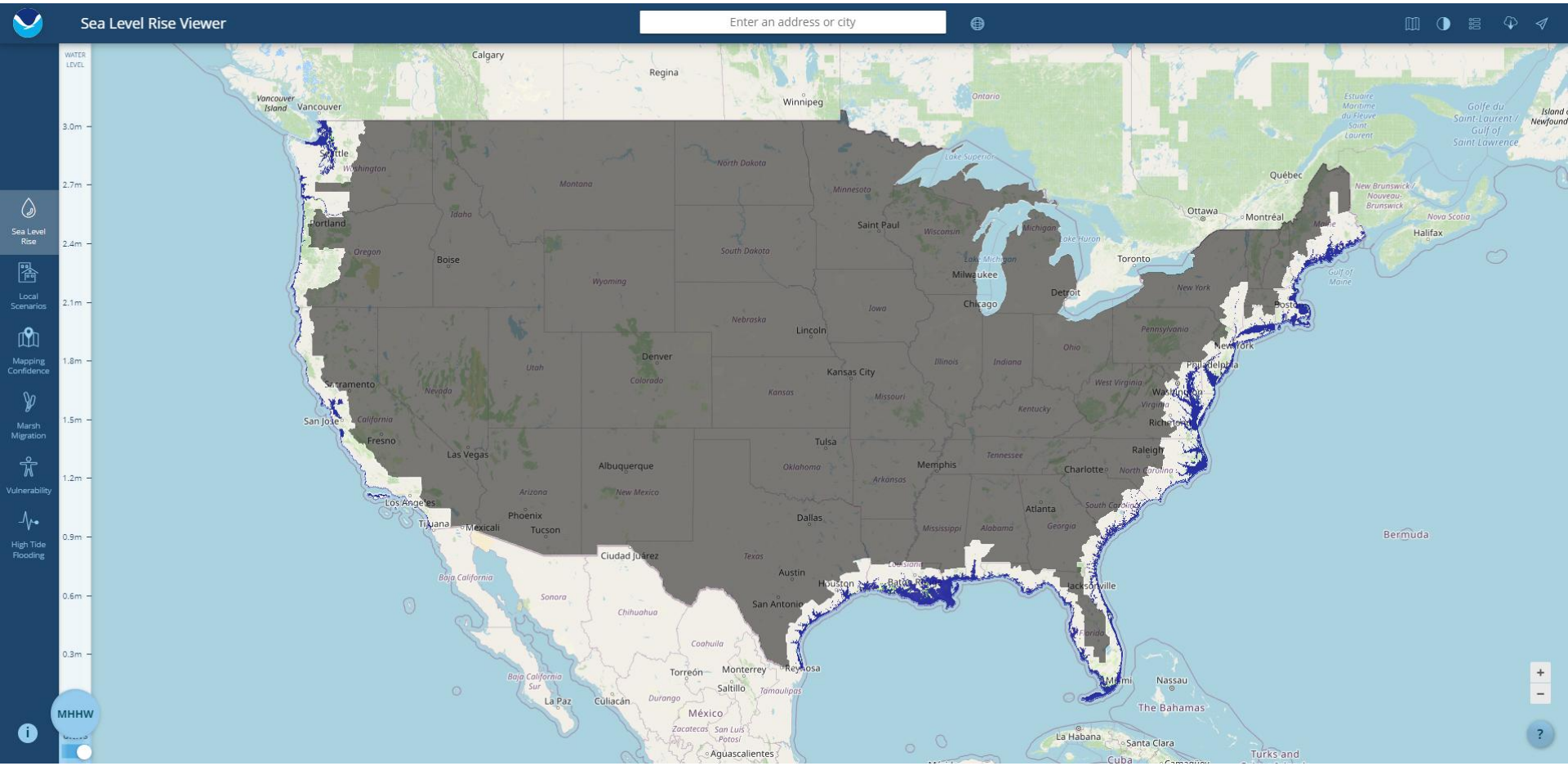
B1: A globally sustainable world focused on clean technology and environmental stewardship.

B2: A locally sustainable world with slower growth and a focus on community-driven solutions.

IS92a: A "business as usual" scenario with moderate growth and no major climate policy changes.

B.2

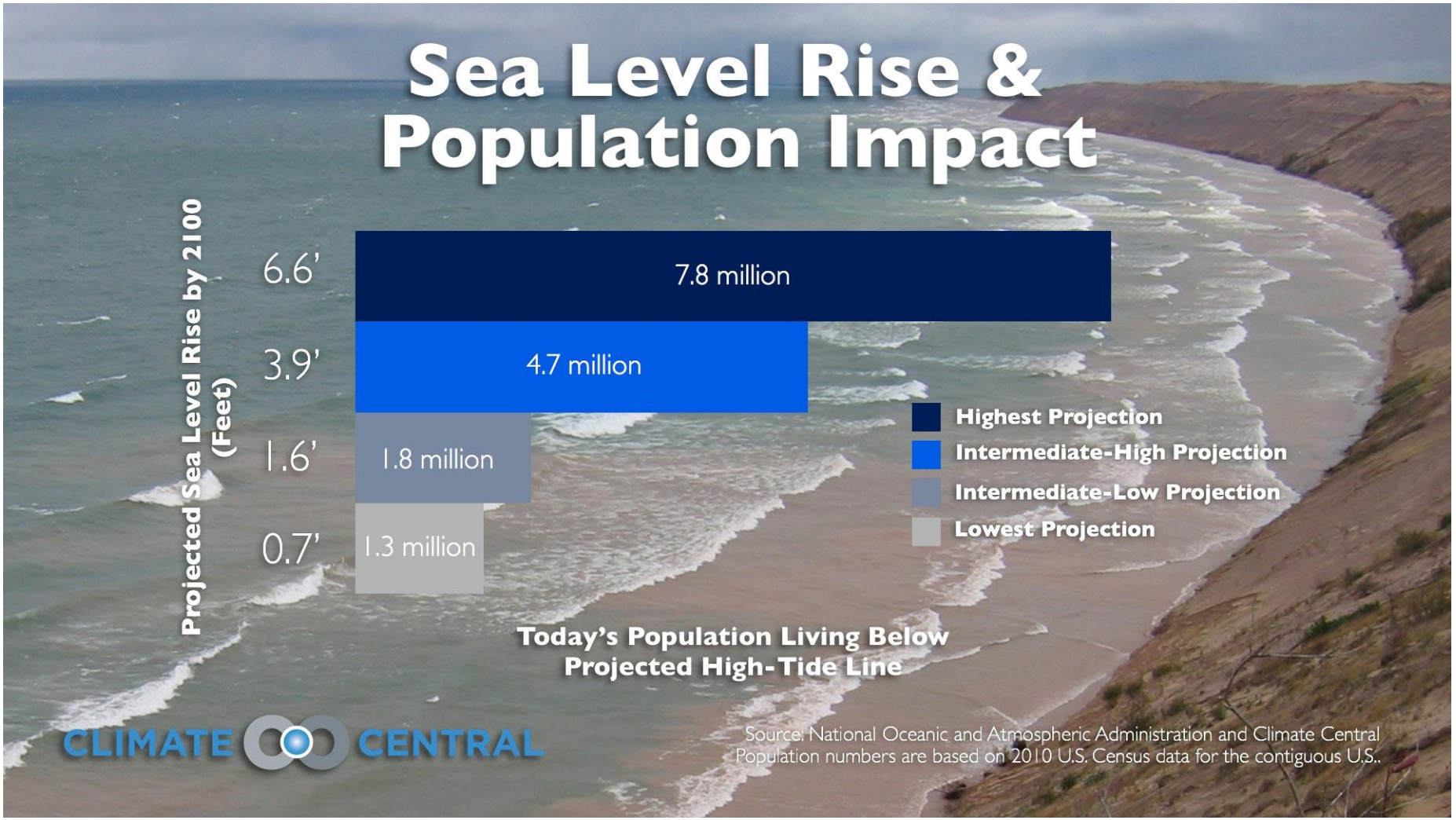
Impacts of Climate Change



https://coast.noaa.gov/slr/#

B.2

Impacts of Climate Change



https://www.climatecentral.org/gallery/graphics/sea-level-rise-and-population-impact

Sea Levels Rising | Melting Ice

B.2

Floating Ice

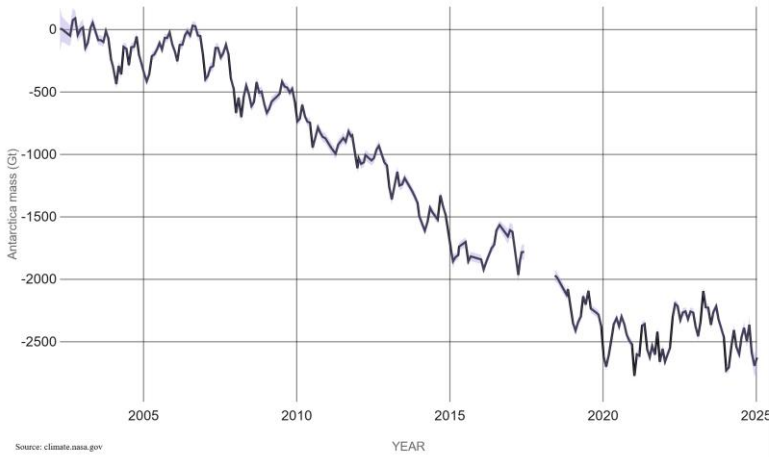
Melting icebergs DO NOT change sea level

Ice sitting on land

Melting glaciers cause the sea level to rise

Sea Levels Rising | Melting Ice

B.2



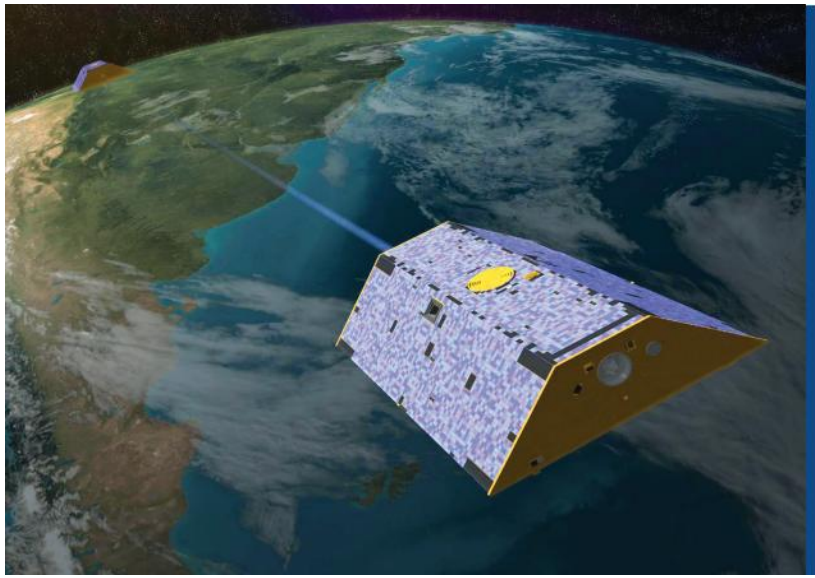
Antarctica ice mass is decreasing at a rate of 150 billion tons per year

Greenland ice mass is decreasing at a rate of 270 billion tons per year

B.2

How are glaciers measured?

A pair of satellites known as GRACE orbit the earth making measurements of the gravitational field by tracking the distance between them. If one orbits over something more massive (like a glacier) it speeds up and the distance between the satellites increases until the other one catches up. By tracking this over time, scientists can identify how glacier mass changes.



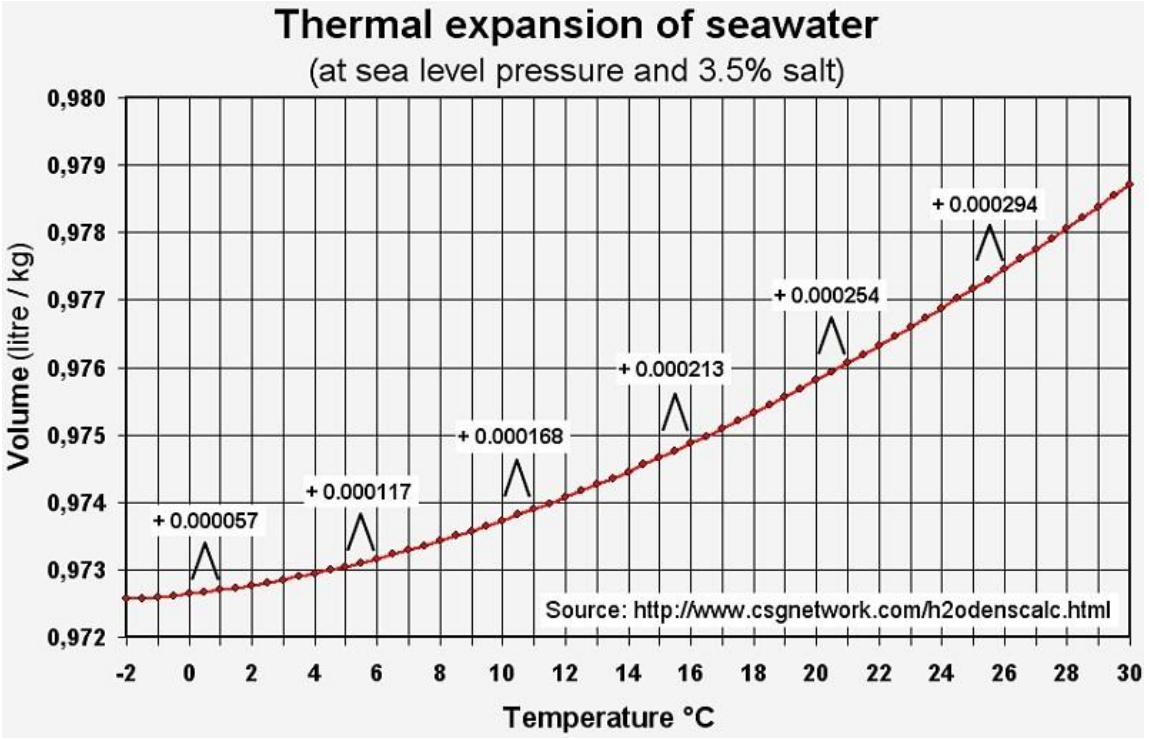
GRACE, twin satellites launched in March 2002, are making detailed measurements of Earth's gravitational field.

Image Source:
NASA / JPL-Caltech

Sea Levels Rising | Expansion

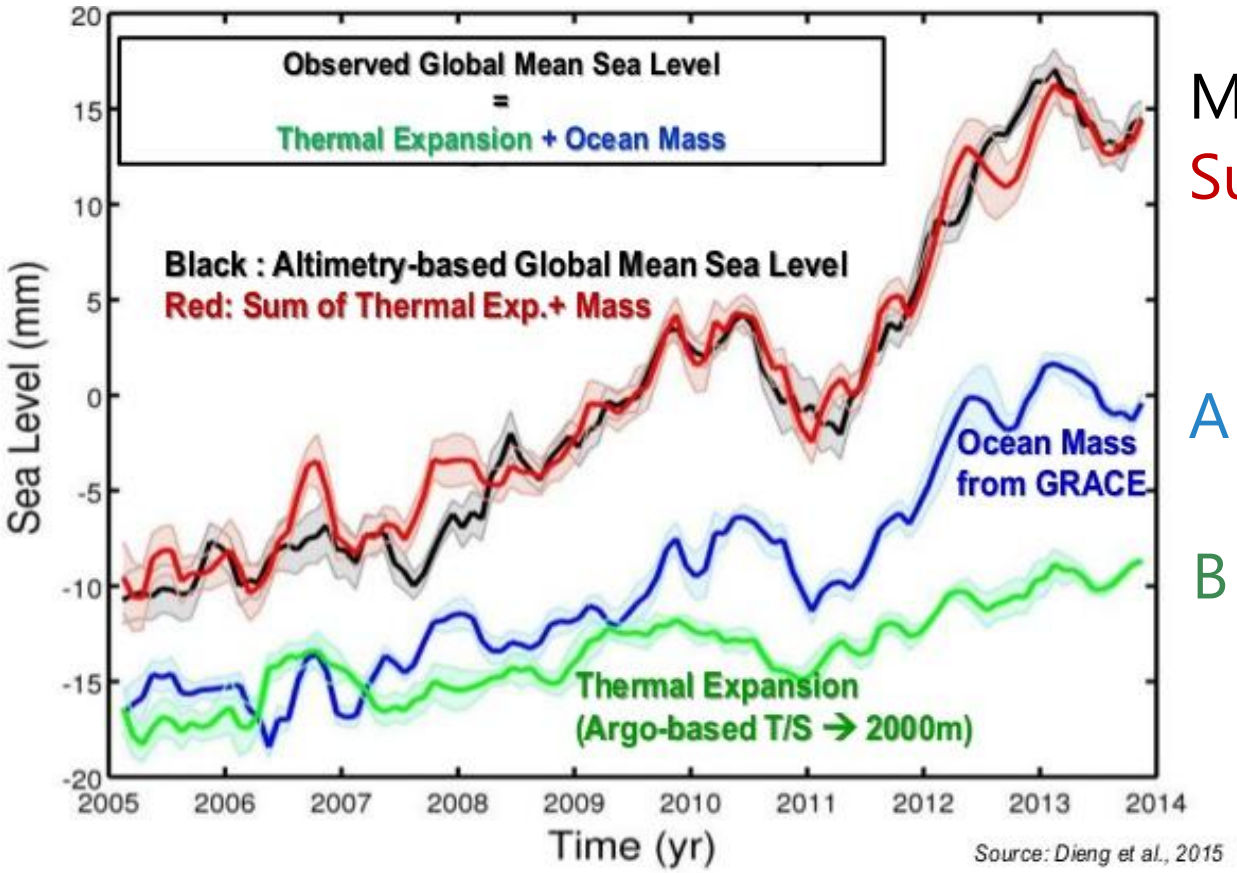
B.2

When most objects are heated they expand. Water is no different.



B.2

Sea Levels Rising



Source: Dieng et al., 2015

Measured Sea Level

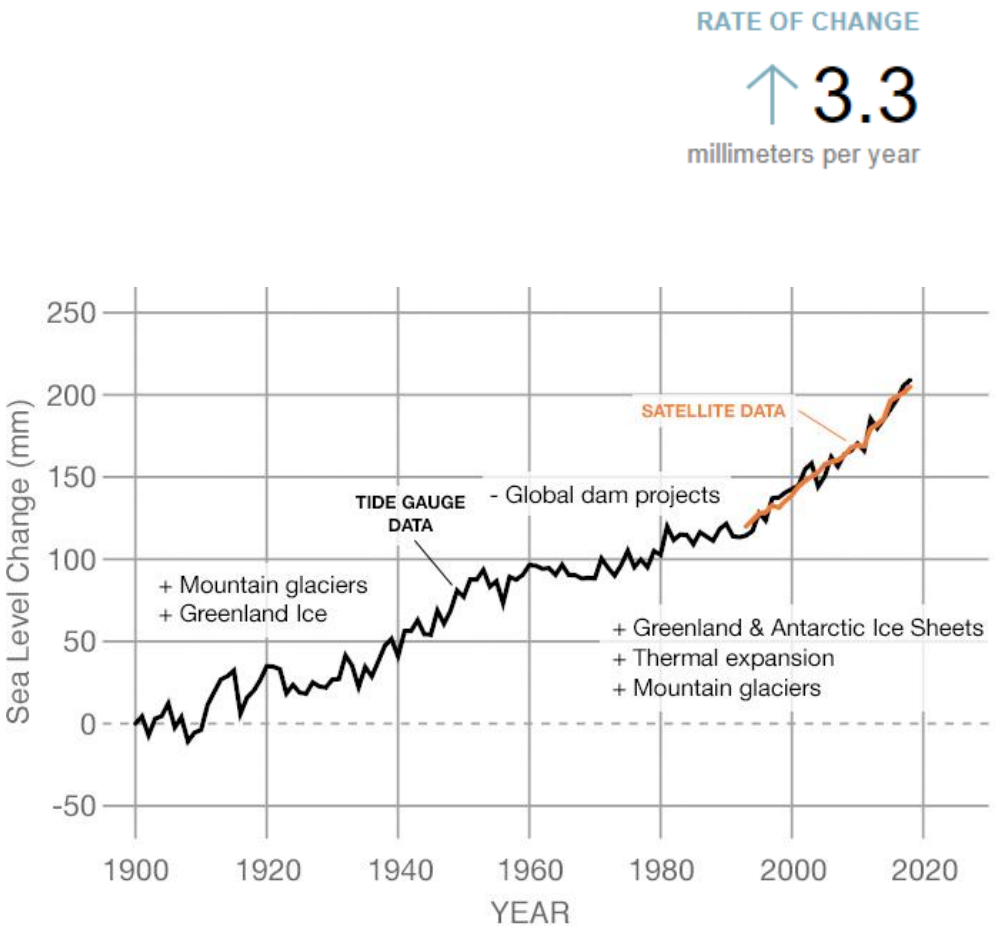
Sum of A and B

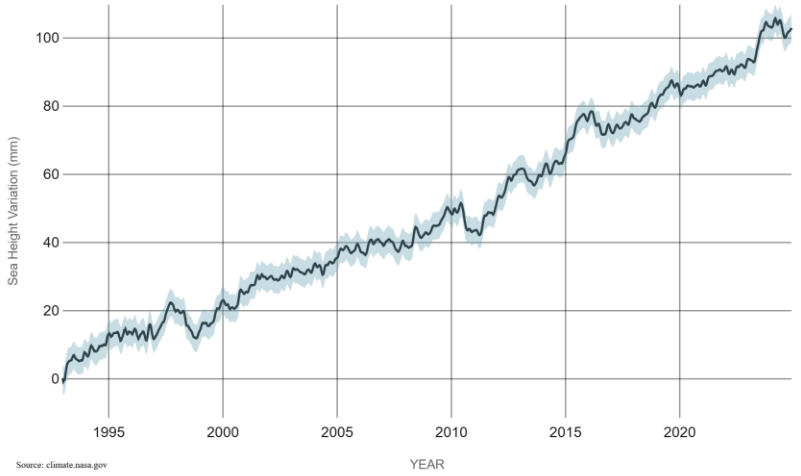
A - Glacier Melt

B - Expanding Water

Ground Based Sea Level | 1900-Present

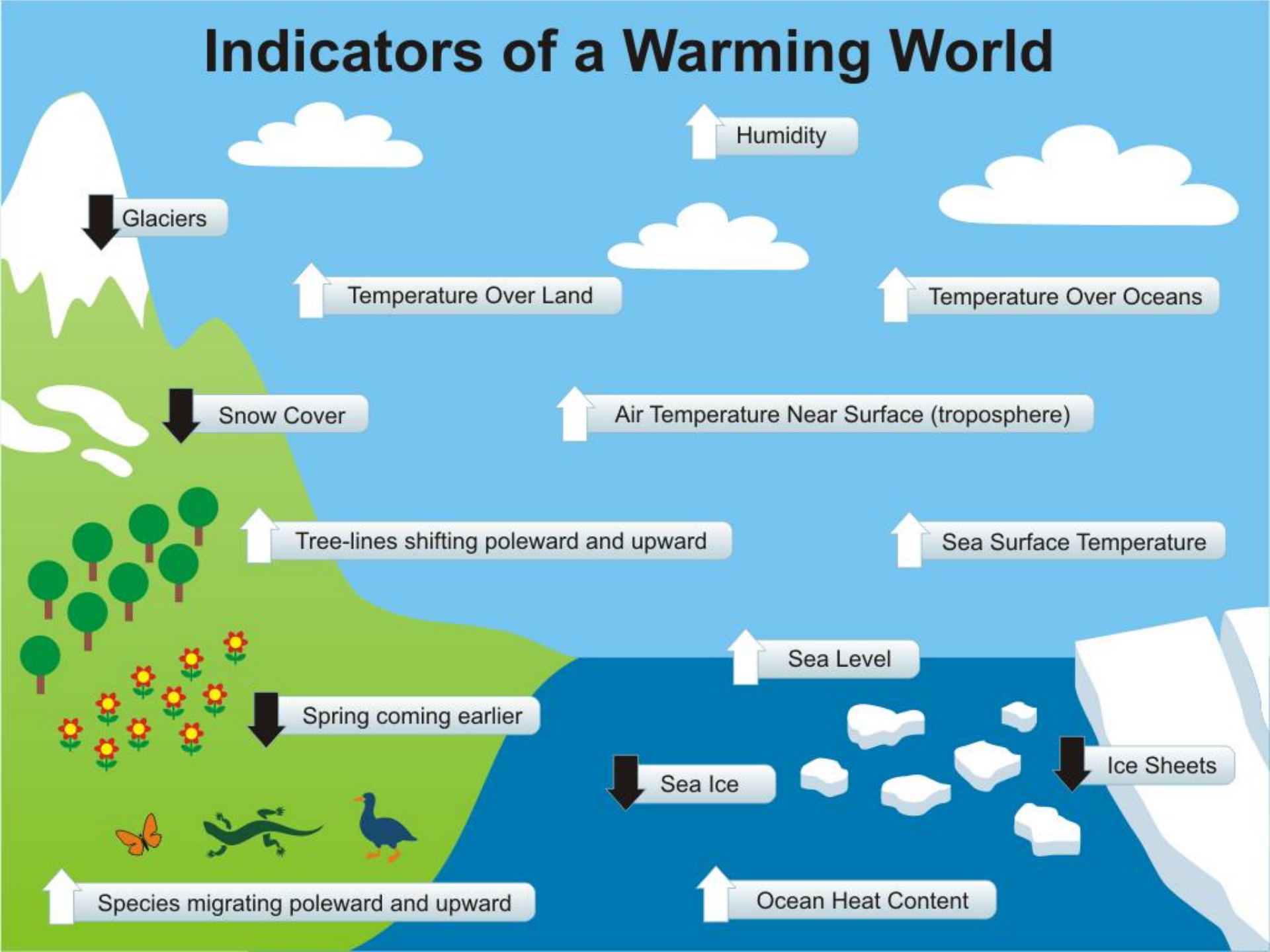
B.2





https://climate.nasa.gov/vital-signs/sea-level

Indicators of a Warming World



B.2

Feedback Loops

Positive Feedback Loop

Warming of Earth leads to events that further warm the Earth

- Melting ice
  - Higher temps decrease ice cover on the planet
  - Decreases albedo
- Melting permafrost
  - Releases methane
- Methane on ocean floor
  - Higher ocean temperatures release frozen methane deposits

Negative Feedback Loop

Warming of Earth leads to events that start to cool the Earth

- More Clouds
  - Higher temps evaporate more water
  - Increase Albedo
- Increased Photosynthesis
  - More CO_2 leads to more plant life that absorbs CO_2
- Renewable Investment
  - Higher temperatures lead to a greater urgency for change

How we know we're causing global warming

Shrinking upper atmosphere

Less heat escaping to space

Cooling upper atmosphere

Rising tropopause

Winter warming faster than summer

More fossil fuel carbon in the air

Less oxygen in the air

Nights warming faster than days

More heat returning to Earth

Pattern of ocean warming

More fossil fuel carbon in trees

More fossil fuel carbon in coral

More fossil fuel carbon in ocean

Lesson Takeaways

B.2

- ❑ I can describe the greenhouse effect as absorption and re-emission of thermal energy
- ❑ I can list the gases that have the largest impact on the greenhouse effect and their natural/human sources
- ❑ I can describe the long term and seasonal trends in the carbon dioxide concentration
- ❑ I can list examples of positive and negative feedback loops in terms of the climate discussion