B.2

# Climate Change

IB PHYSICS | ASTROPHYSICS

# Temperature has been Rising

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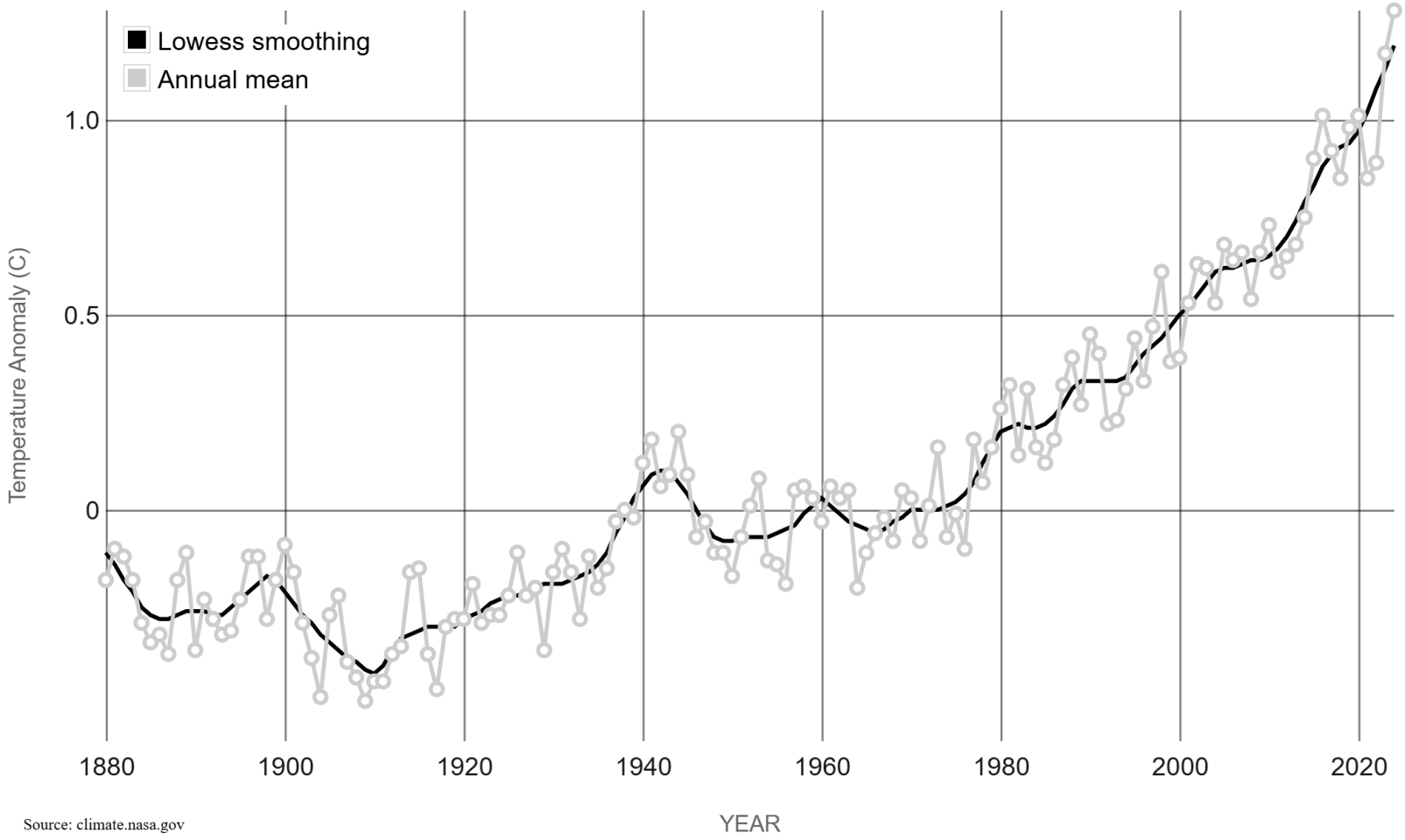
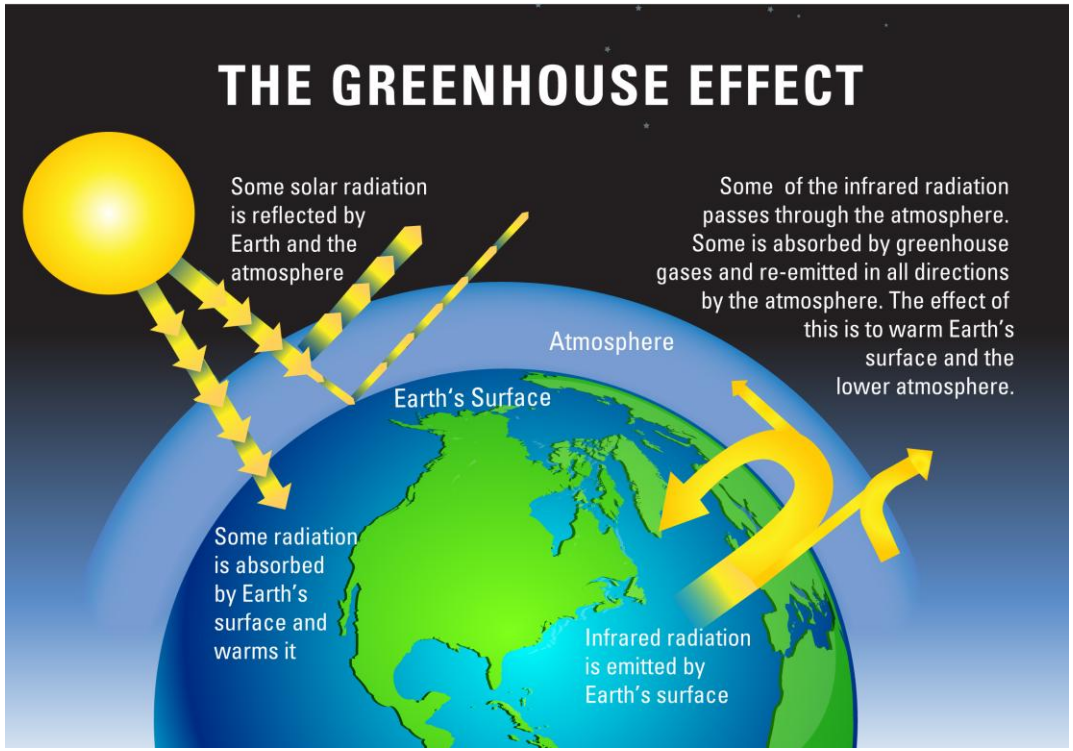



Source: climate.nasa.gov

# Greenhouse Effect

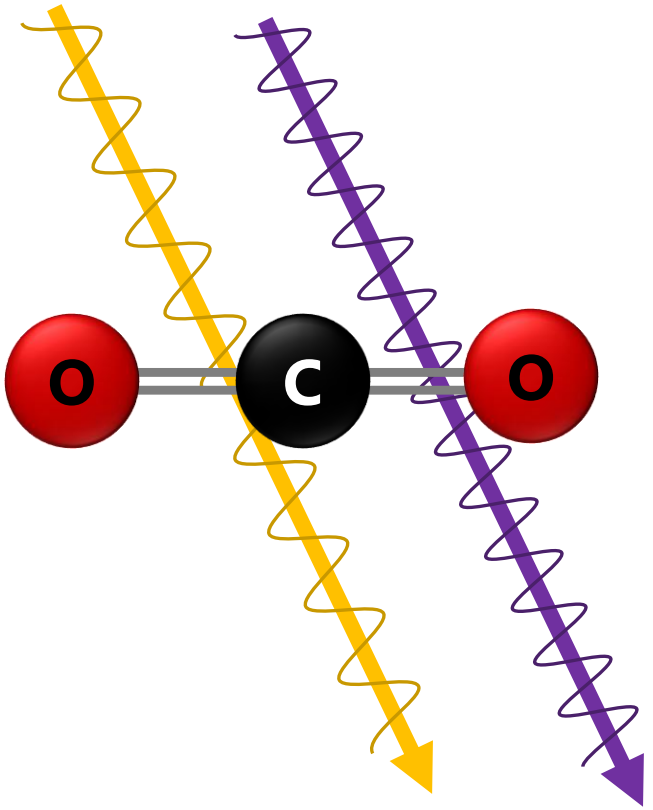
If there was no atmosphere, the earth would experience a net loss of energy and reach equilibrium at an average temperature about 30°C colder than it is currently.

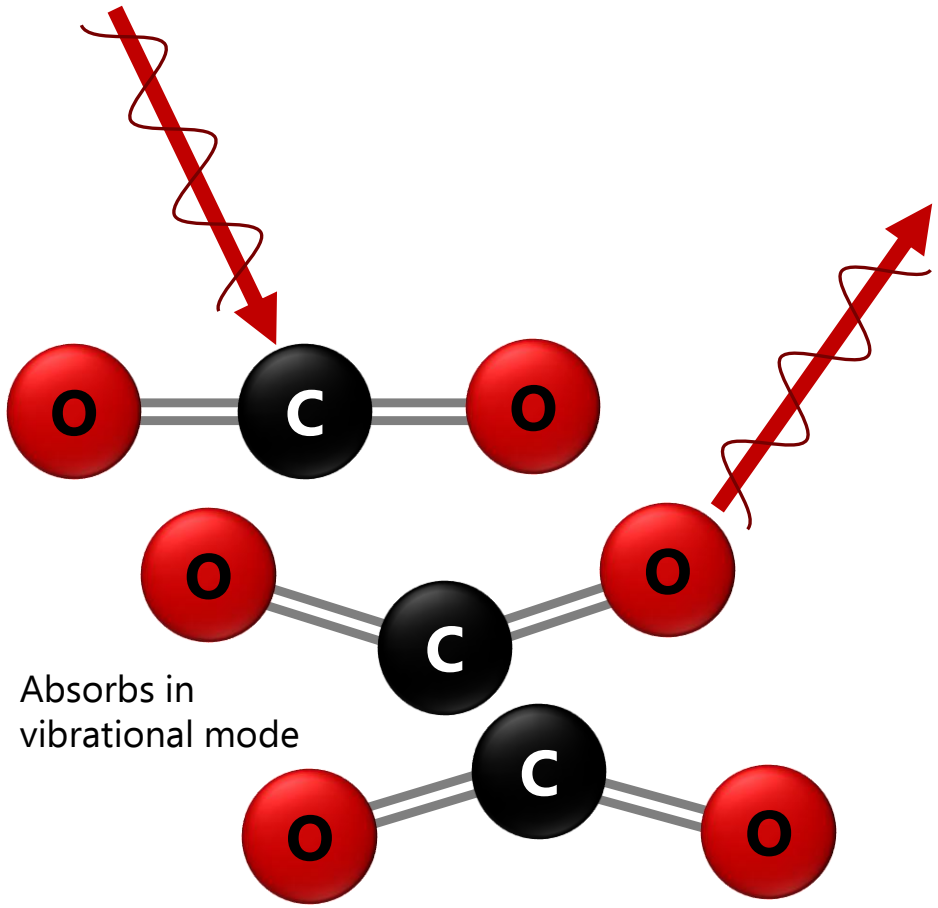



We see from the climate models that the concentration of greenhouse gases is the driving factor causing the climate to change

# Some Gases Absorb Light

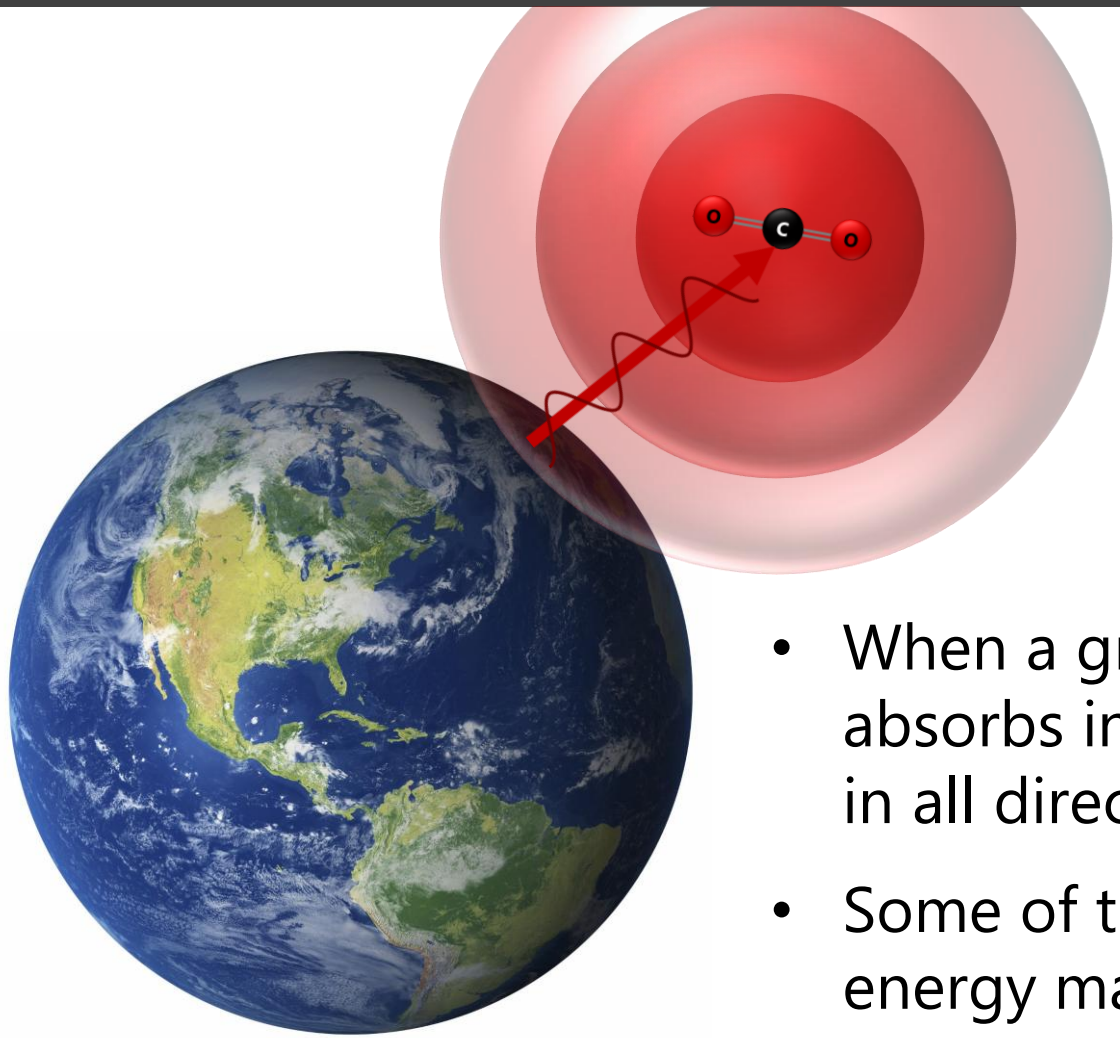
B.2



# Energy is Re-emitted

B.2



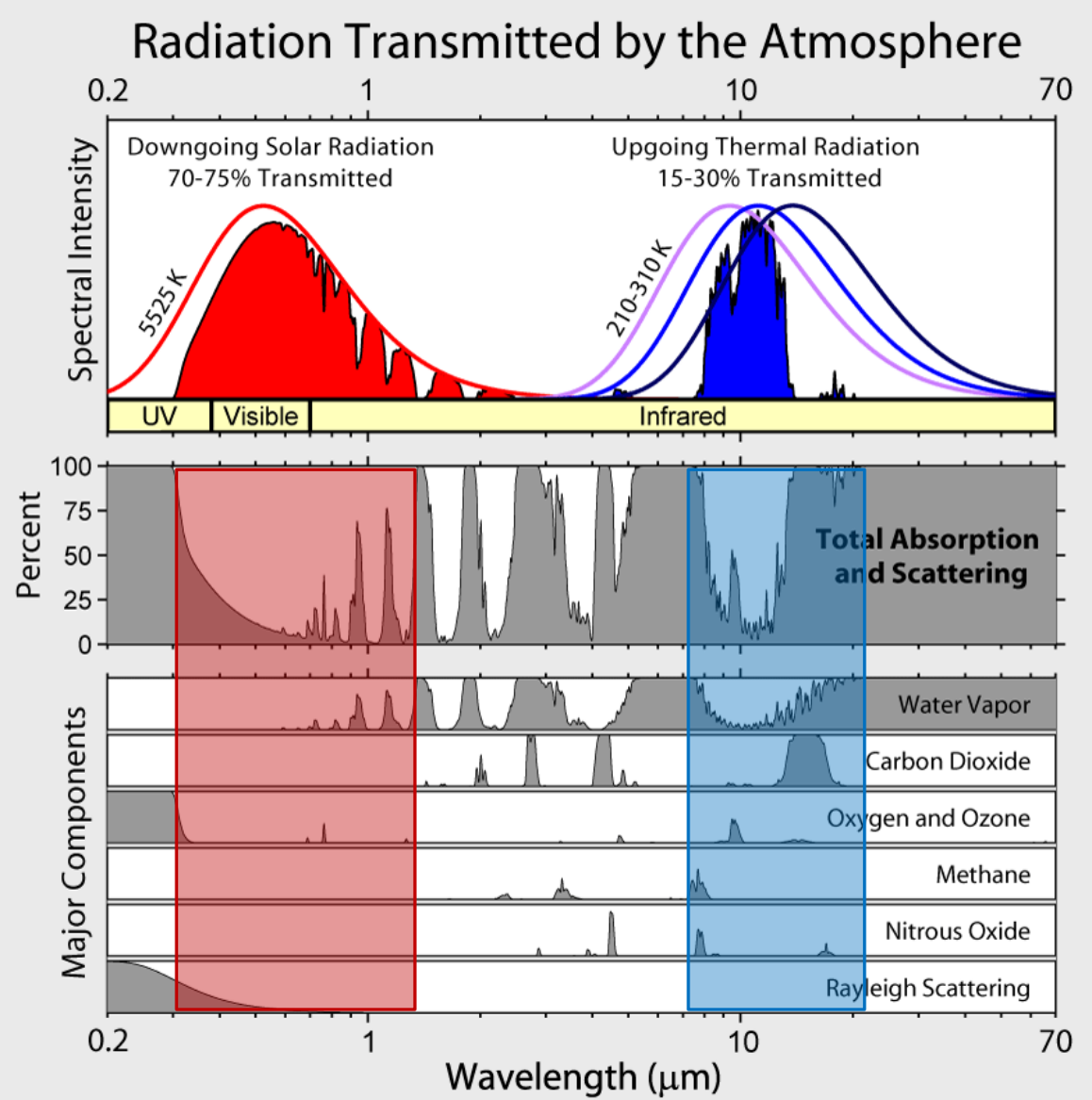

- When a greenhouse gas absorbs infrared, it re-emits in all directions.
- Some of this re-emitted energy makes it back to earth

# The Greenhouse Effect

B.2

# Role of the Atmosphere

B.2



B.2

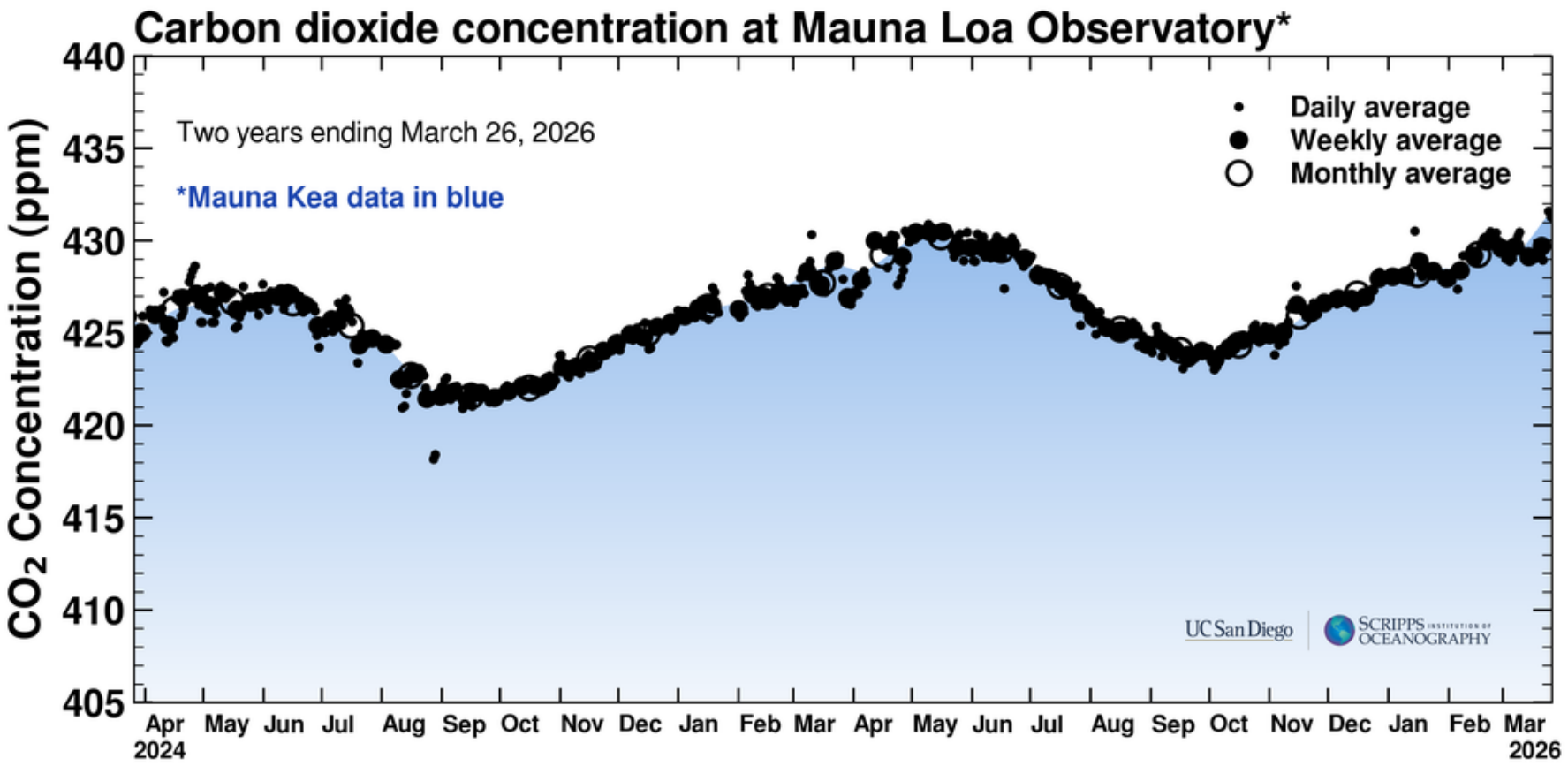
# Where do they come from?

| Greenhouse Gas | Natural | Human Activity |
| --- | --- | --- |
| Water Vapor | | |
| Carbon Dioxide | | |
| Oxygen / Ozone | | |
| Methane | | |
| Nitrous Oxide | | |

# $CO_2$ Concentration | 2 years

B.2

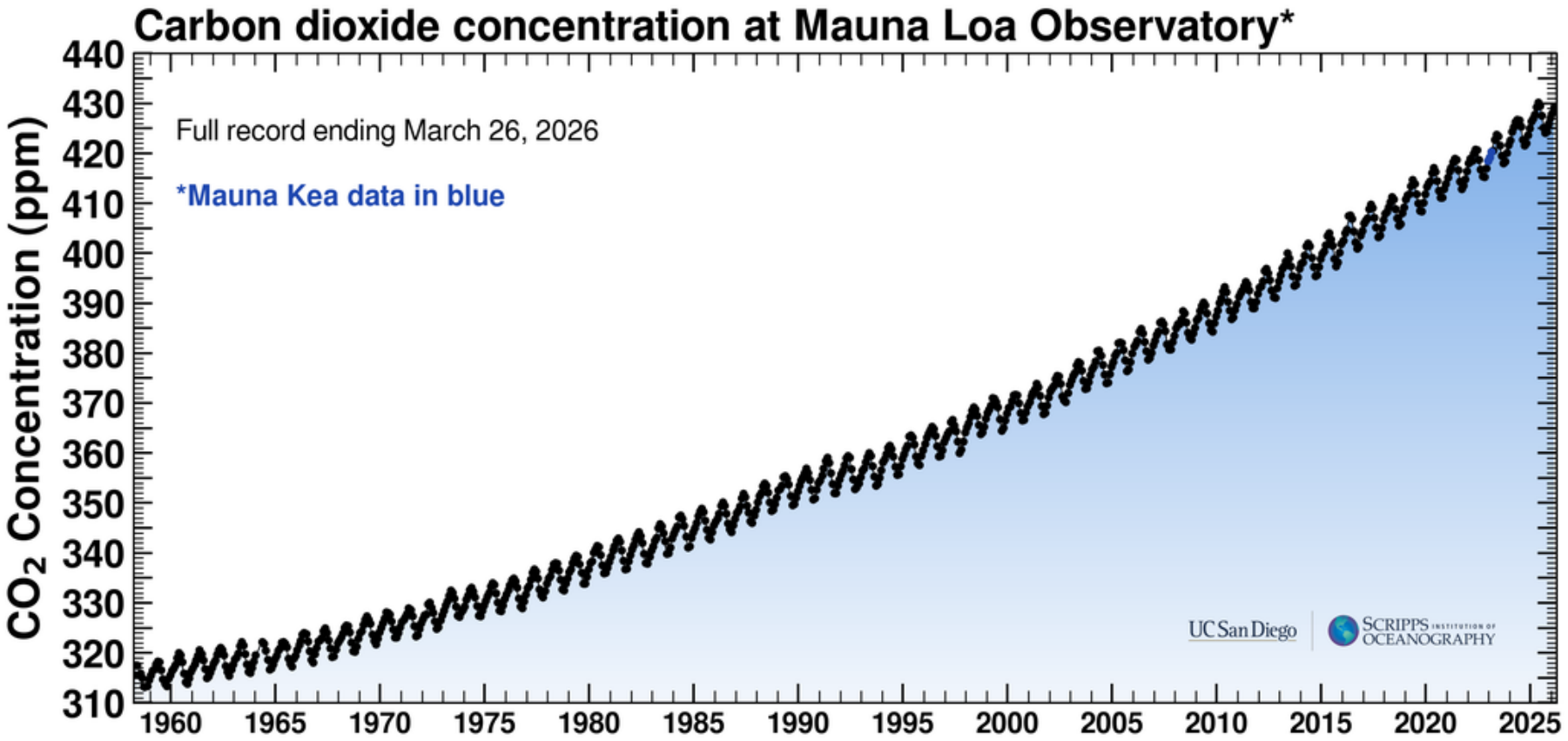
Latest $CO_2$ Reading: **431.28 ppm**




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

# $CO_2$ Concentration | 63 years

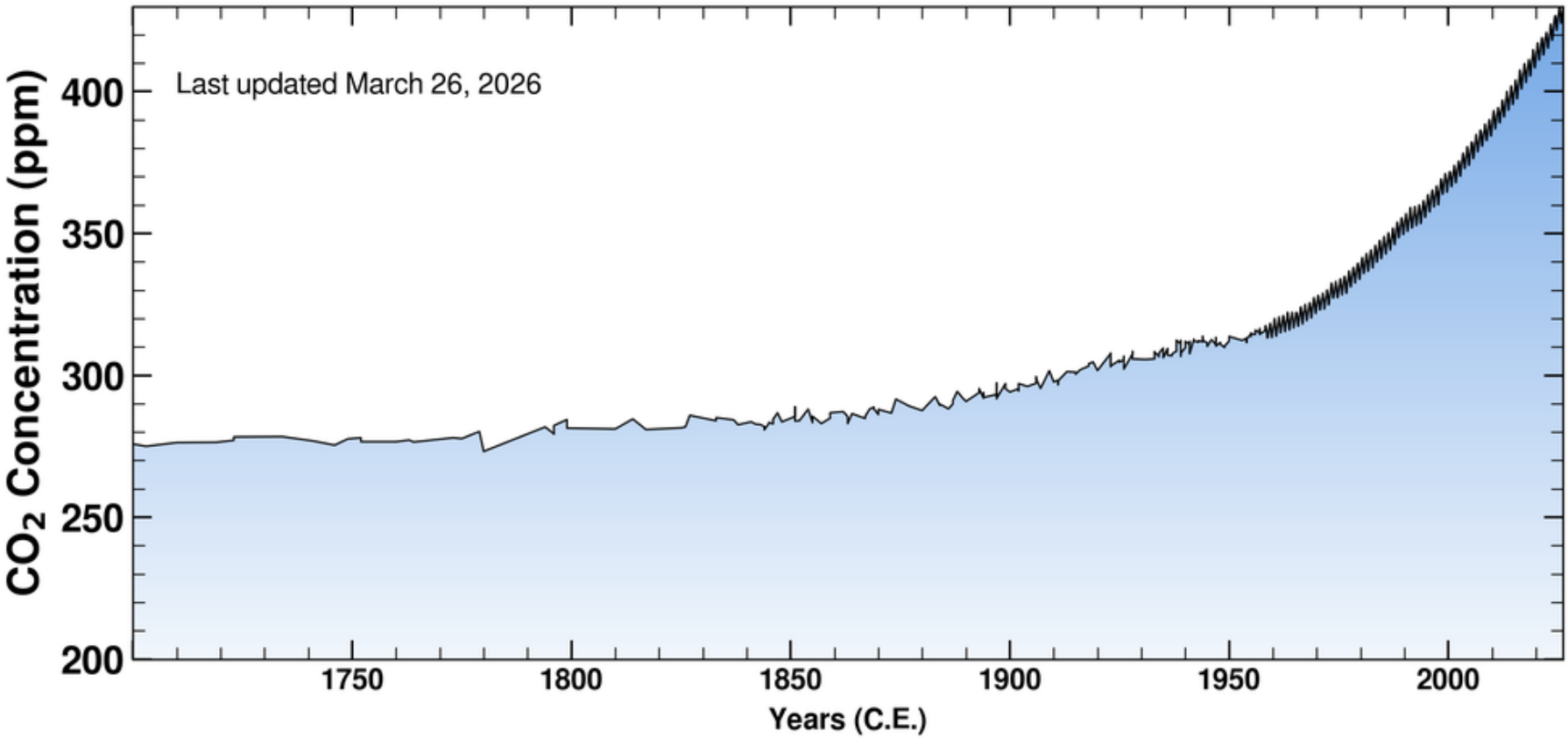
B.2




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

# $CO_2$ Concentration | 300 years

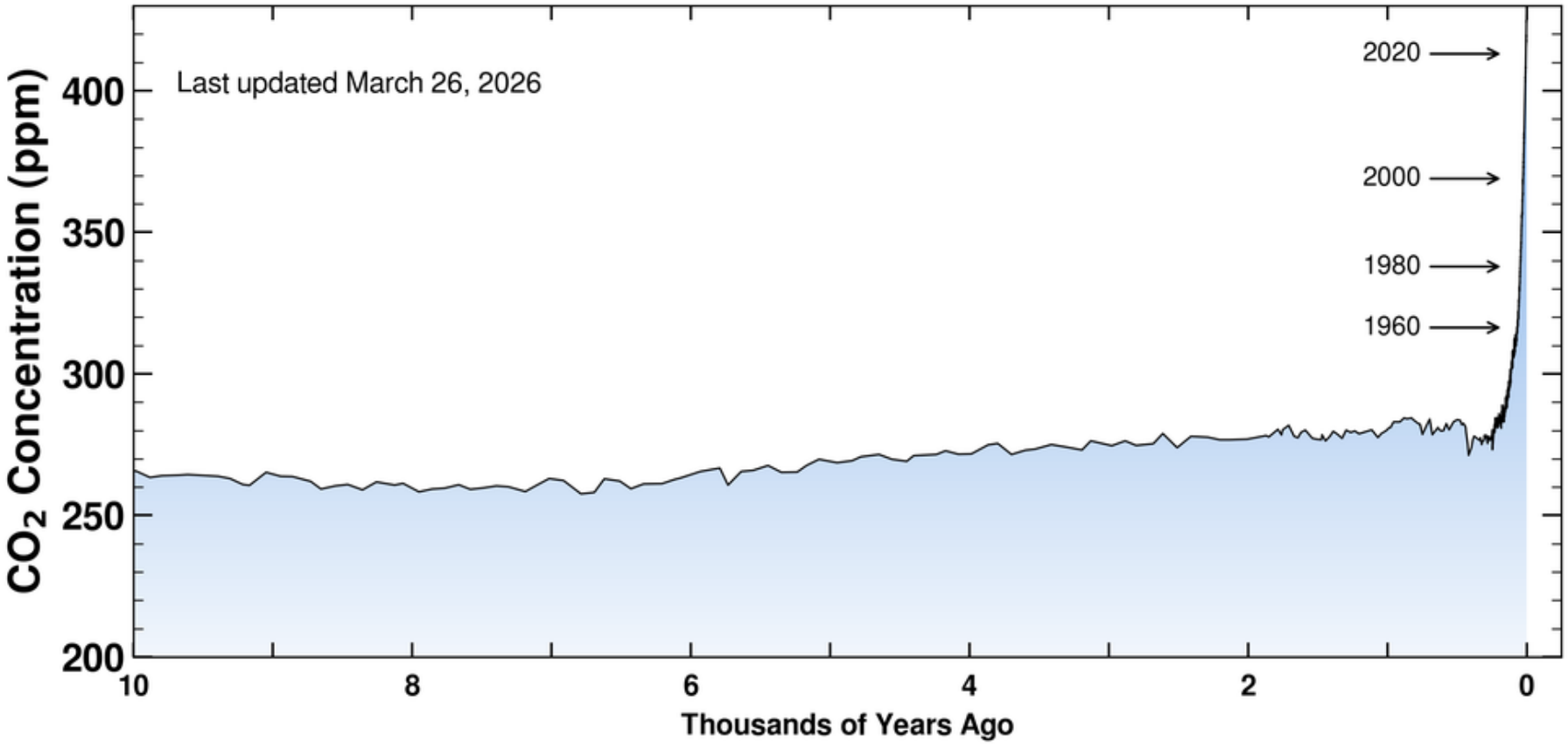
B.2




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

# $CO_2$ Concentration | 10,000 years

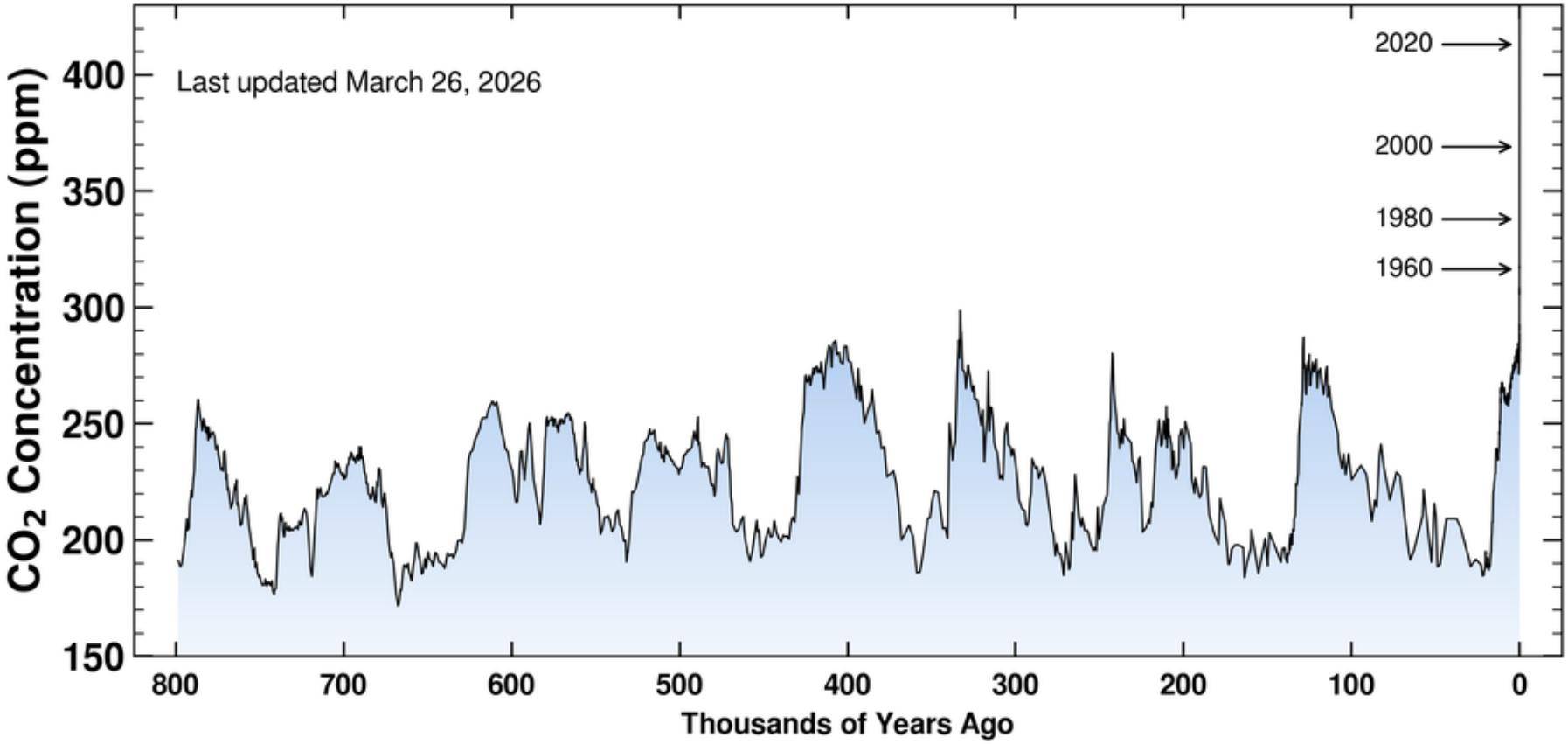
B.2




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

# $CO_2$ Concentration | 800,000 years

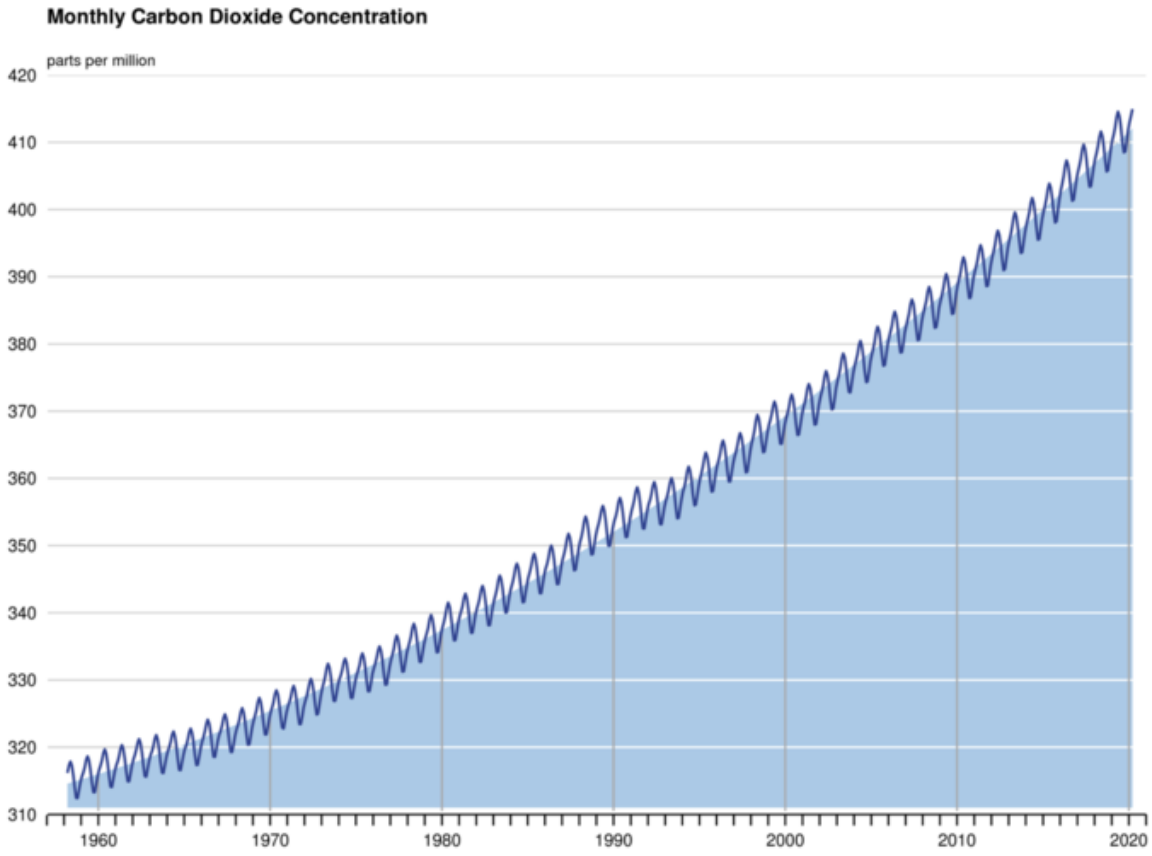
B.2




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

# Why does the level fluctuate yearly?

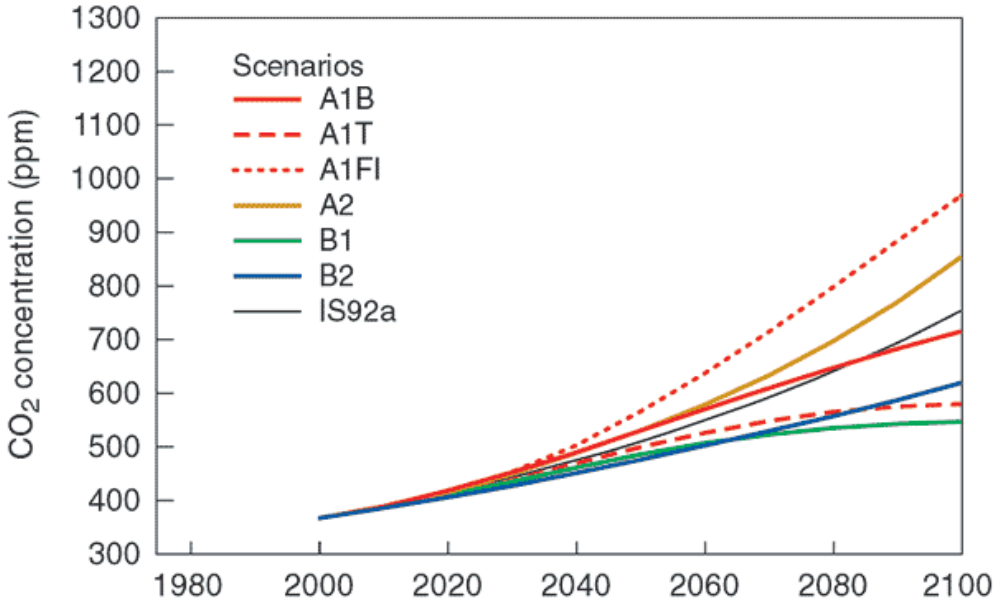
B.2



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.

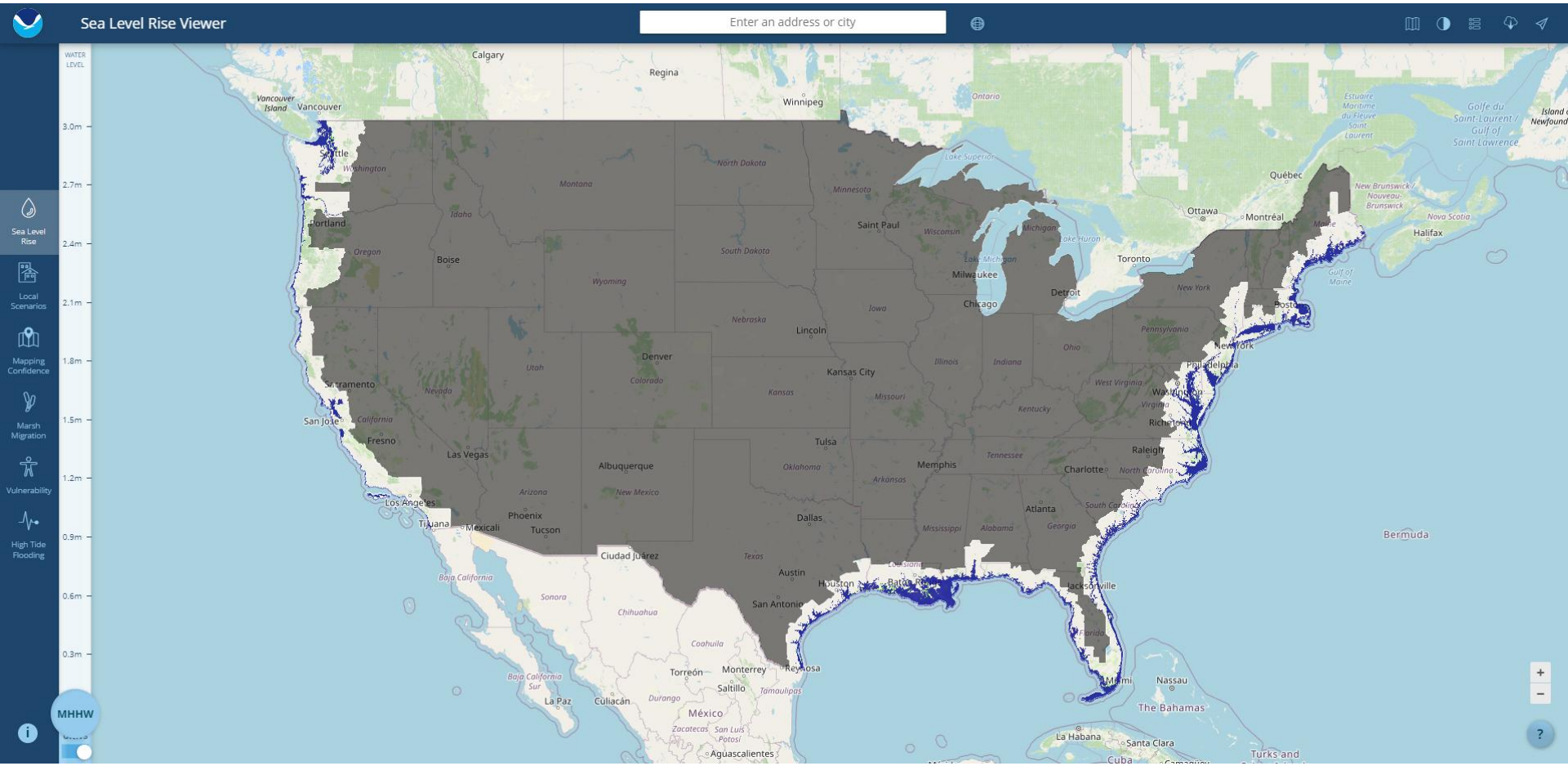
B1: A globally sustainable world focused on clean technology and environmental stewardship.

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/#

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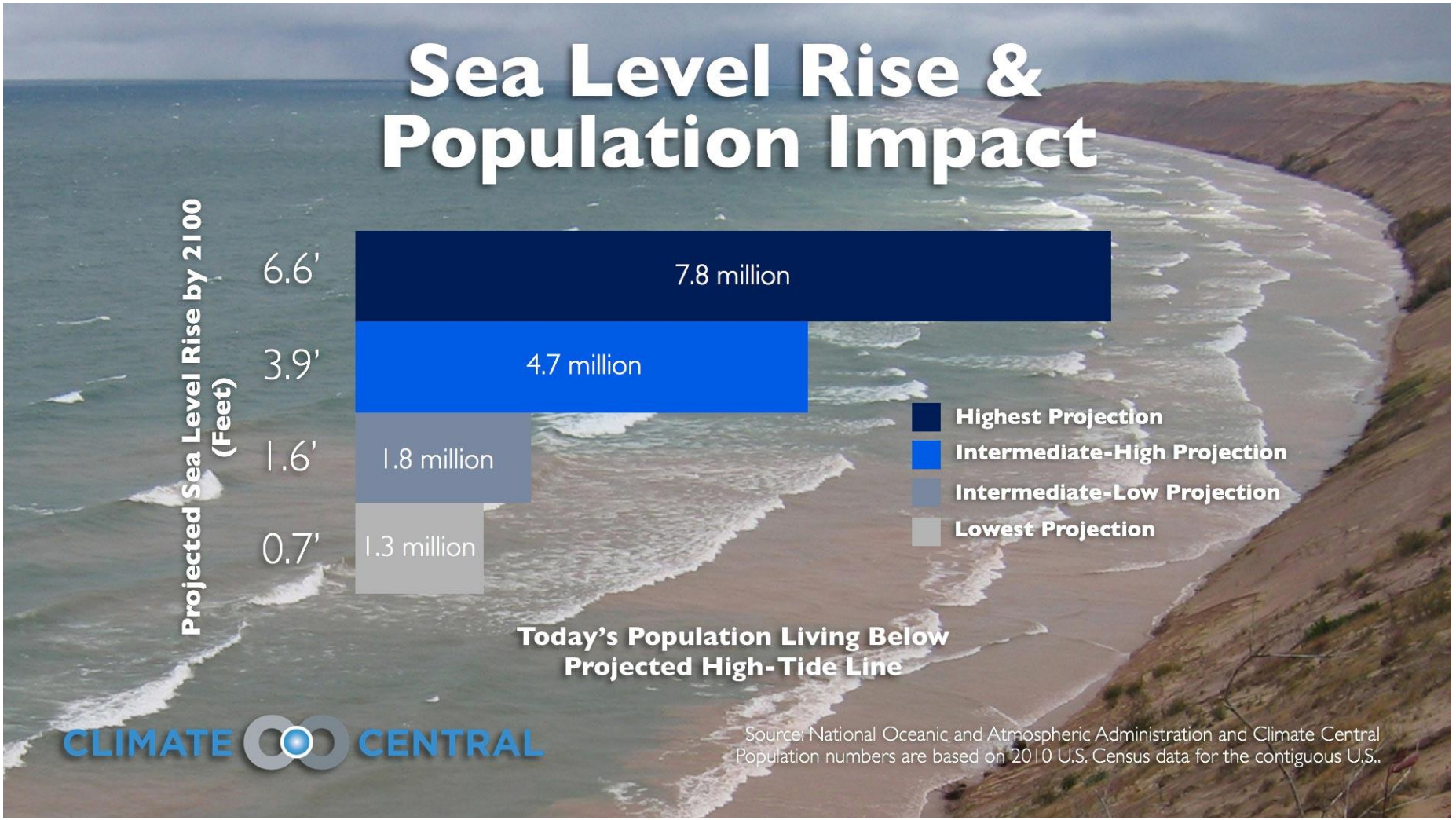
# Impacts of Climate Change




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

# Sea Levels Rising | Melting Ice

B.2

Floating Ice

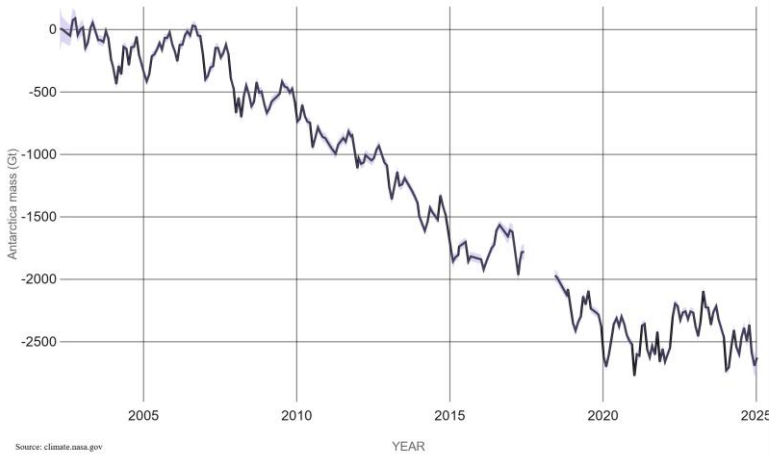
Melting icebergs DO NOT change sea level

Ice sitting on land

Melting glaciers cause the sea level to rise

# Sea Levels Rising | Melting Ice

B.2



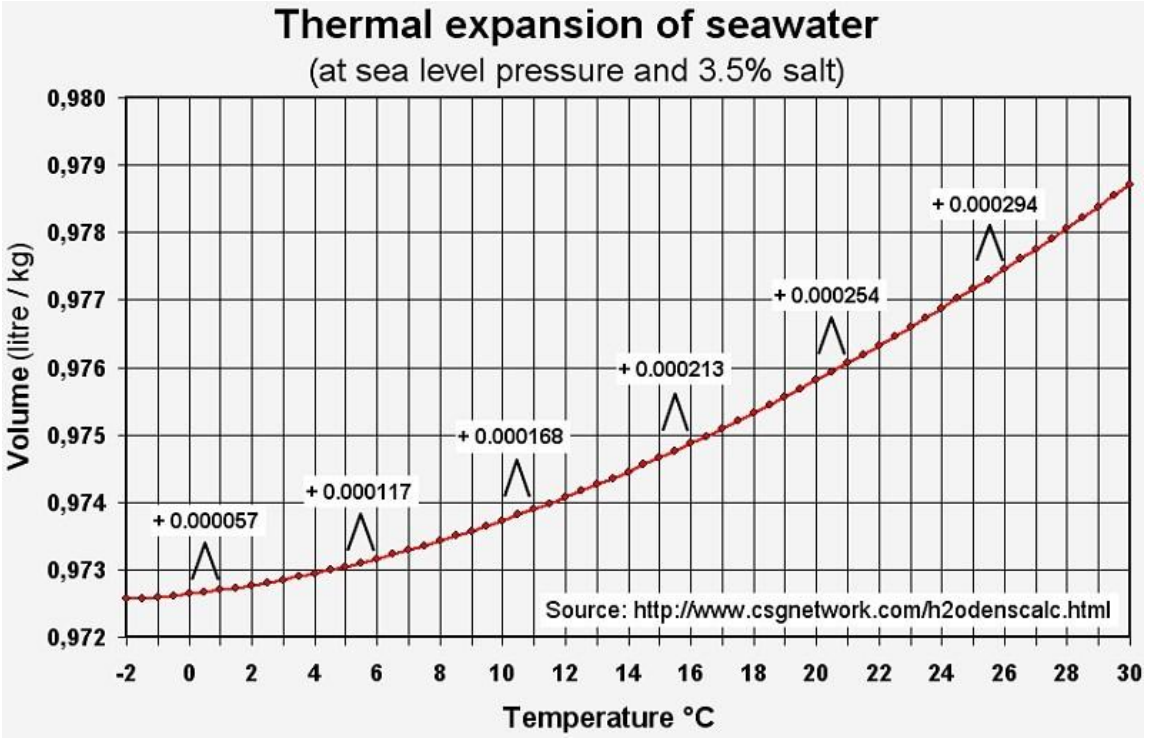

Antarctica ice mass is decreasing at a rate of 150 billion tons per year

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

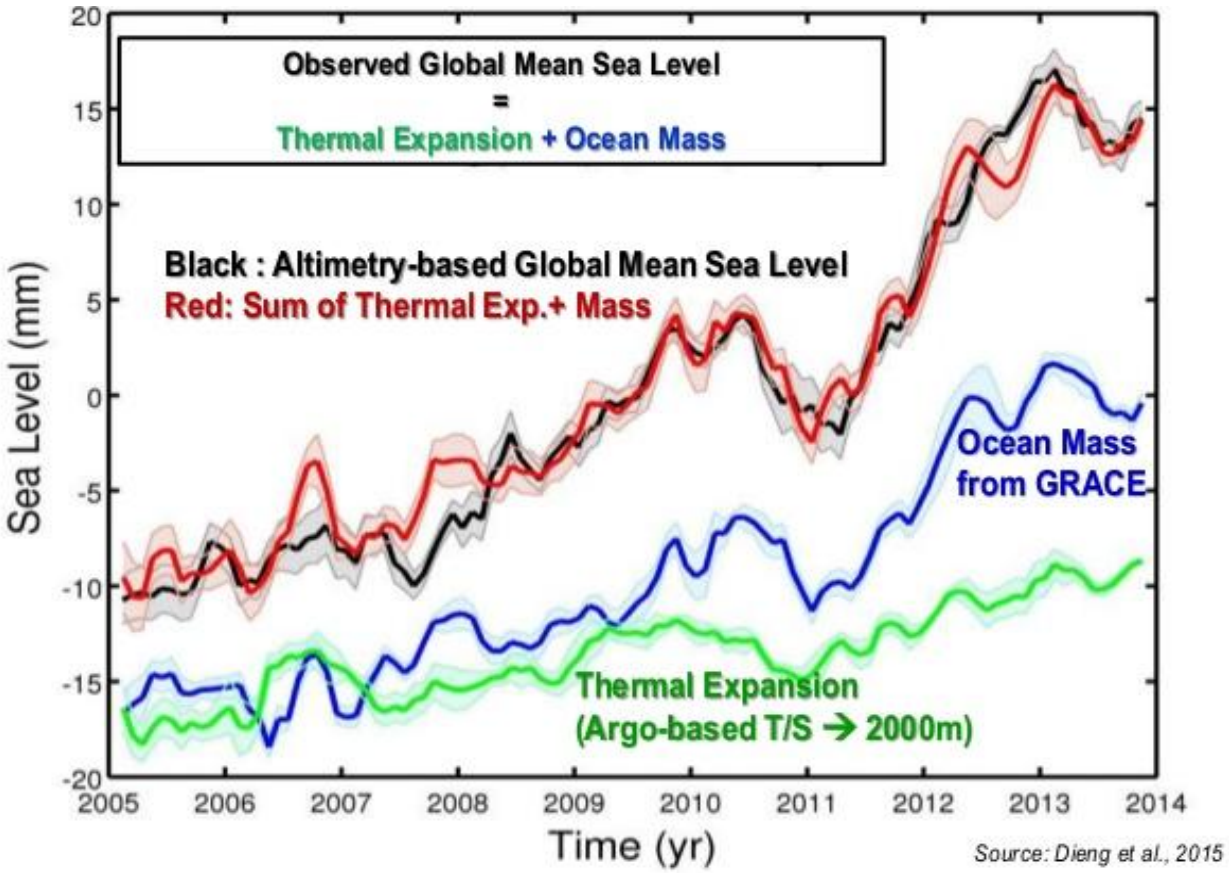
# Sea Levels Rising | Expansion

B.2

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



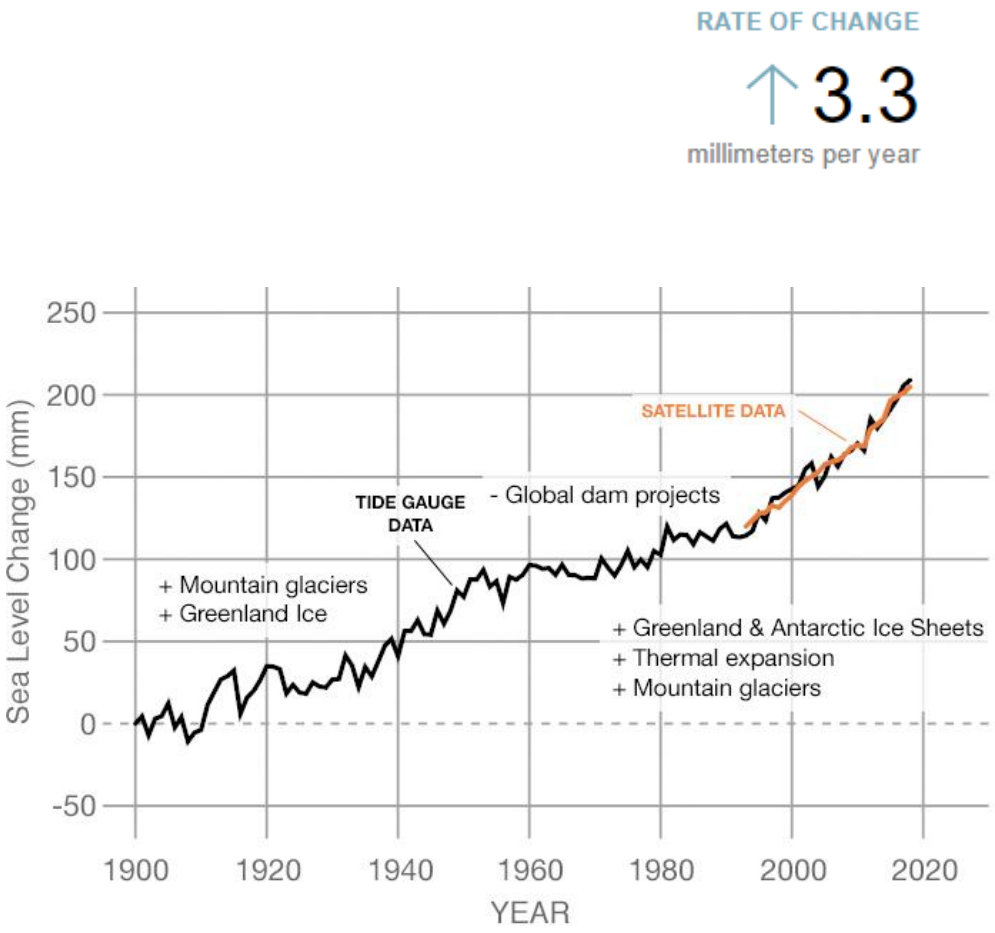
# Sea Levels Rising

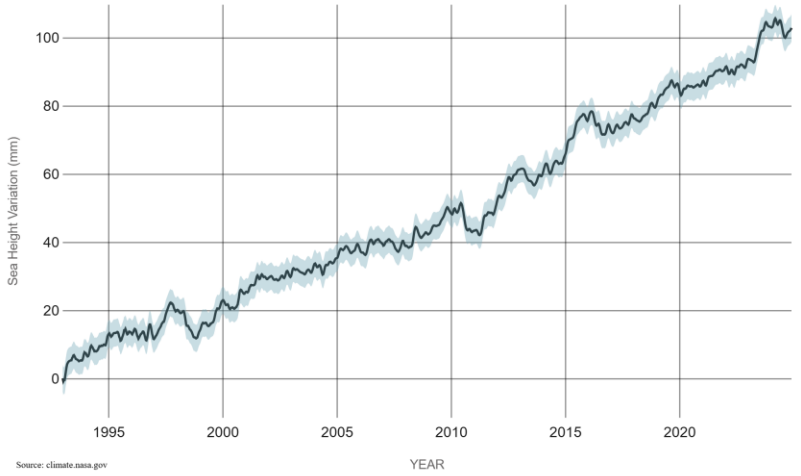



*Source: Dieng et al., 2015*

# Ground Based Sea Level | 1900-Present

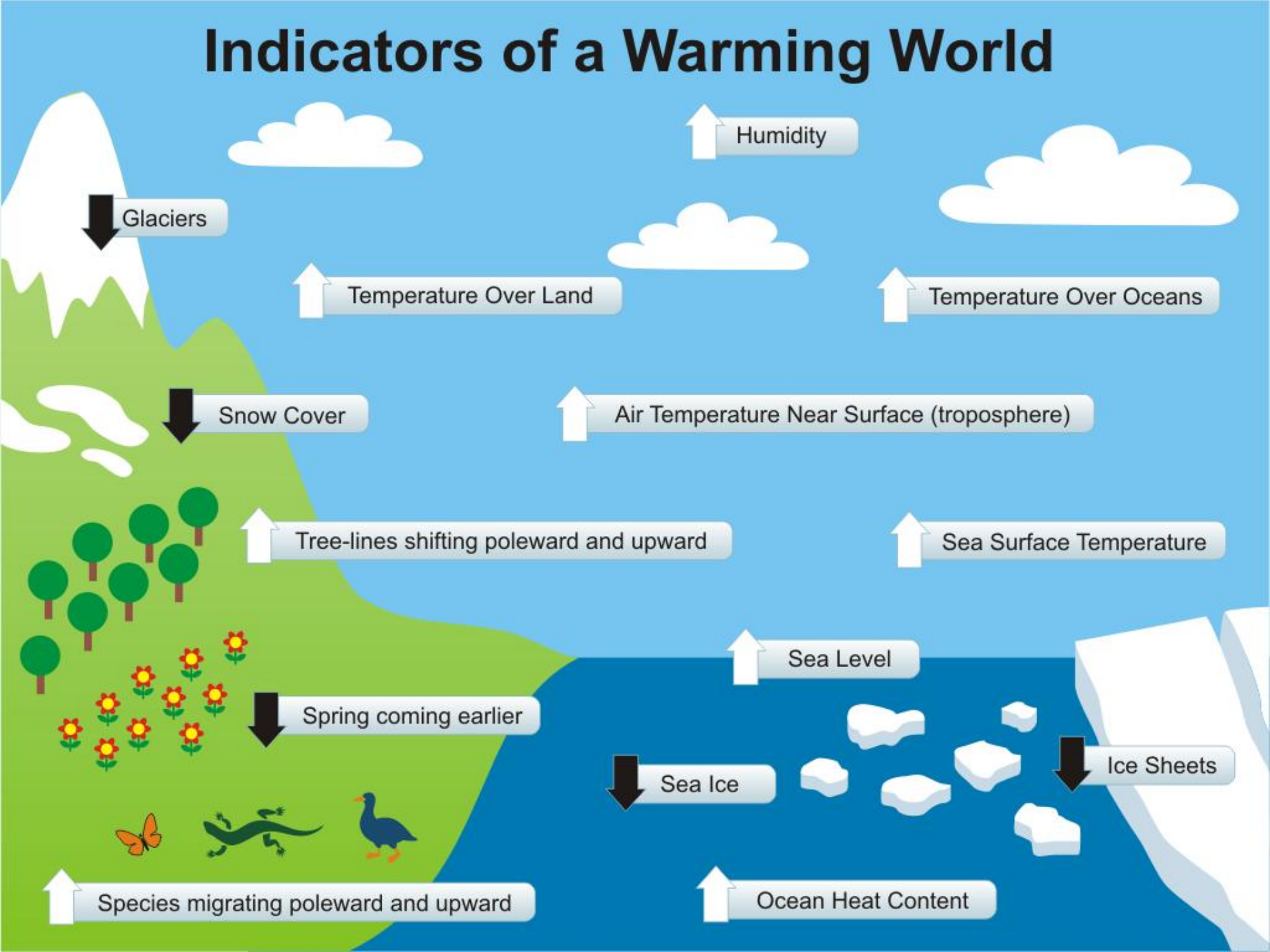
B.2




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

# Indicators of a Warming World



# Feedback Loops

B.2

## Positive Feedback Loop

Warming of Earth leads to events that further warm the Earth

## Negative Feedback Loop

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

# 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