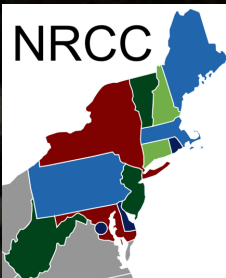
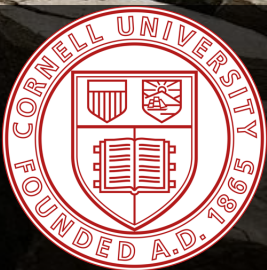




# The Climate Crisis:

Where are we in 2023?

Colin Evans, Ph.D.  
Postdoctoral Research Associate  
Northeast Regional Climate Center  
Cornell University



A satellite view of Earth from space, showing a large, swirling storm system over the ocean. The satellite's structure, including a large solar panel array, is visible in the upper left corner. The text "Two main drivers of climate and weather on Earth" is overlaid in white on a dark horizontal band across the center of the image.

Two main drivers of climate and weather on Earth

1



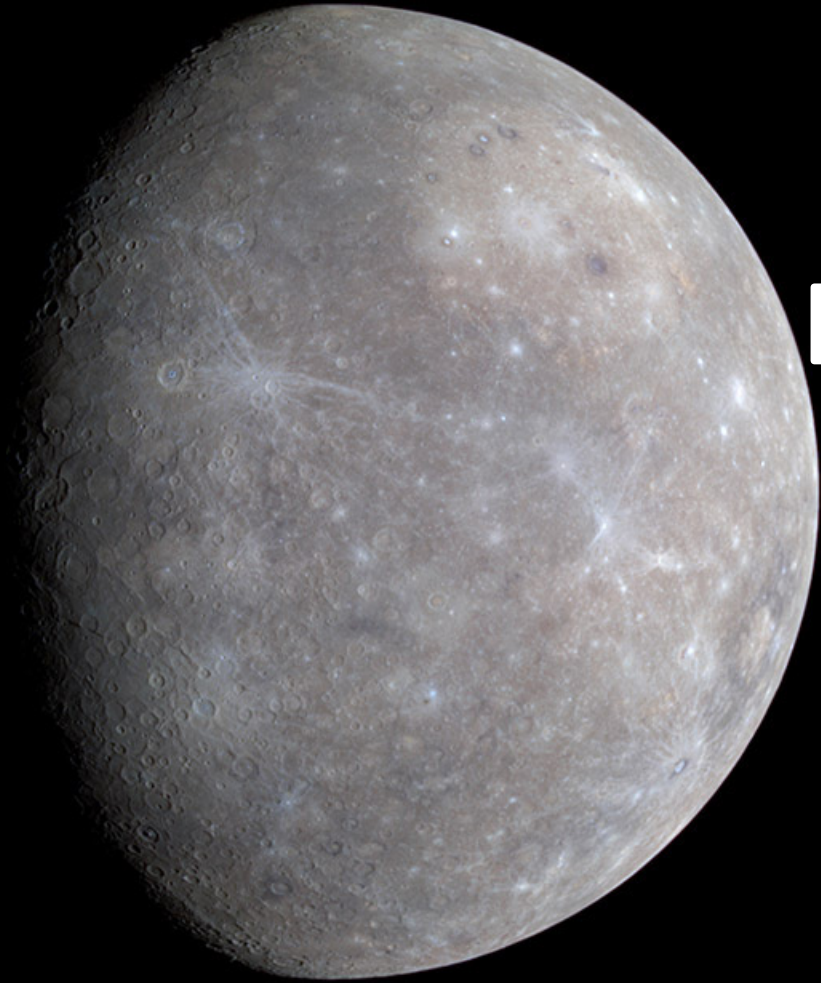
2





Not all the planets are so lucky...

# Mercury – no atmosphere



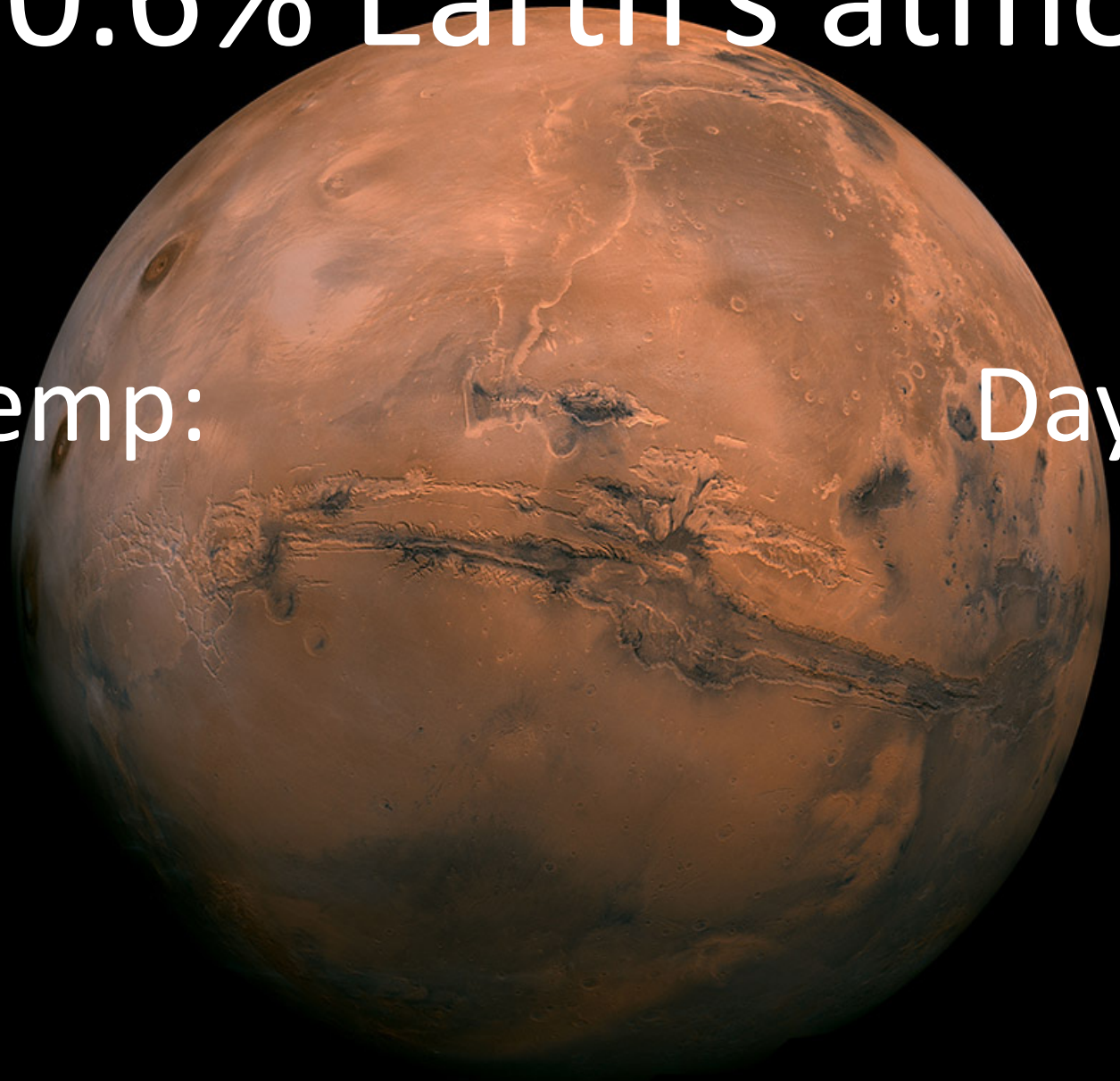
Night side temp:

-300°F

Day side temp:

800°F

# Mars – 0.6% Earth's atmosphere



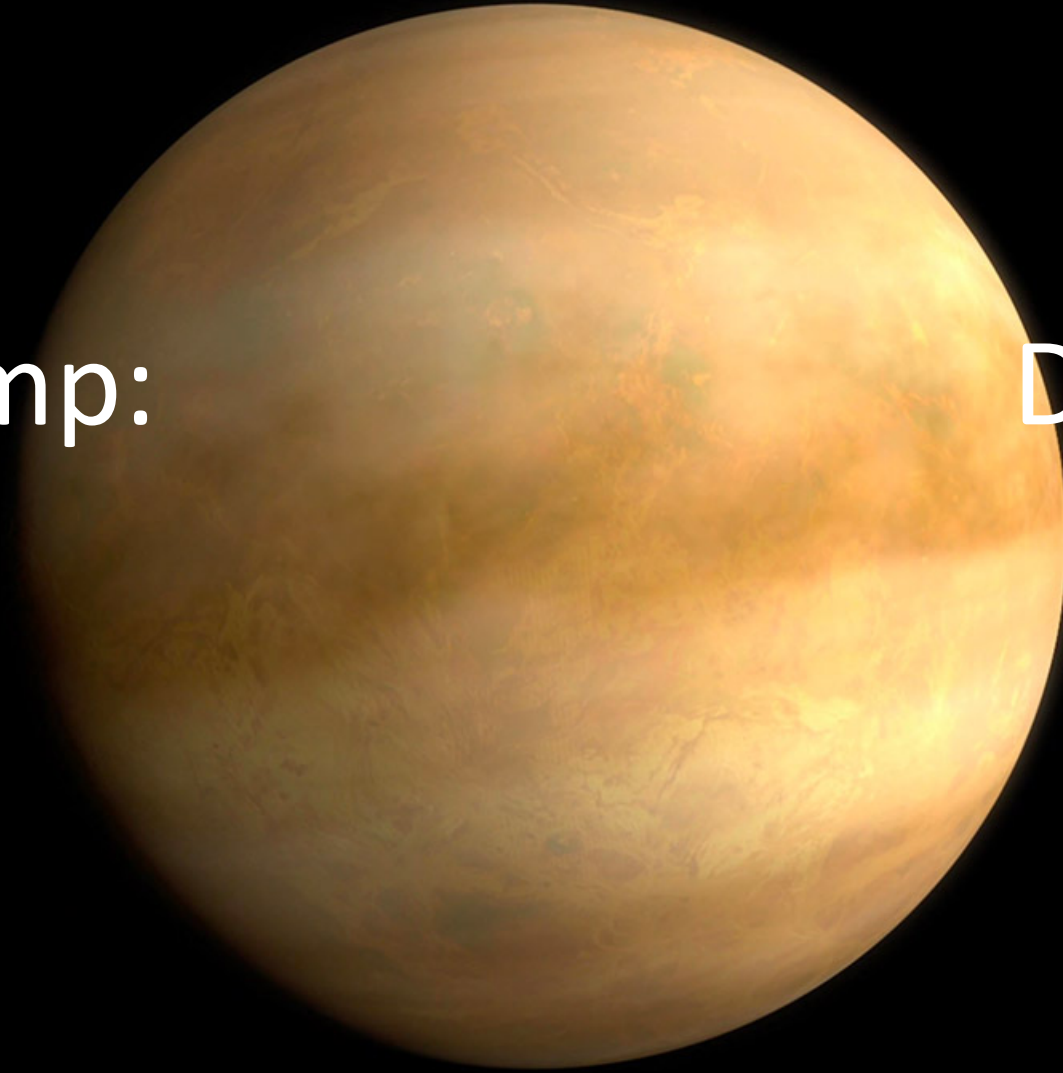
Night side temp:

-150°F

Day side temp:

14°F

# Venus – 92x Earth's atmosphere



Night side temp:

870°F

Day side temp:

870°F



Venus – 92x Earth's atmosphere

Night side temp:

Day side temp:

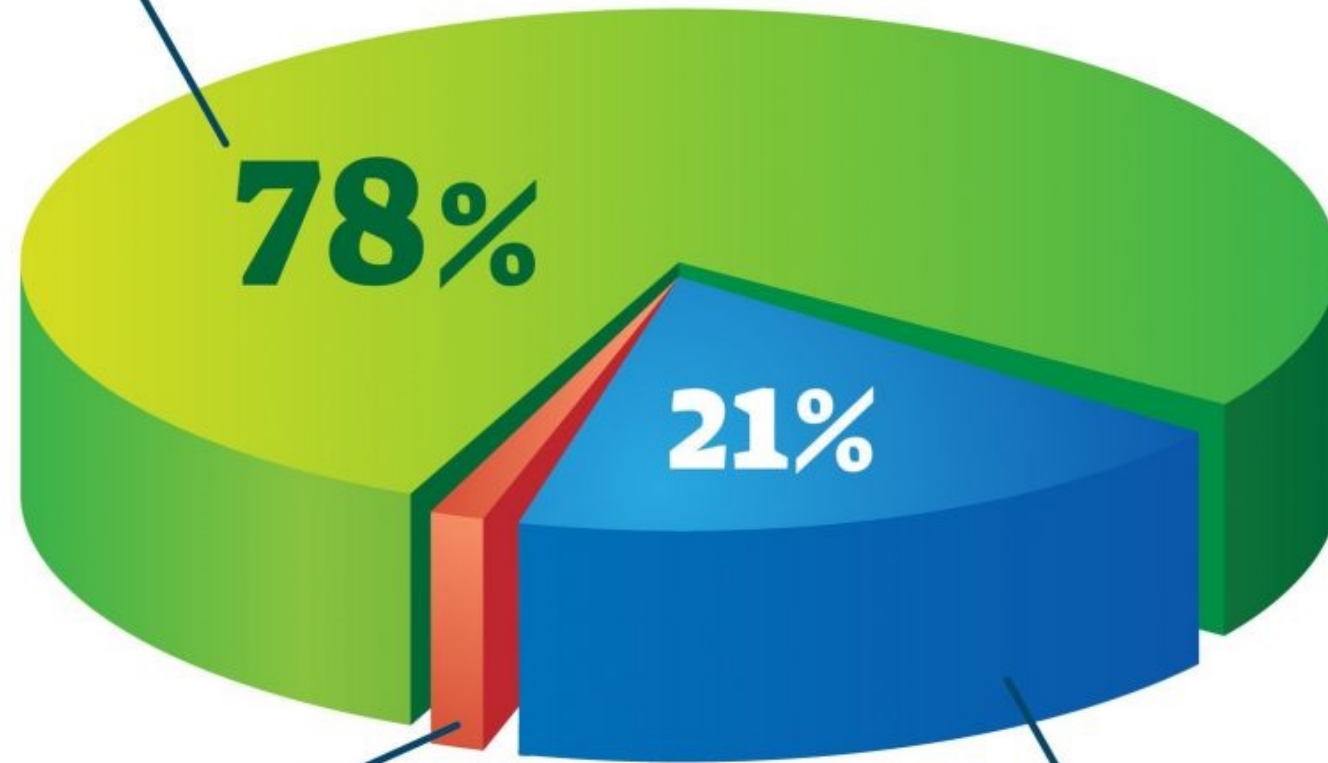
**96% Carbon Dioxide**

900°F

900°F



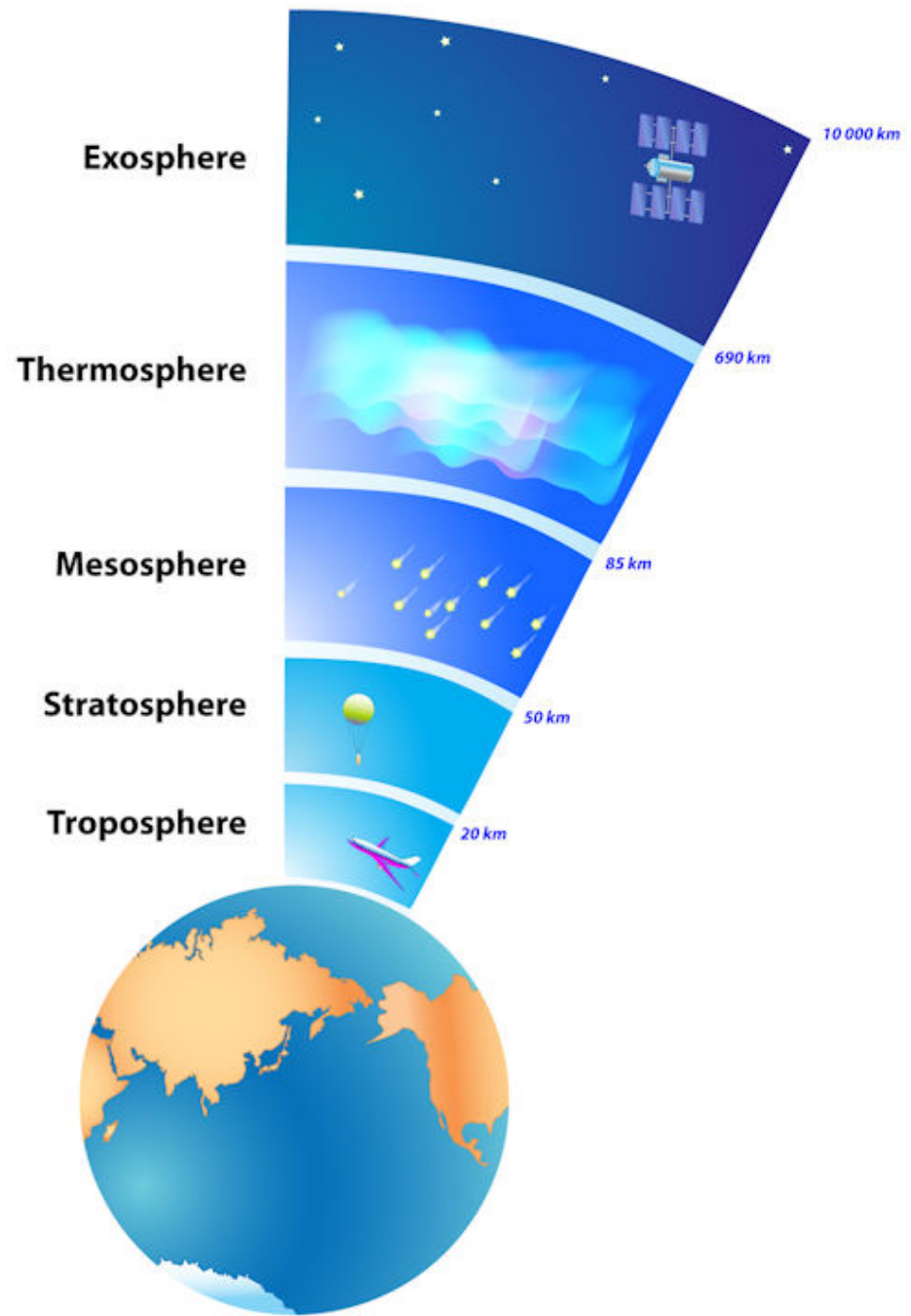
Nitrogen



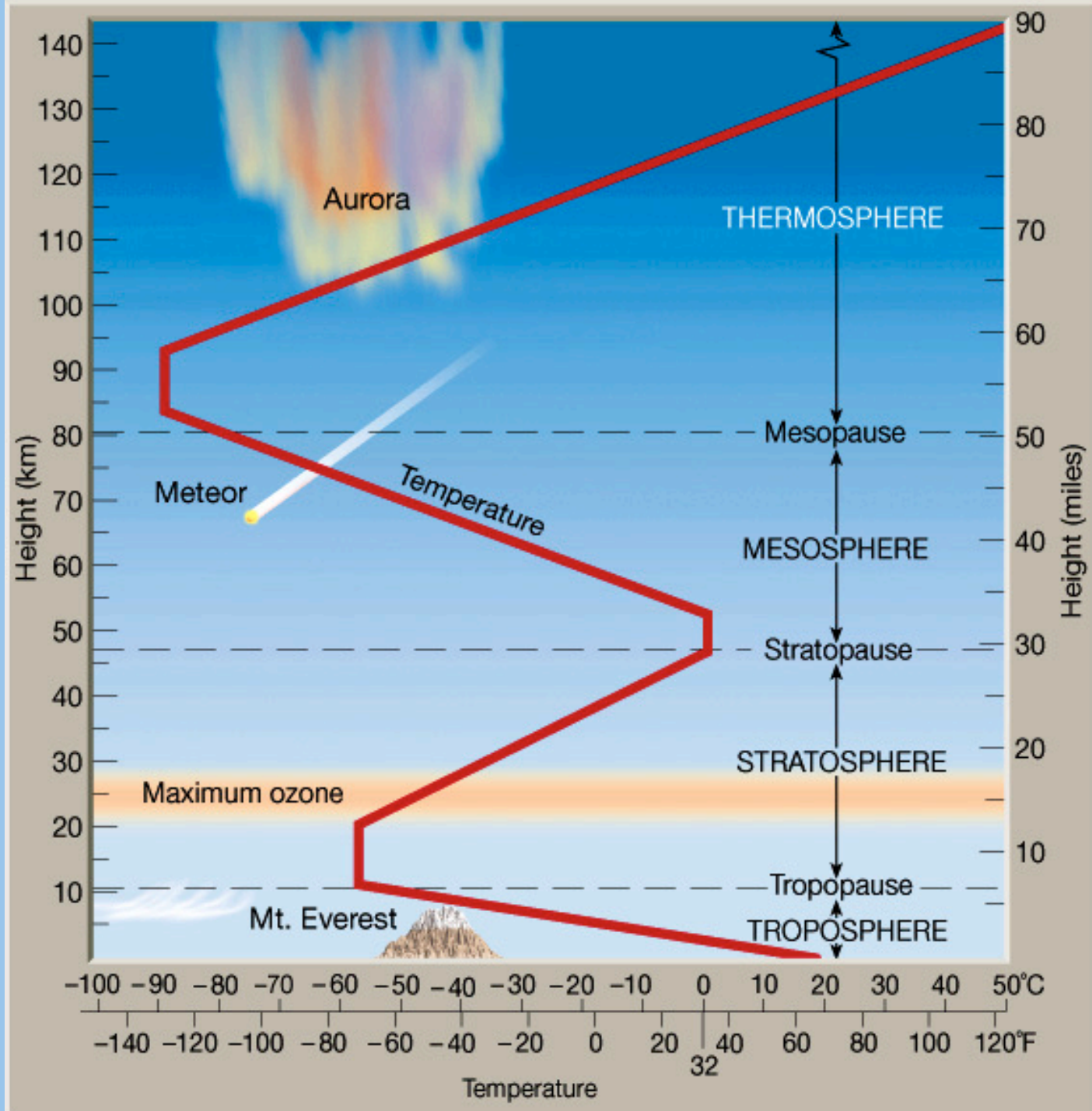
21%

Oxygen

**1%** Carbon dioxide,  
Argon, Water vapor, Other gases



Note: not to scale



Weather

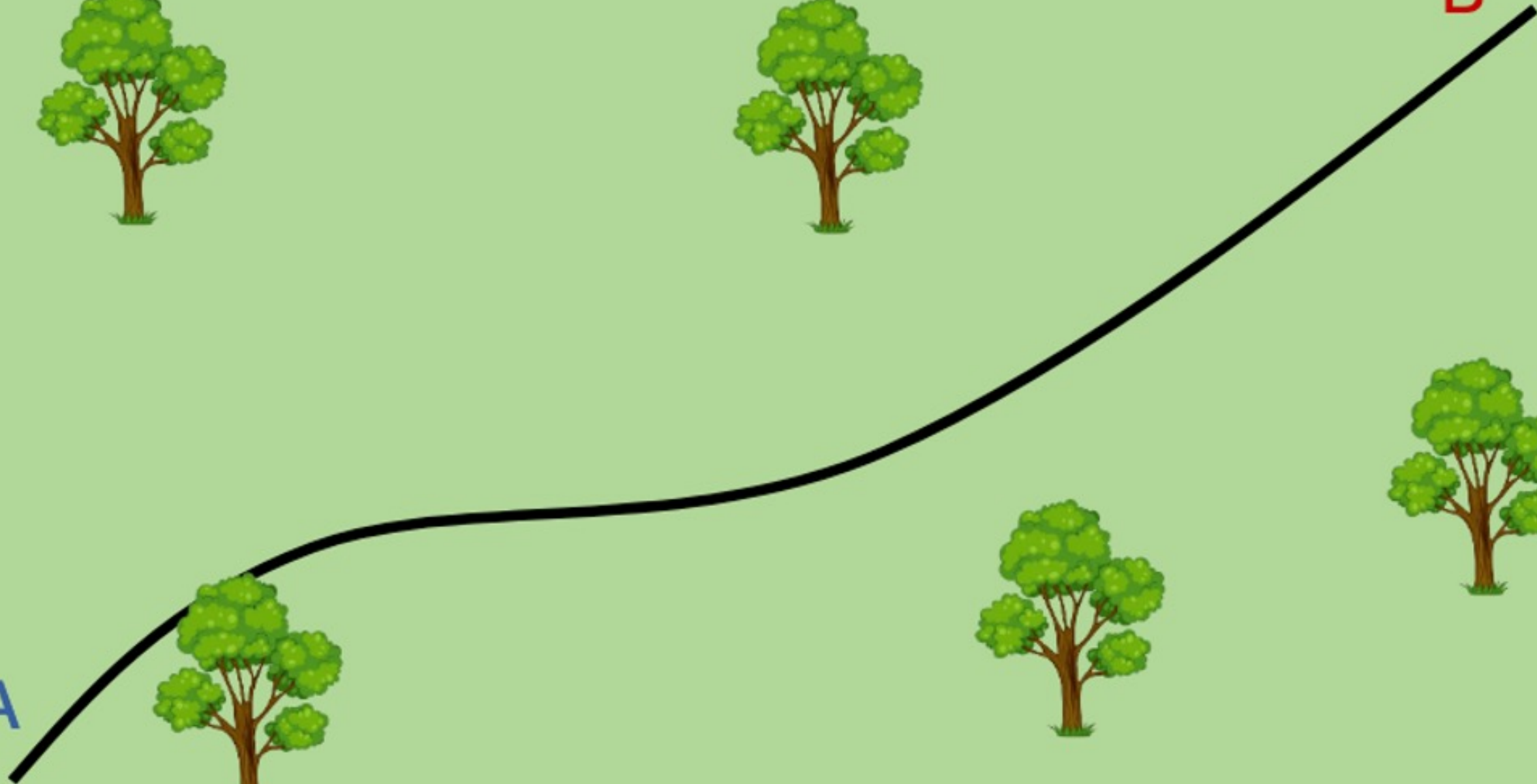
≠

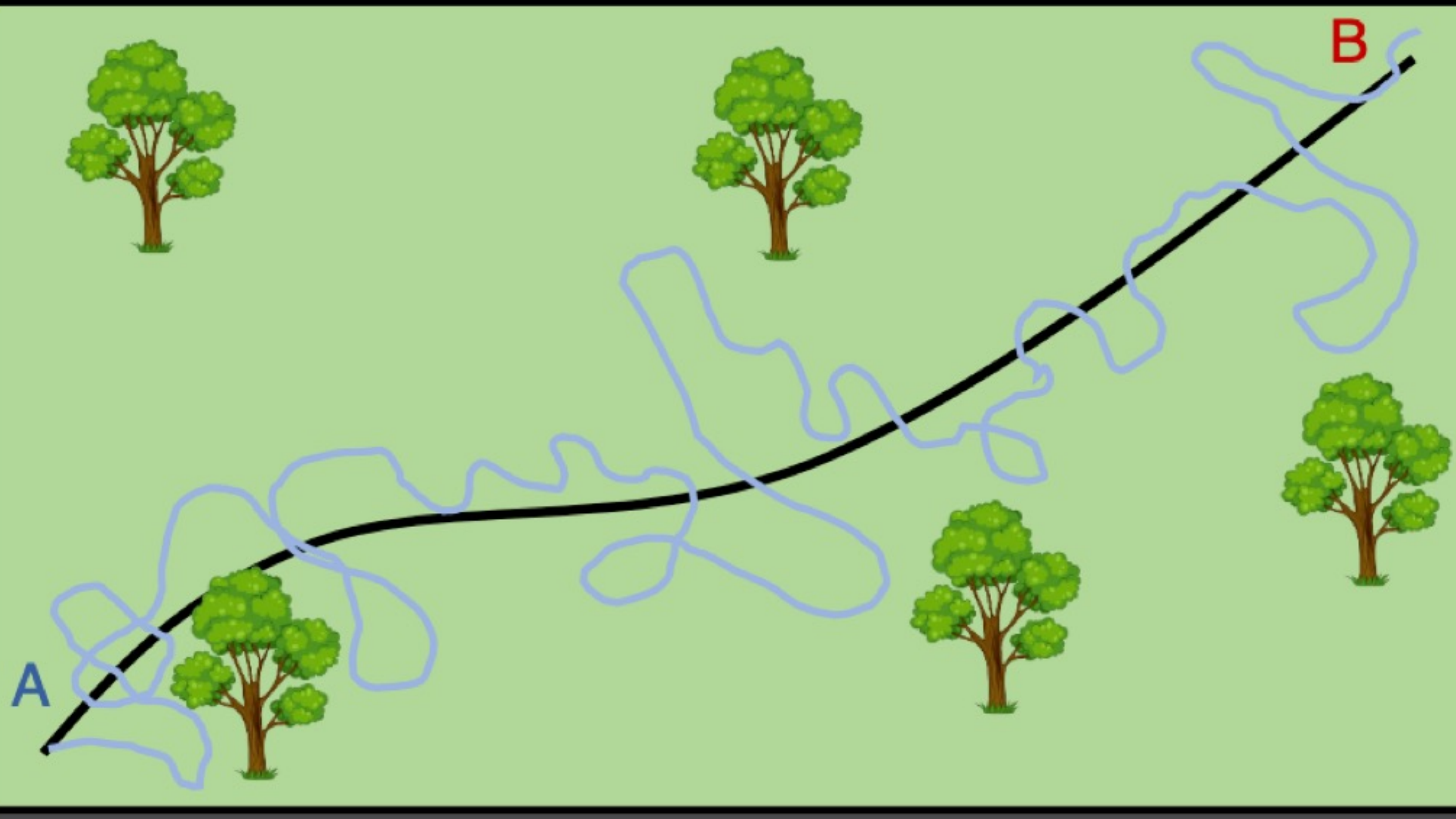
Climate

A



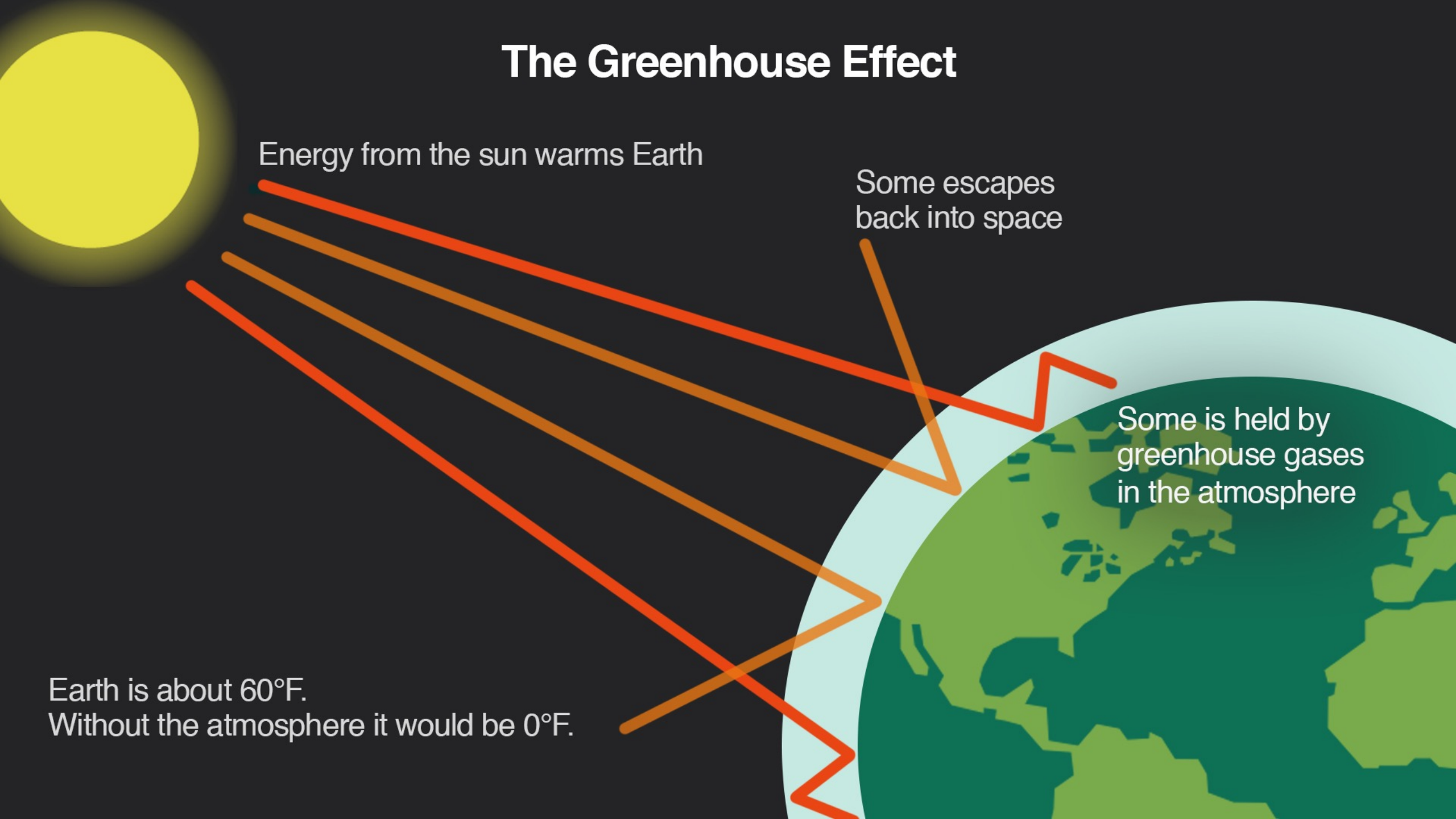
B







# The Greenhouse Effect



Energy from the sun warms Earth

Some escapes back into space

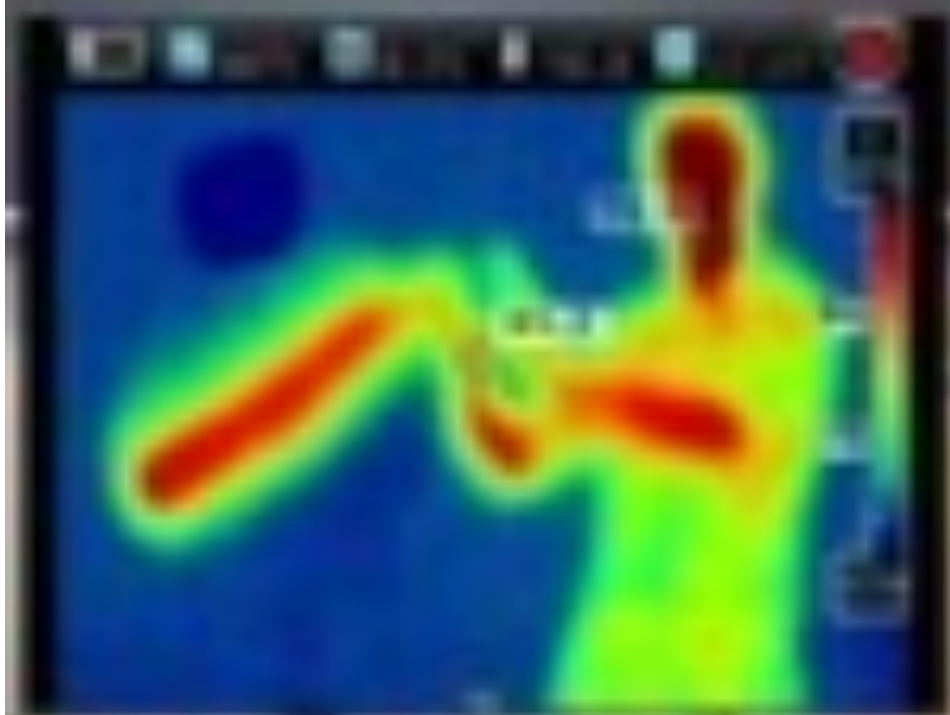
Some is held by greenhouse gases in the atmosphere

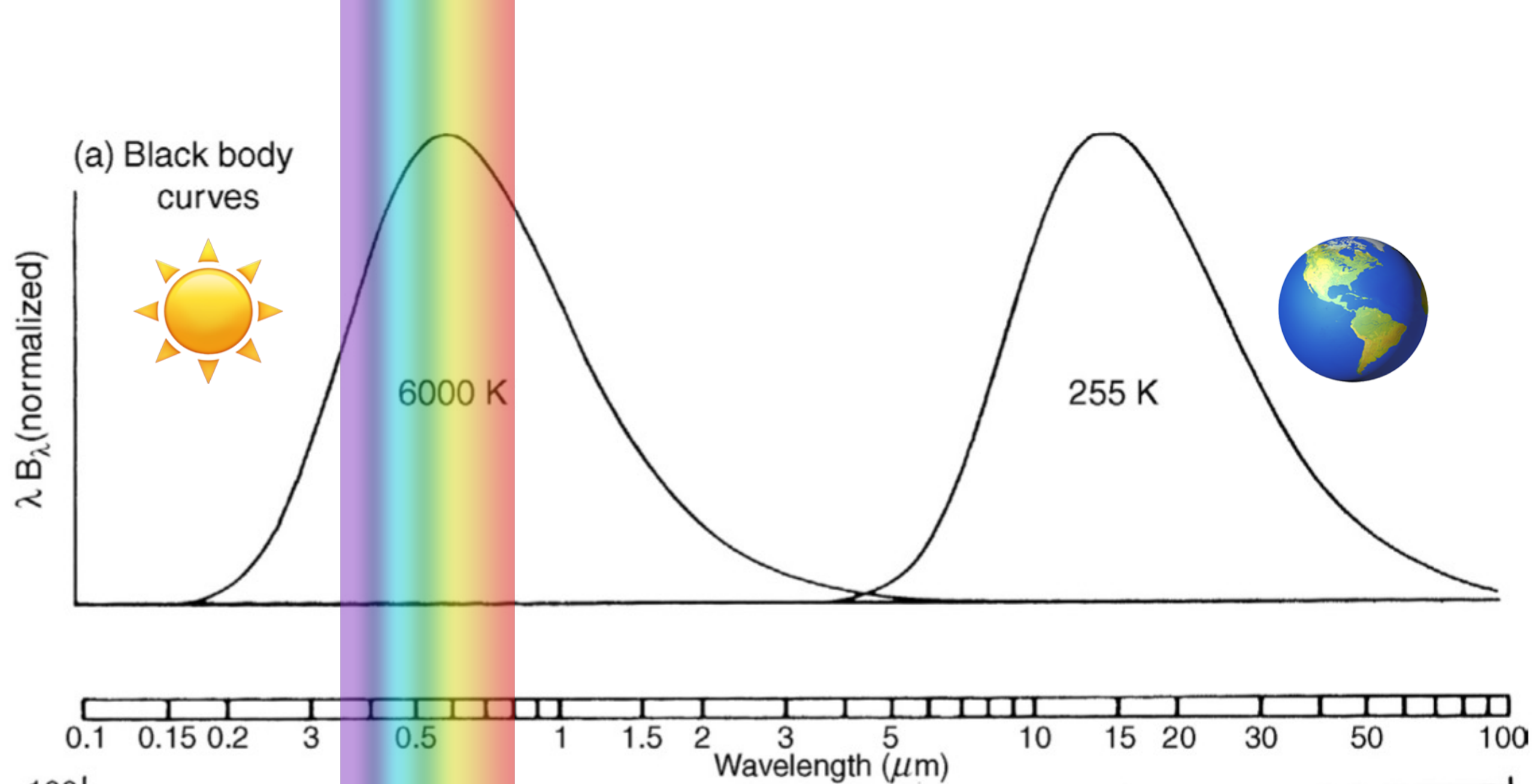
Earth is about 60°F.  
Without the atmosphere it would be 0°F.

Why is too much CO<sub>2</sub> such a  
problem?

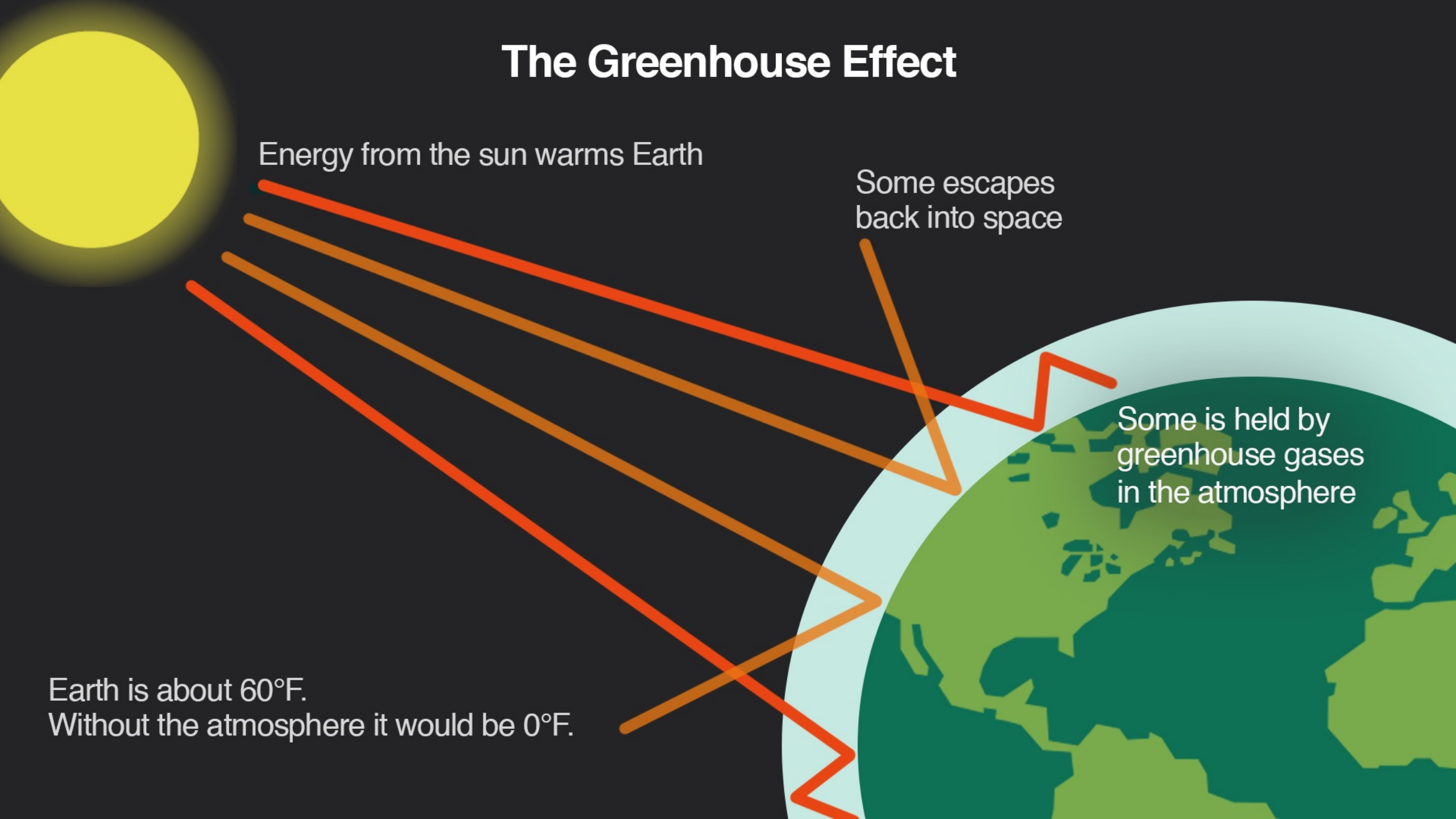
PHYSICS!

(or really bad luck...)





# The Greenhouse Effect



Energy from the sun warms Earth

Some escapes back into space

Some is held by greenhouse gases in the atmosphere

Earth is about 60°F.  
Without the atmosphere it would be 0°F.

Peaks between  
11 $\mu\text{m}$  and 19 $\mu\text{m}$

(a) Black body curves

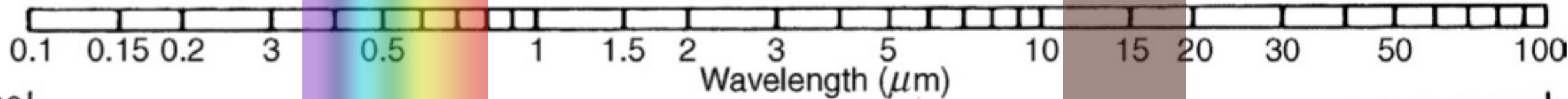


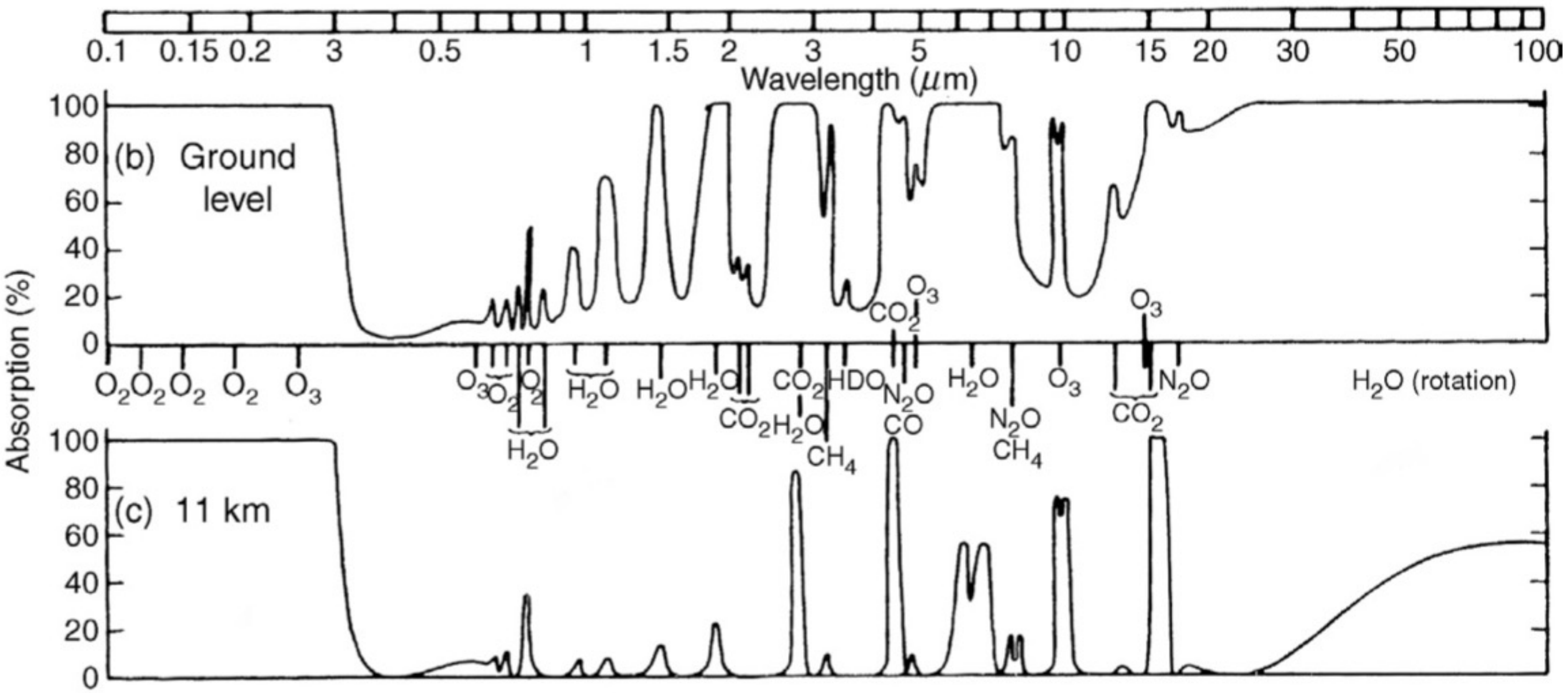
6000 K

255 K

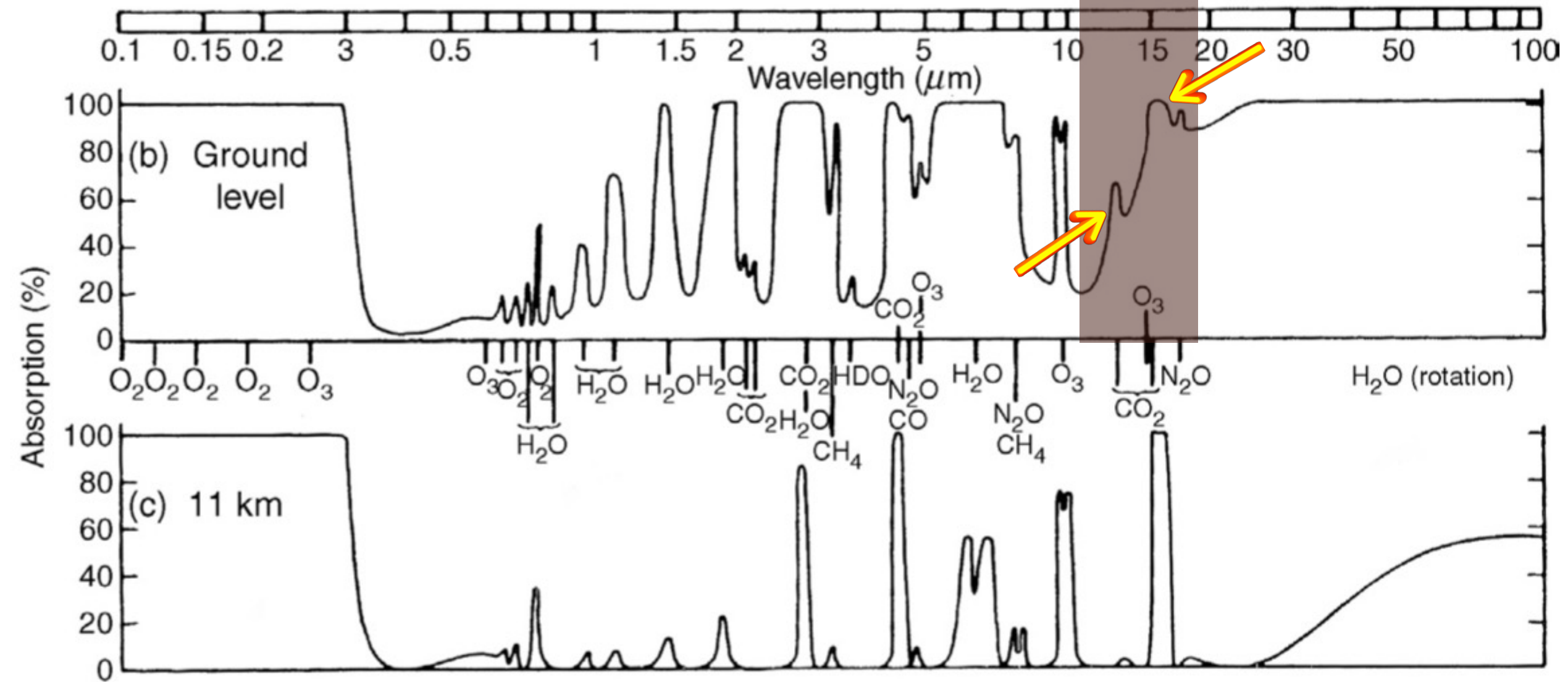


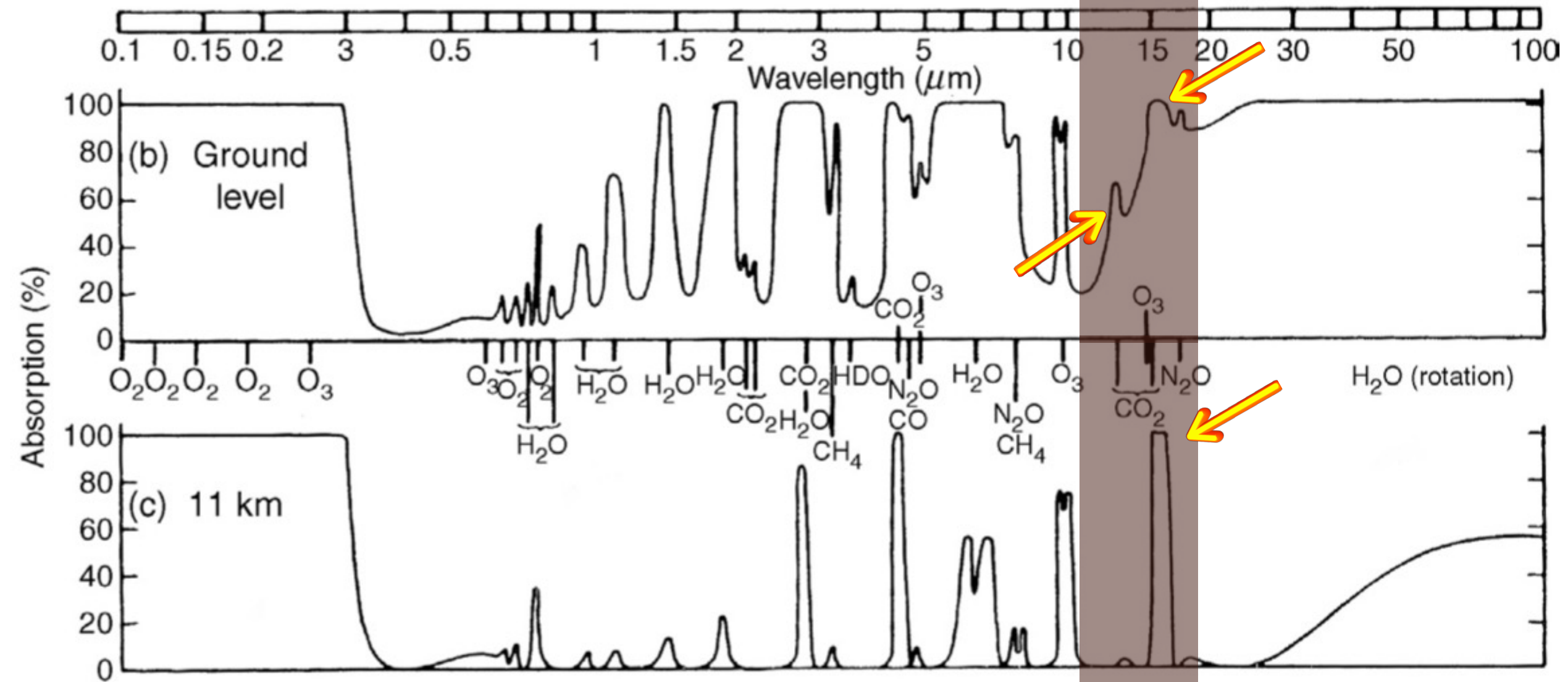
$\lambda B_\lambda$  (normalized)



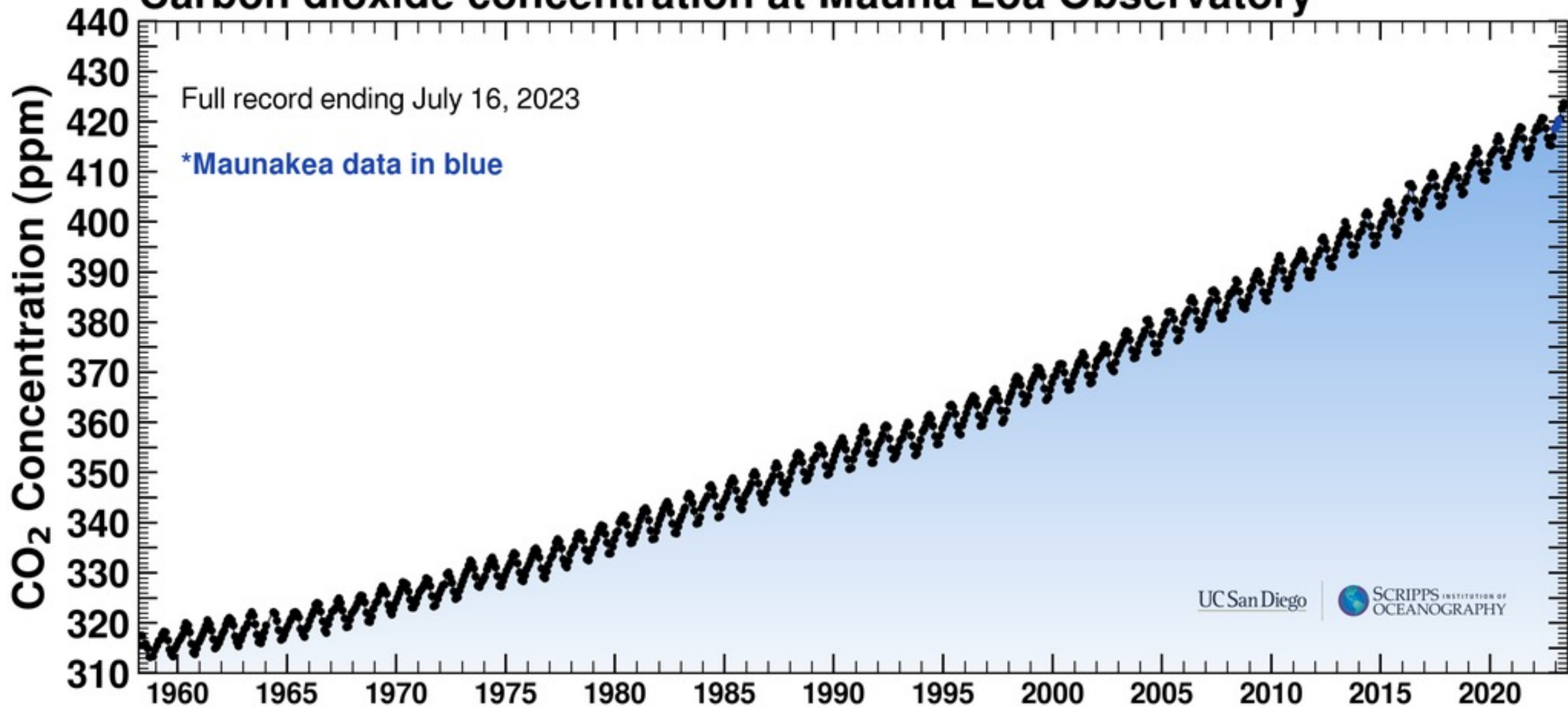


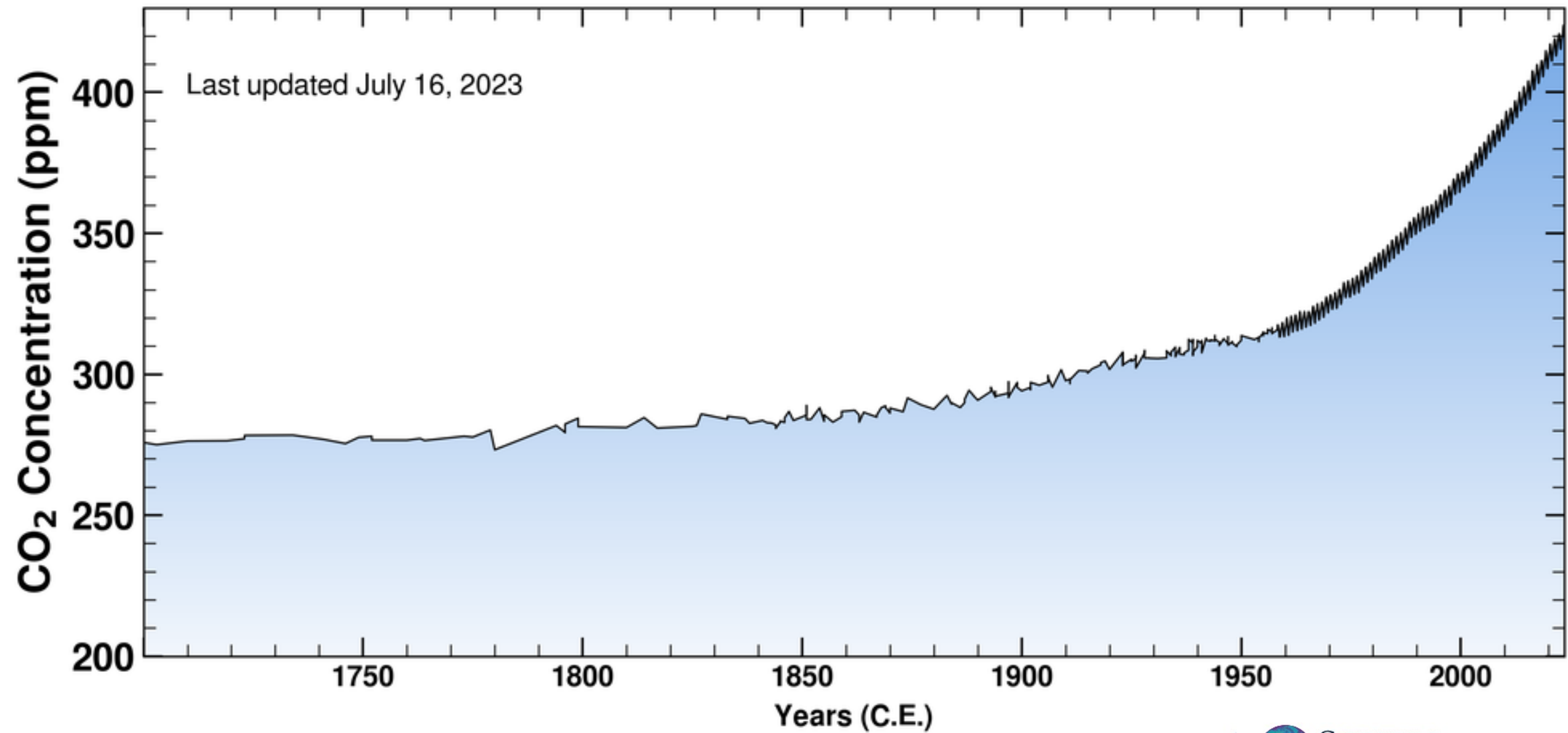


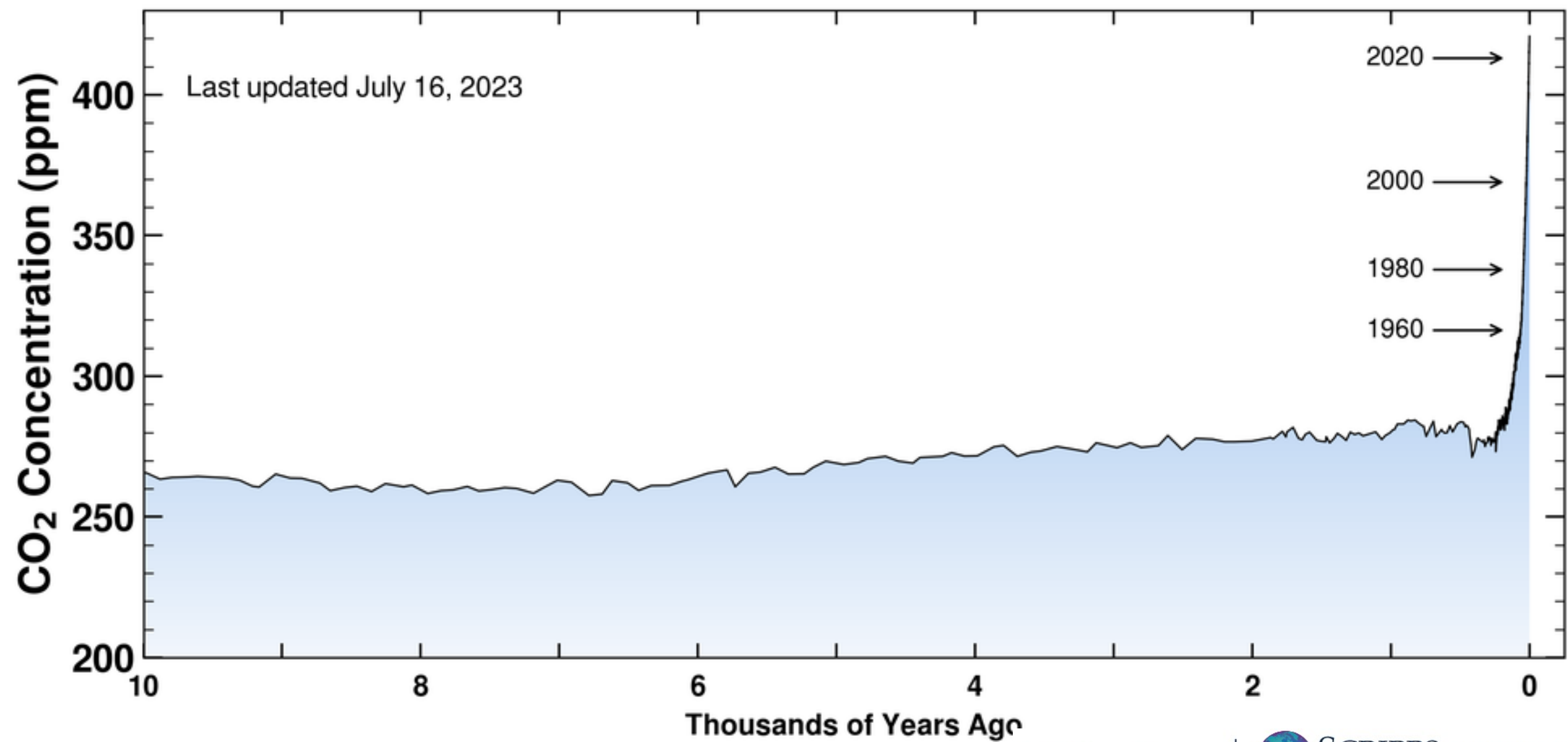


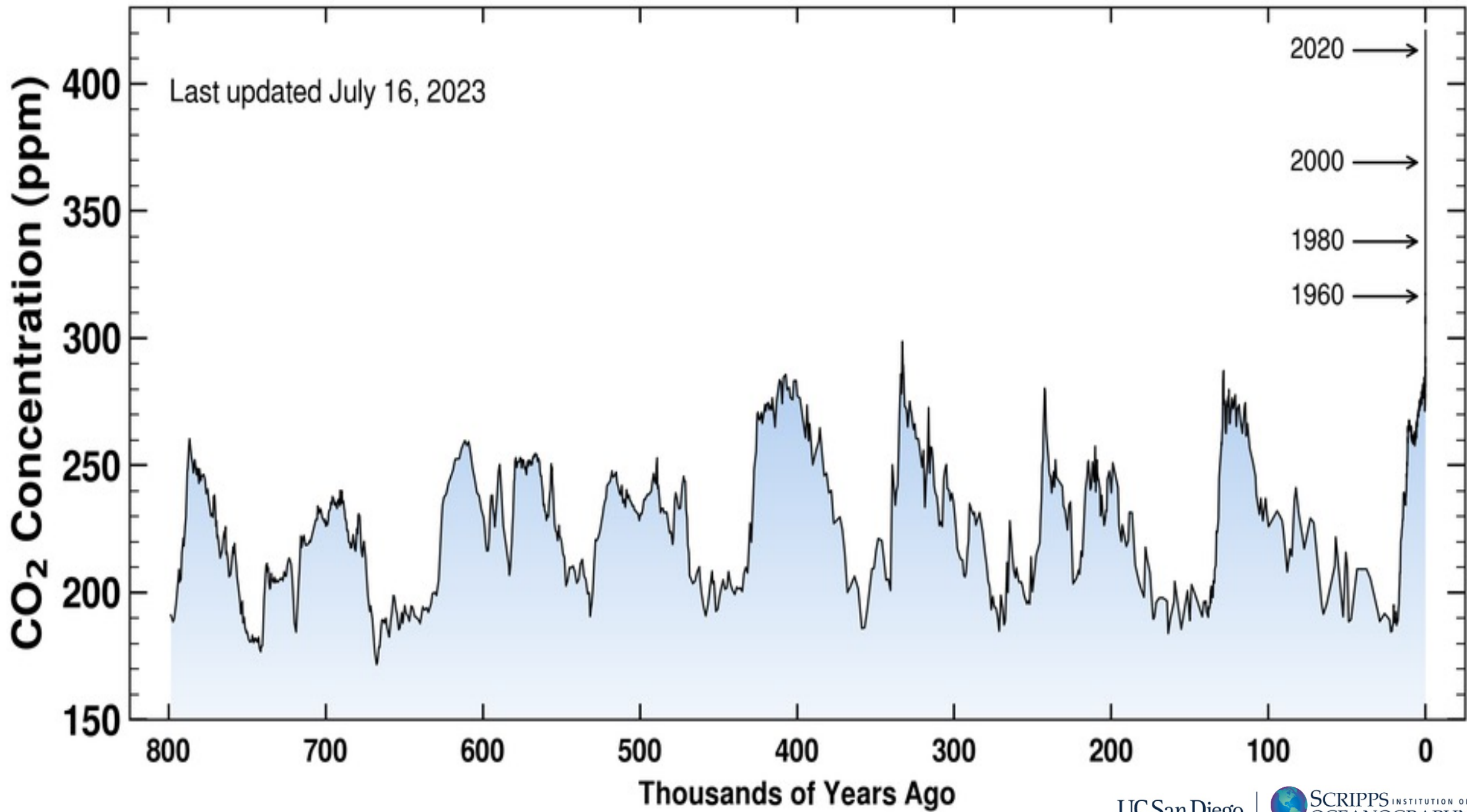


# Carbon dioxide concentration at Mauna Loa Observatory\*

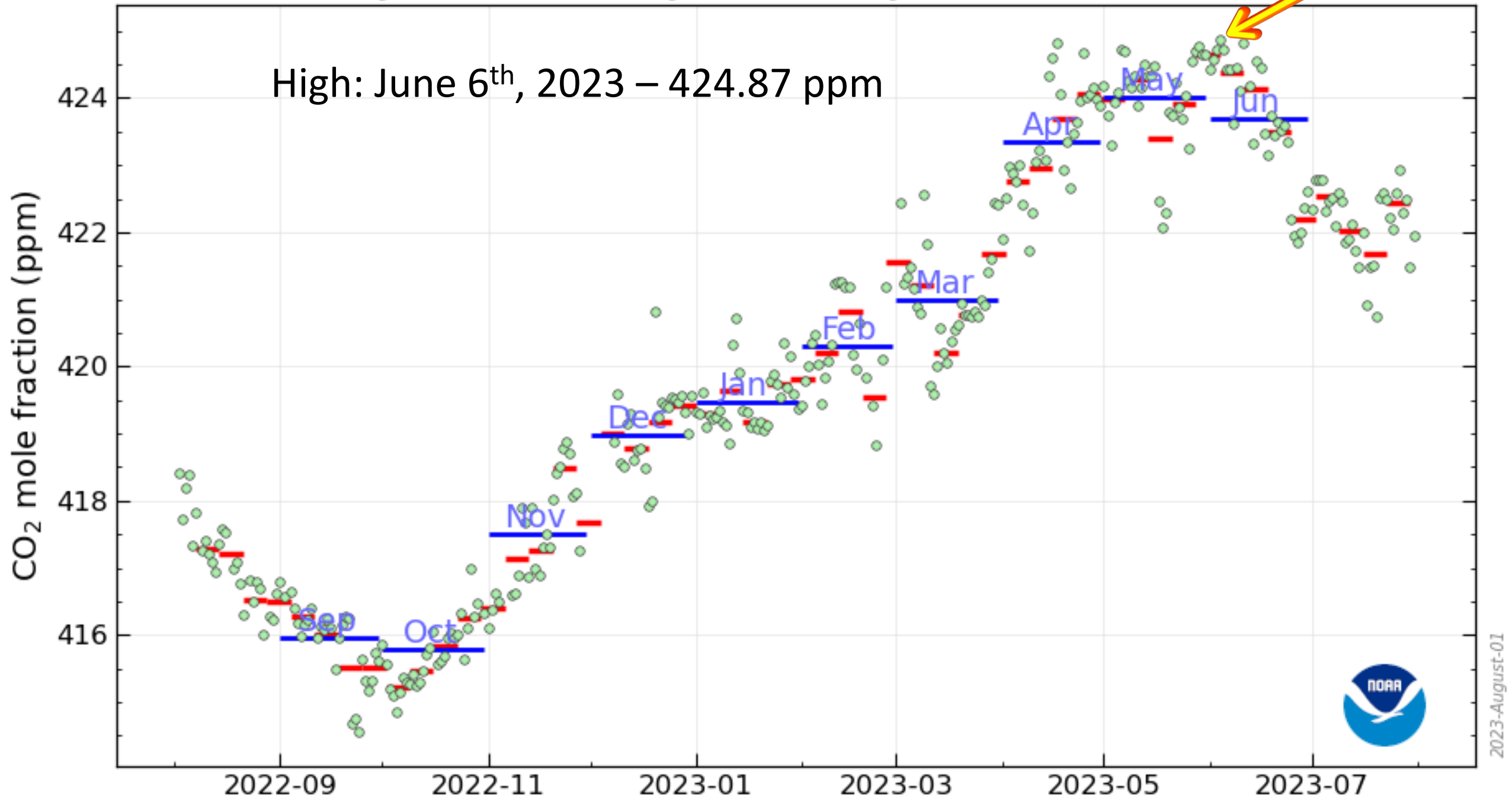






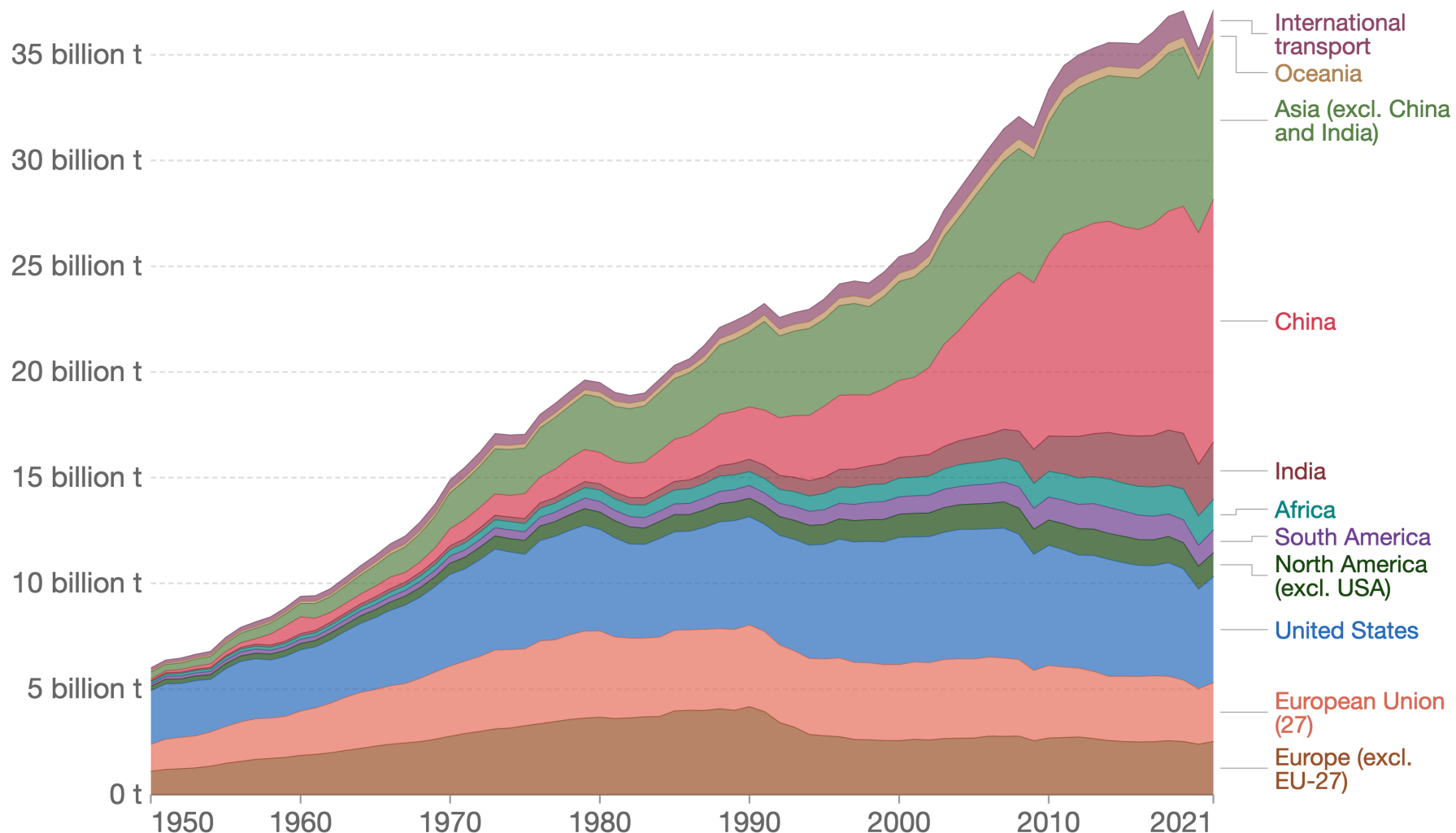


# One year of CO<sub>2</sub> daily and weekly means at Mauna Loa



# Annual CO<sub>2</sub> emissions by world region

This measures fossil fuel and industry emissions<sup>1</sup>. Land use change is not included.



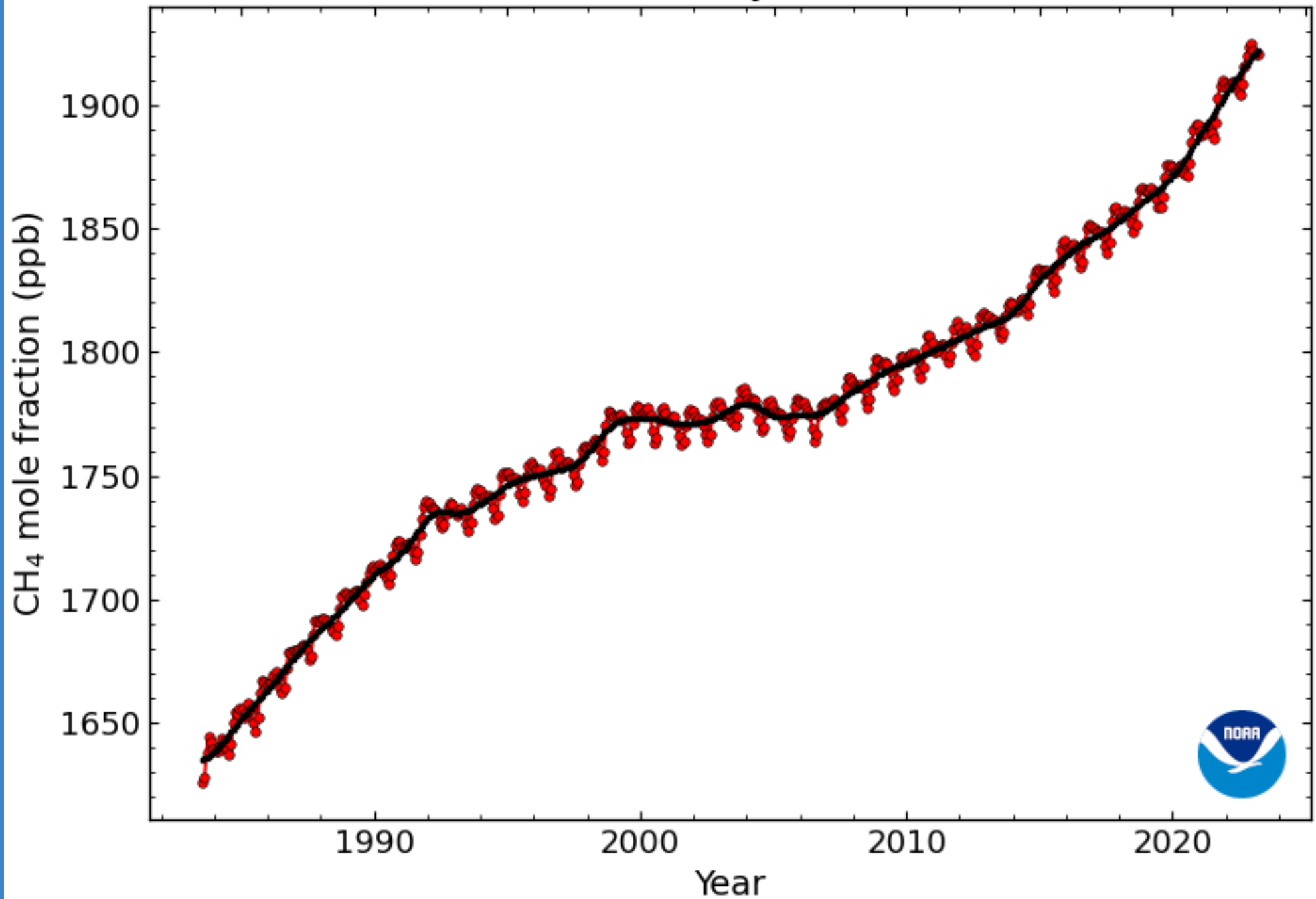
Source: Global Carbon Budget (2022)

OurWorldInData.org/co2-and-greenhouse-gas-emissions • CC BY

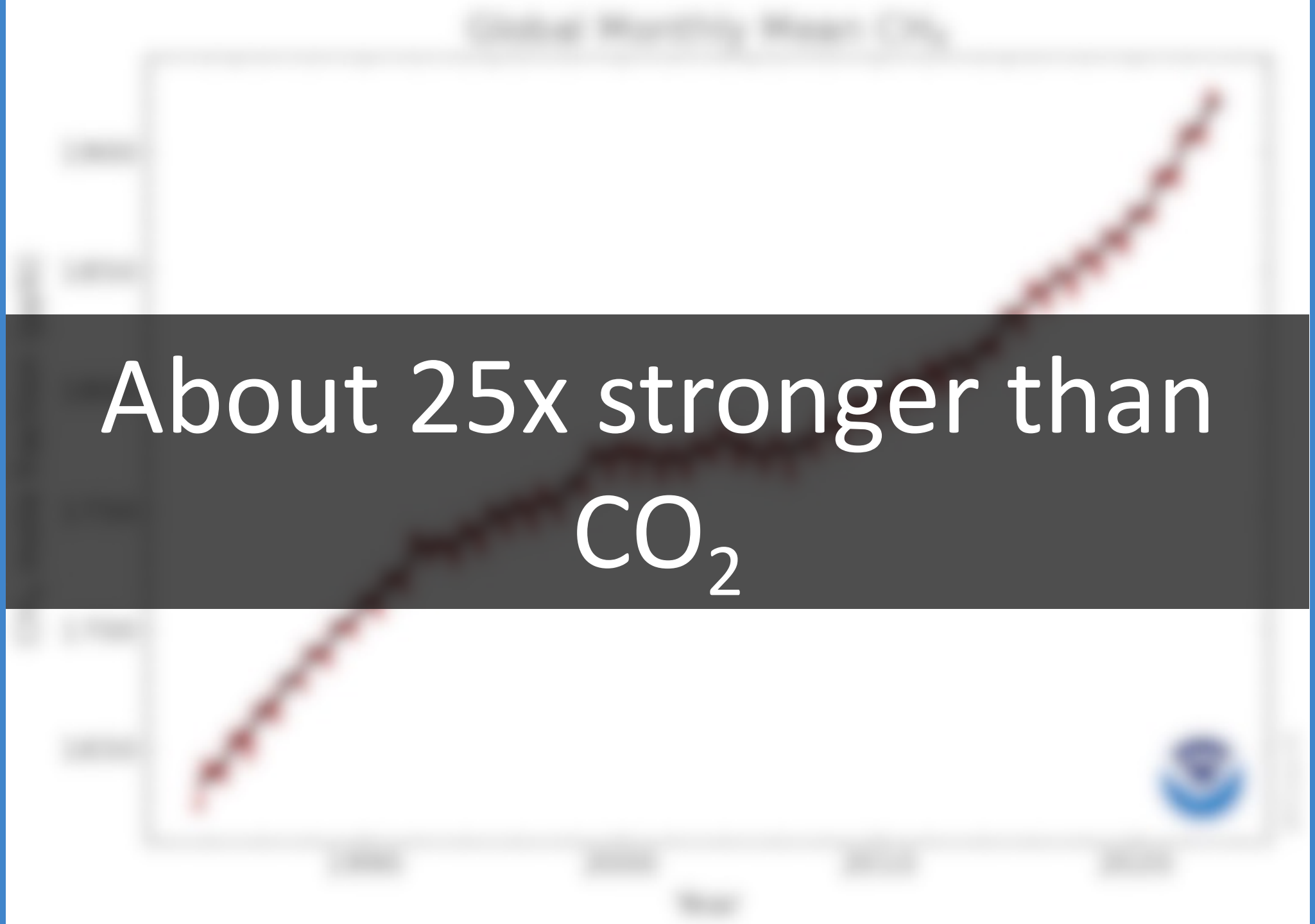
**1. Fossil emissions:** Fossil emissions measure the quantity of carbon dioxide (CO<sub>2</sub>) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO<sub>2</sub> includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.



# Global Monthly Mean CH<sub>4</sub>

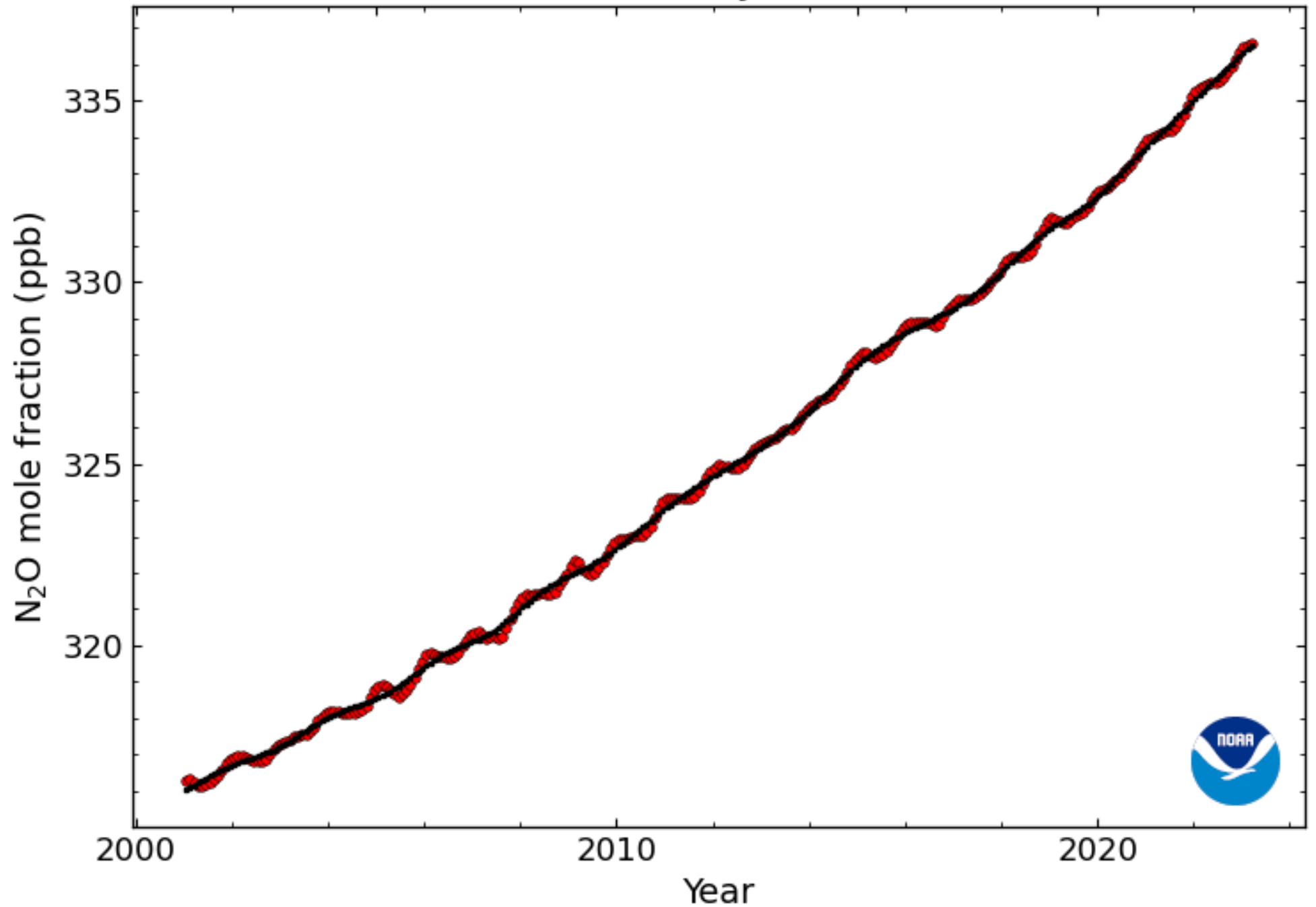


2023-july-05

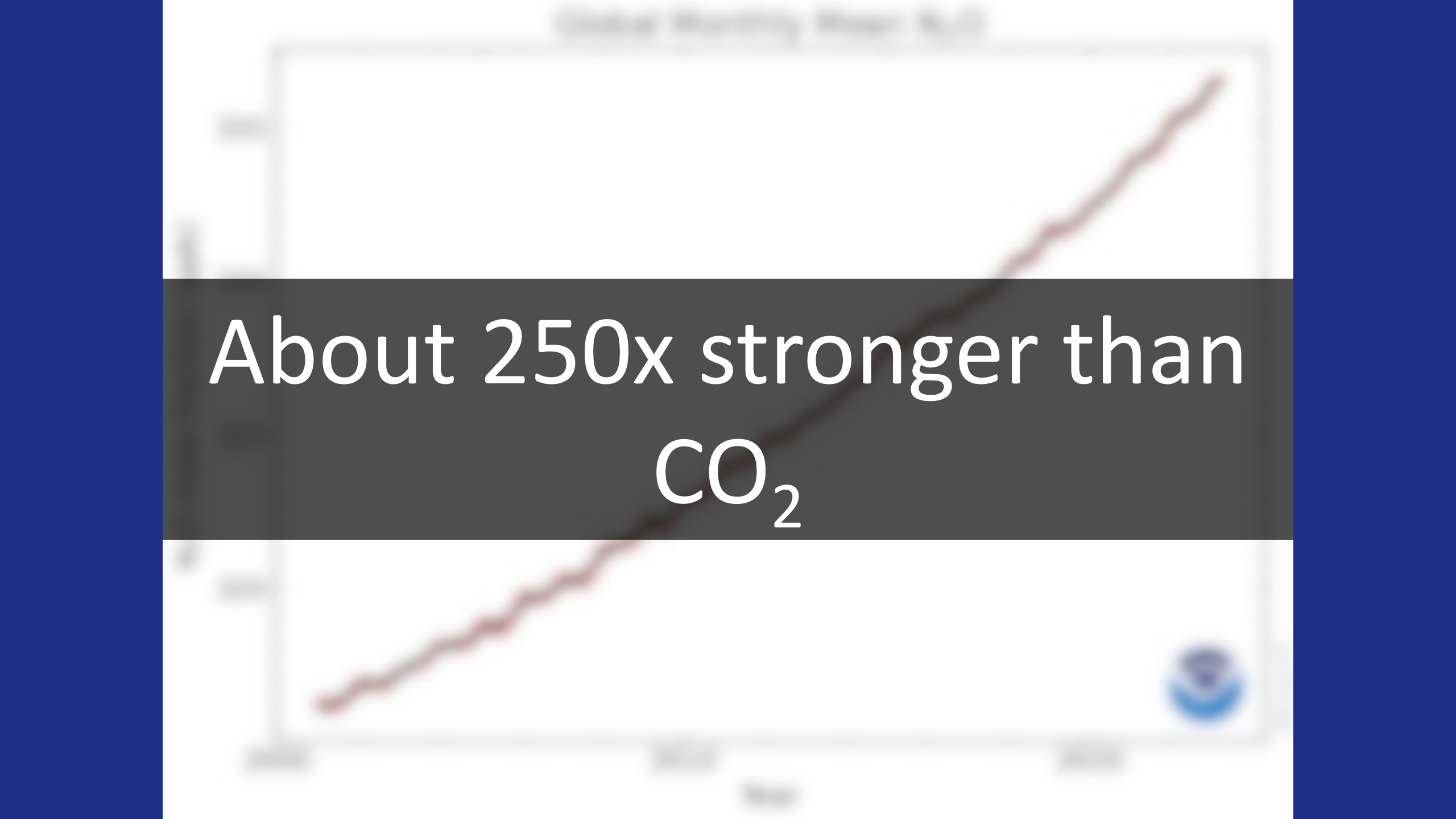


About 25x stronger than  
 $\text{CO}_2$

# Global Monthly Mean N<sub>2</sub>O

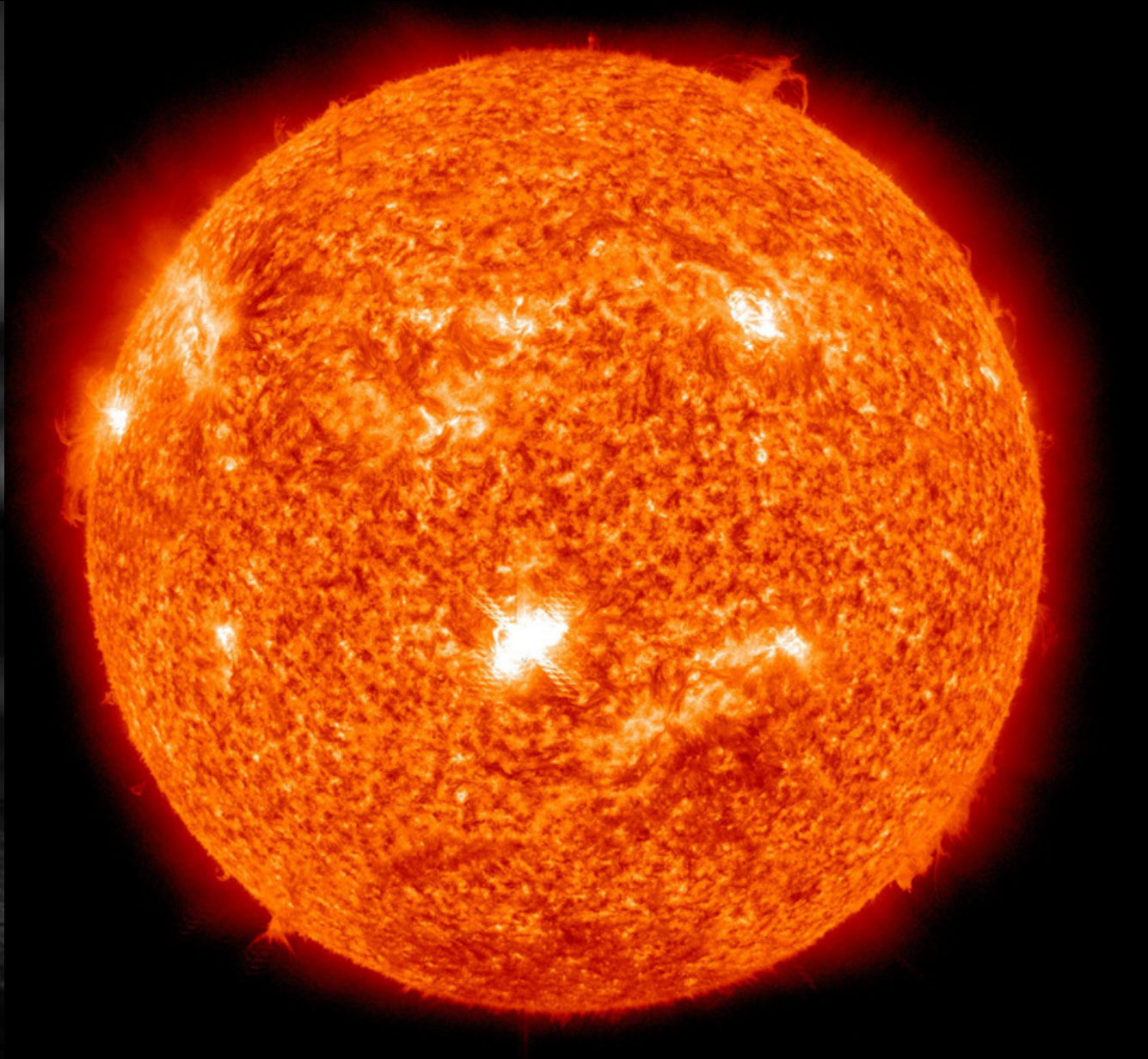


2023-July-05



About 250x stronger than  
 $\text{CO}_2$

# What about...?





VOLCANOES

CARBON DIOXIDE EMISSIONS

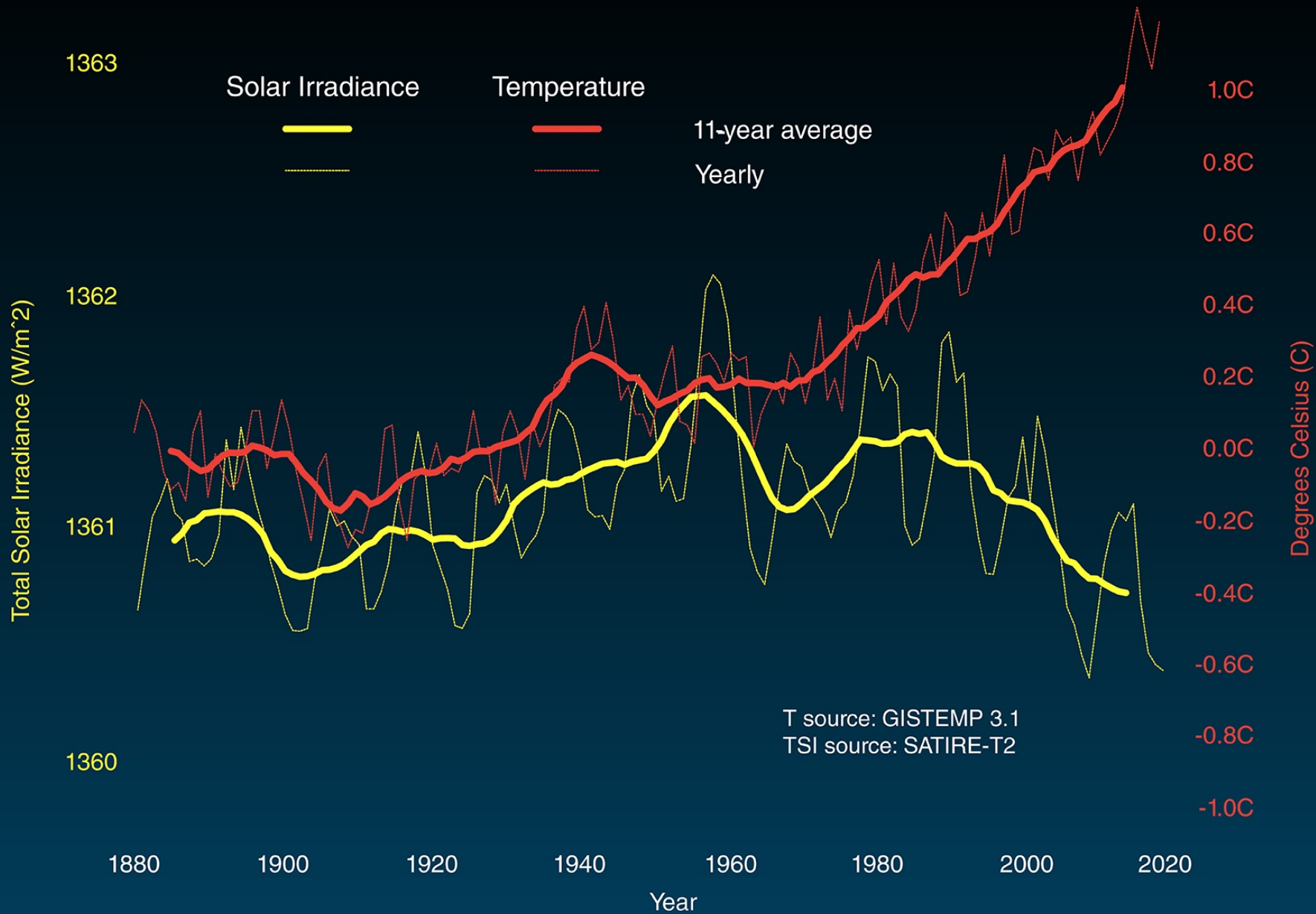
MAN-MADE SOURCES

Geo 2011

A blurred background image of a balance scale. The left pan is higher and contains a small volcano with a red base and a purple plume of smoke. The right pan is lower and contains a small boat with a blue hull and a brown cabin. The scale is centered in the frame, and the background is a light, hazy sky. The text "Volcanos actually cool the planet..." is overlaid in white on a dark grey horizontal band across the middle of the image.

Volcanos actually cool the planet...

# Temperature vs Solar Activity



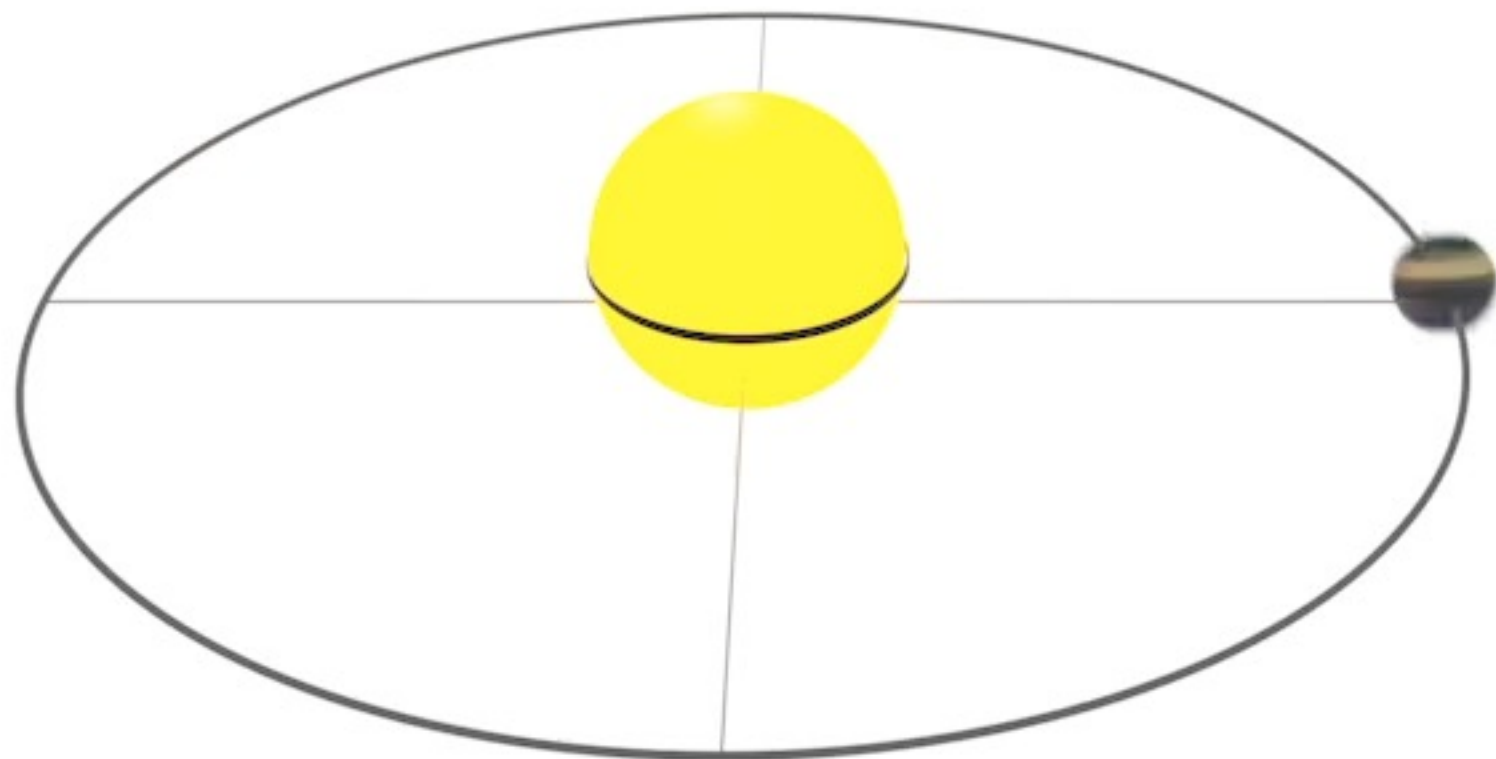
T source: GISTEMP 3.1  
TSI source: SATIRE-T2



There are  
natural drivers  
of climate  
change...

## Changes in Eccentricity (Orbit Shape)

100,000-year cycles

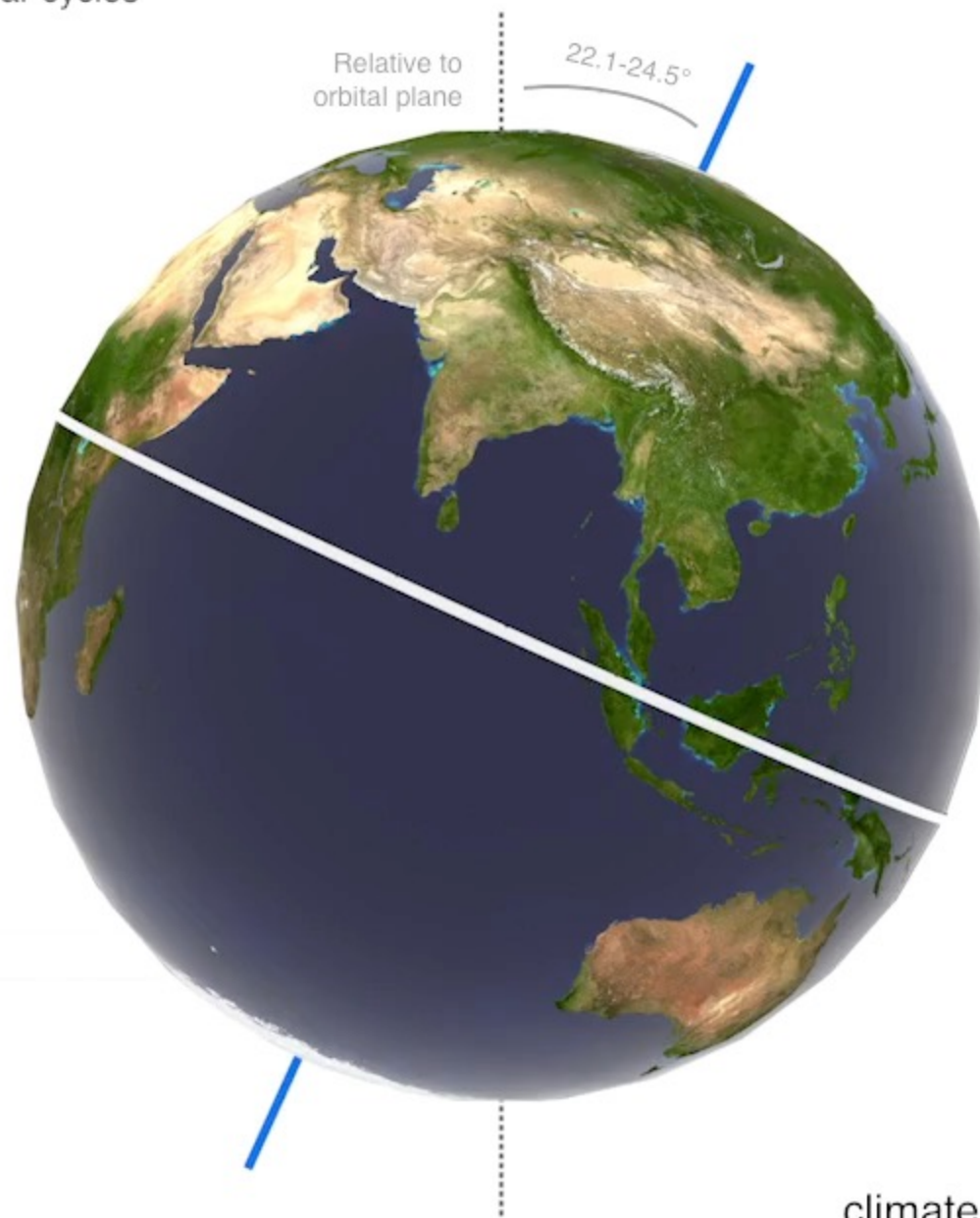


\*Changes in eccentricity exaggerated so the effect can be seen. Earth's orbit shape varies between 0.0034 (almost a perfect circle) to 0.058 (slightly elliptical).

[climate.nasa.gov](https://climate.nasa.gov)

## Changes in Obliquity (Tilt)

41,000-year cycles

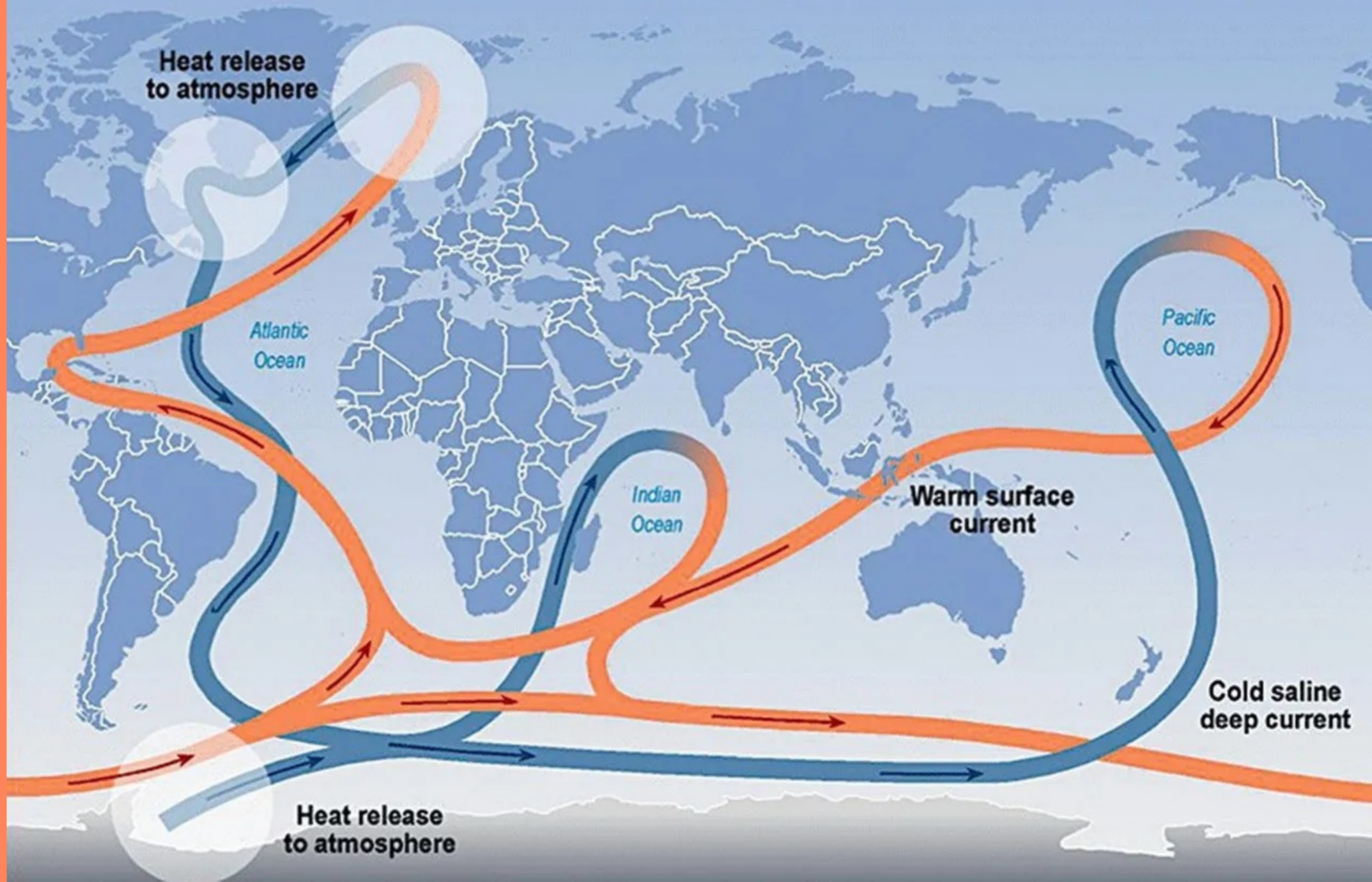


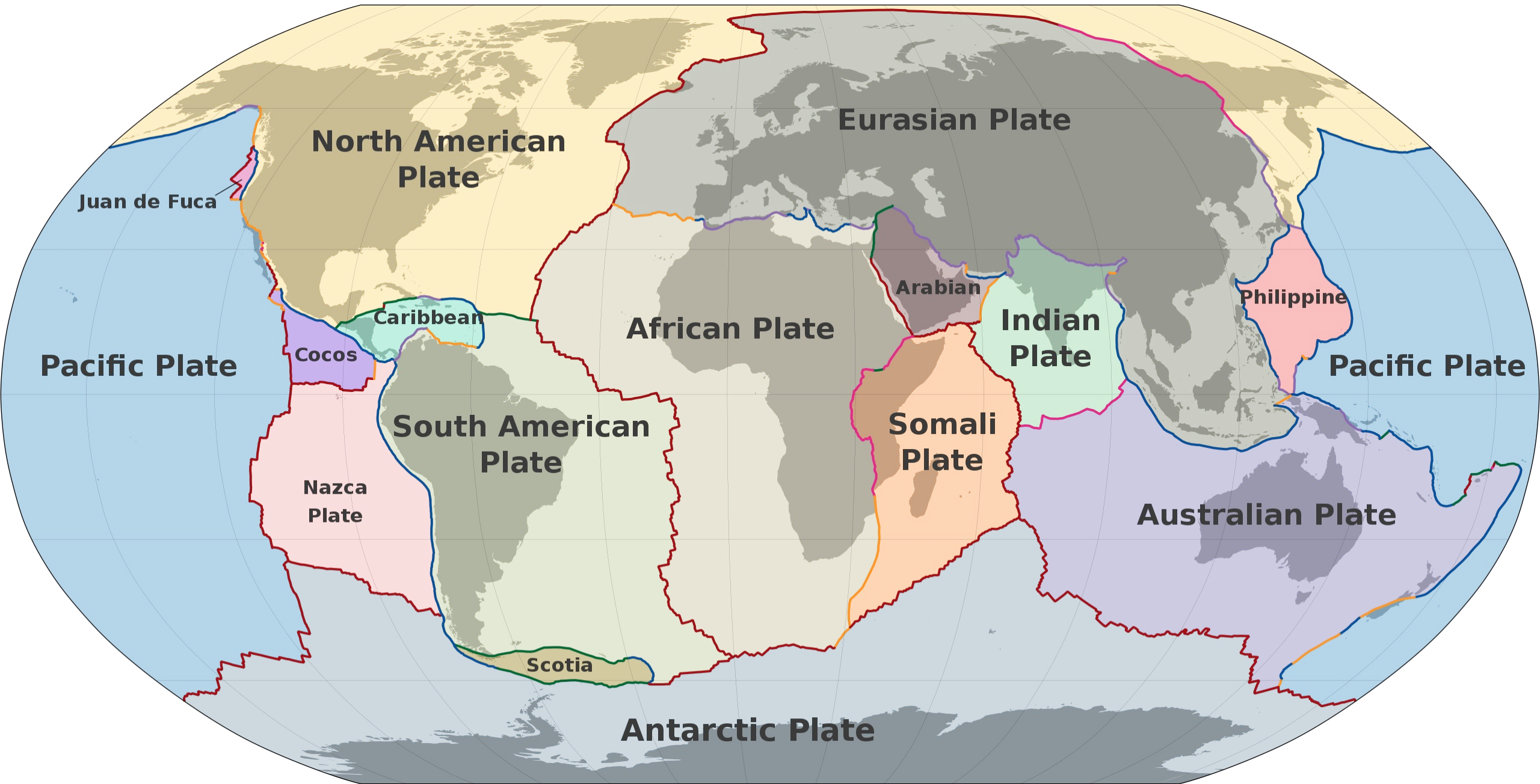
## Axial Precession (Wobble)

26,000-year cycles



# Great ocean conveyor belt

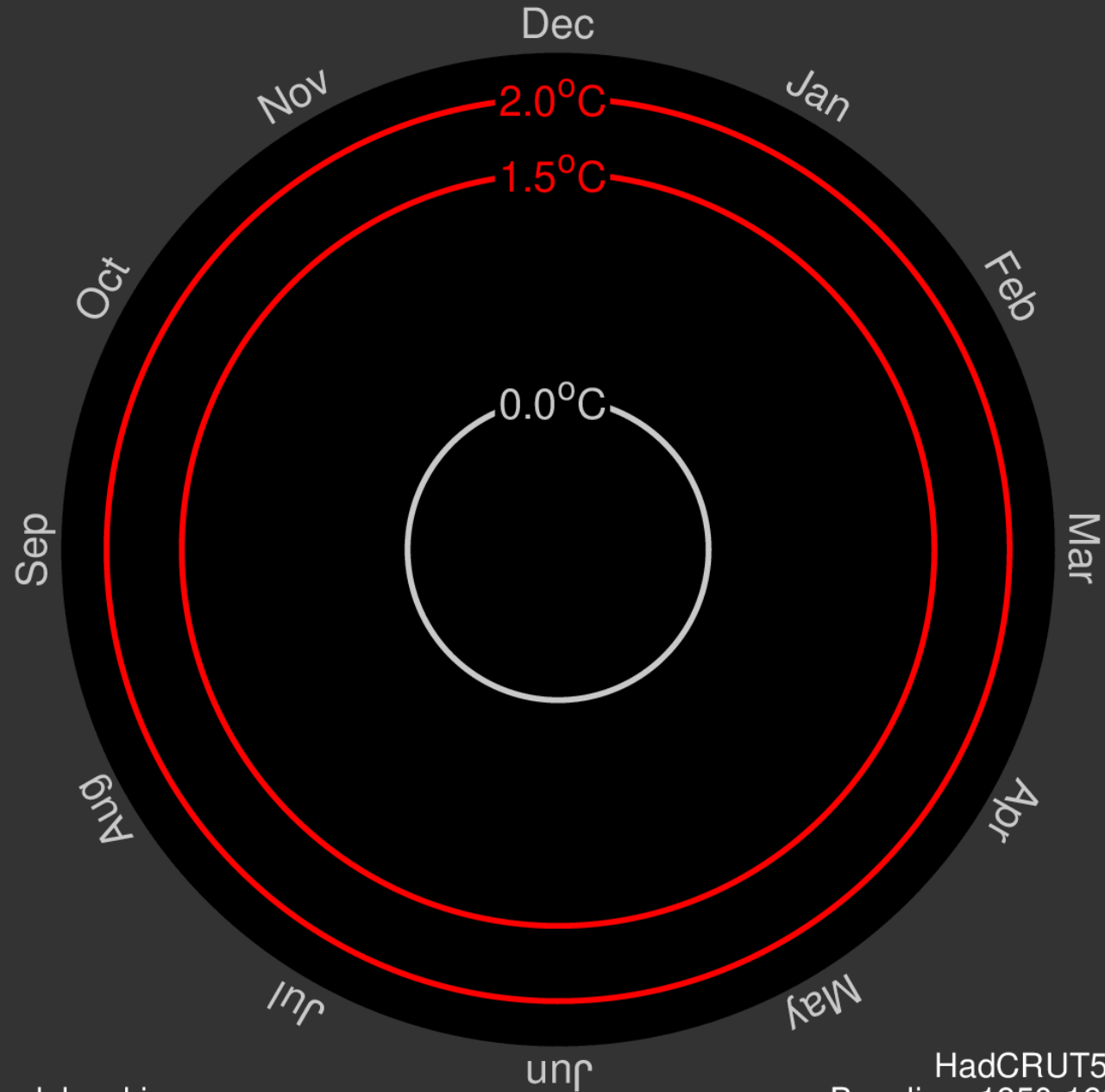




But...

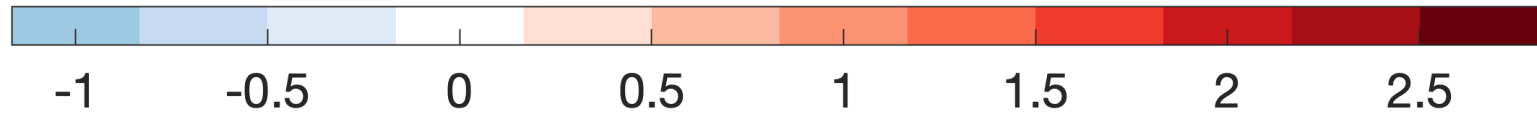
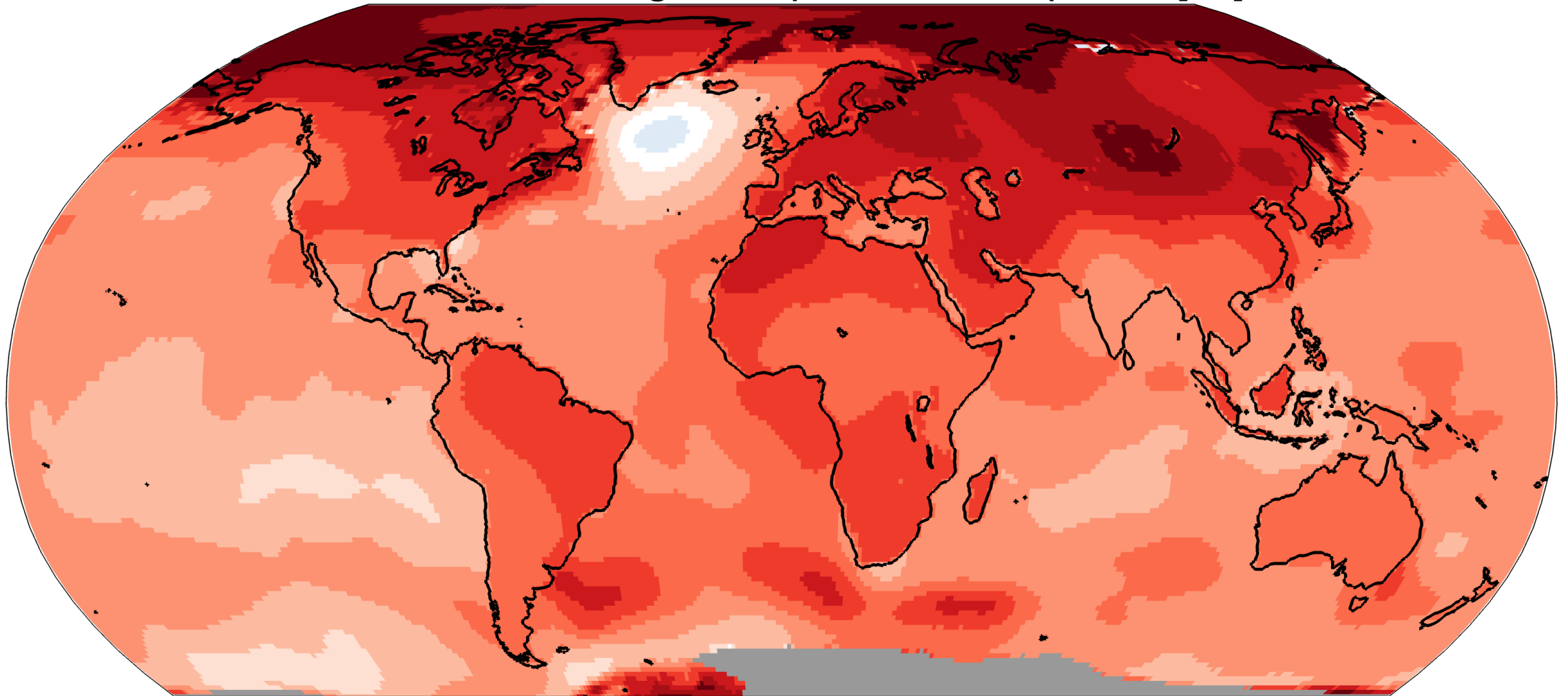
Too slow

# Global temperature change (1850-2022)

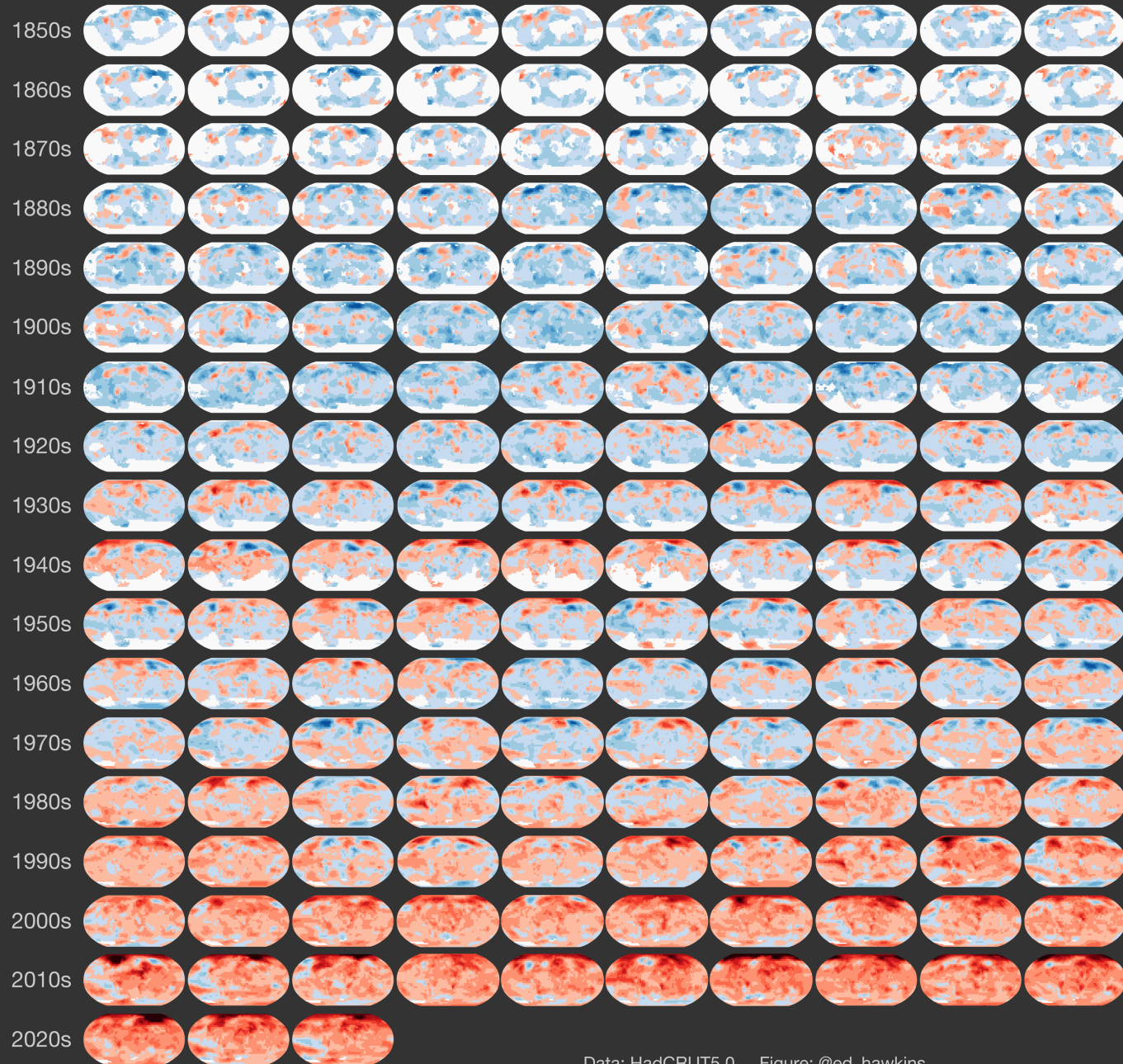




Observed warming since pre-industrial period [°C]



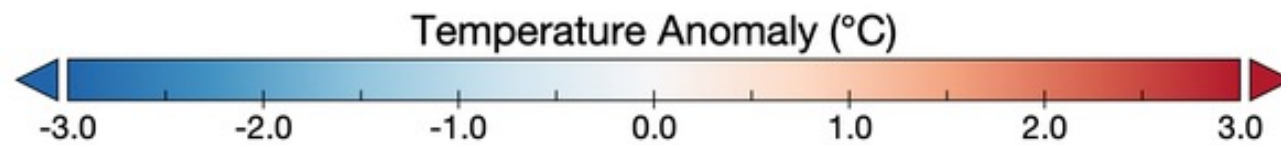
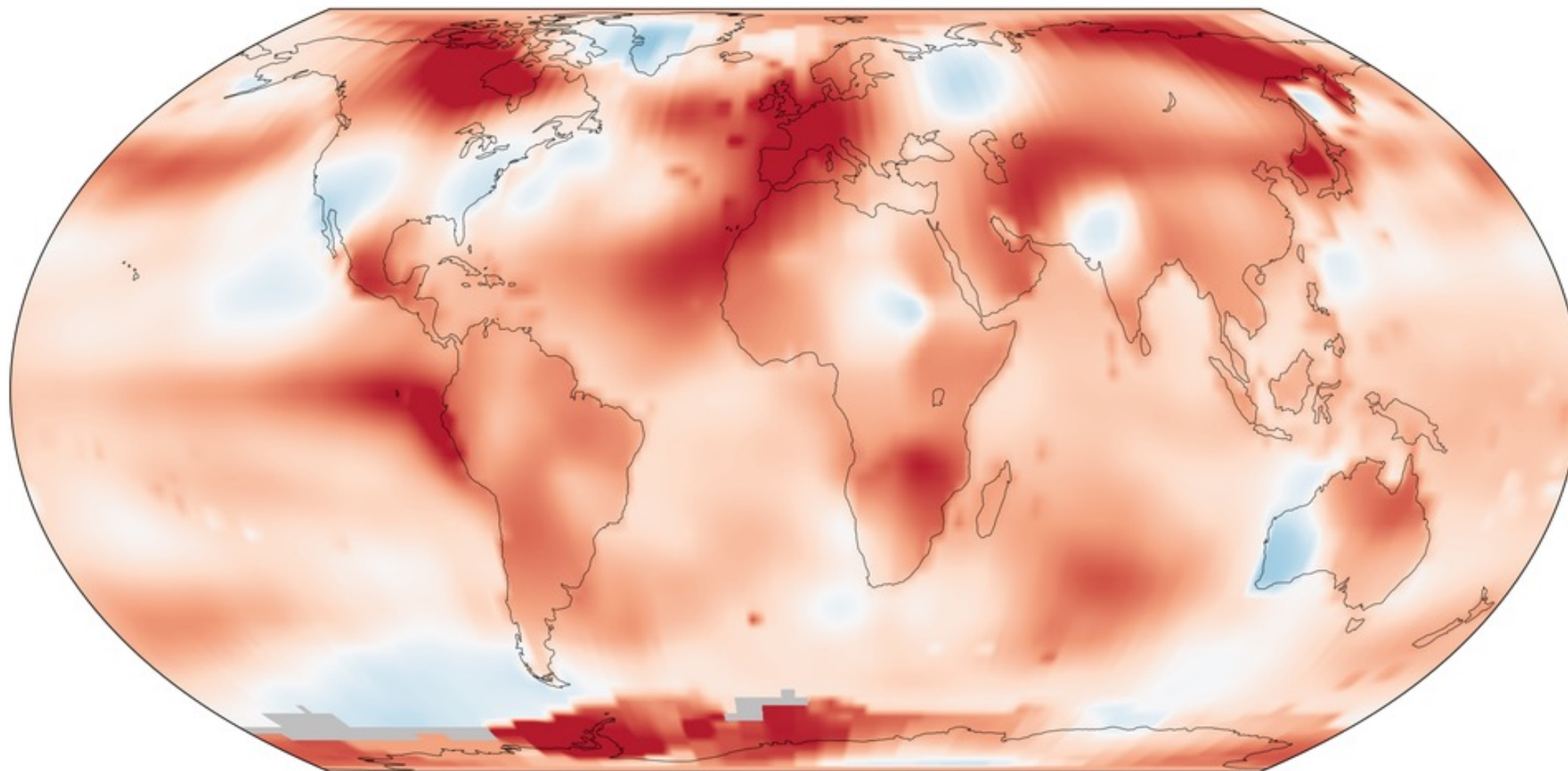
# Mapping changes in temperature: every year from 1850 to 2022



# NASA Finds June 2023 Hottest on Record

## June 2023 Global Temperature

NASA GISTEMP (1951-1980 baseline)





MARKETS

BUSINESS

INVESTING

TECH

POLITICS

CNBC TV

INVESTING CLUB



PRO



WEATHER AND NATURAL DISASTERS

# Record heat meets record wildfires in Canada, and scientists say this is the new reality

PUBLISHED THU, JUL 13 2023-3:17 PM EDT | UPDATED THU, JUL 13 2023-5:23 PM EDT



Catherine Clifford

[@IN/CATCLIFFORD/](#)

[@CATCLIFFORD](#)

SHARE





U.S. >

# Air quality alerts issued for Canadian wildfire smoke in Great Lakes, Midwest, High Plains

BY ALIZA CHASAN

JULY 16, 2023 / 4:09 PM / CBS NEWS





World

Africa

Americas

Asia

Australia

China

Europe

India

Middle East

United Kingdom

# This week's record-breaking global temperatures are likely highest in 'at least 100,000 years'

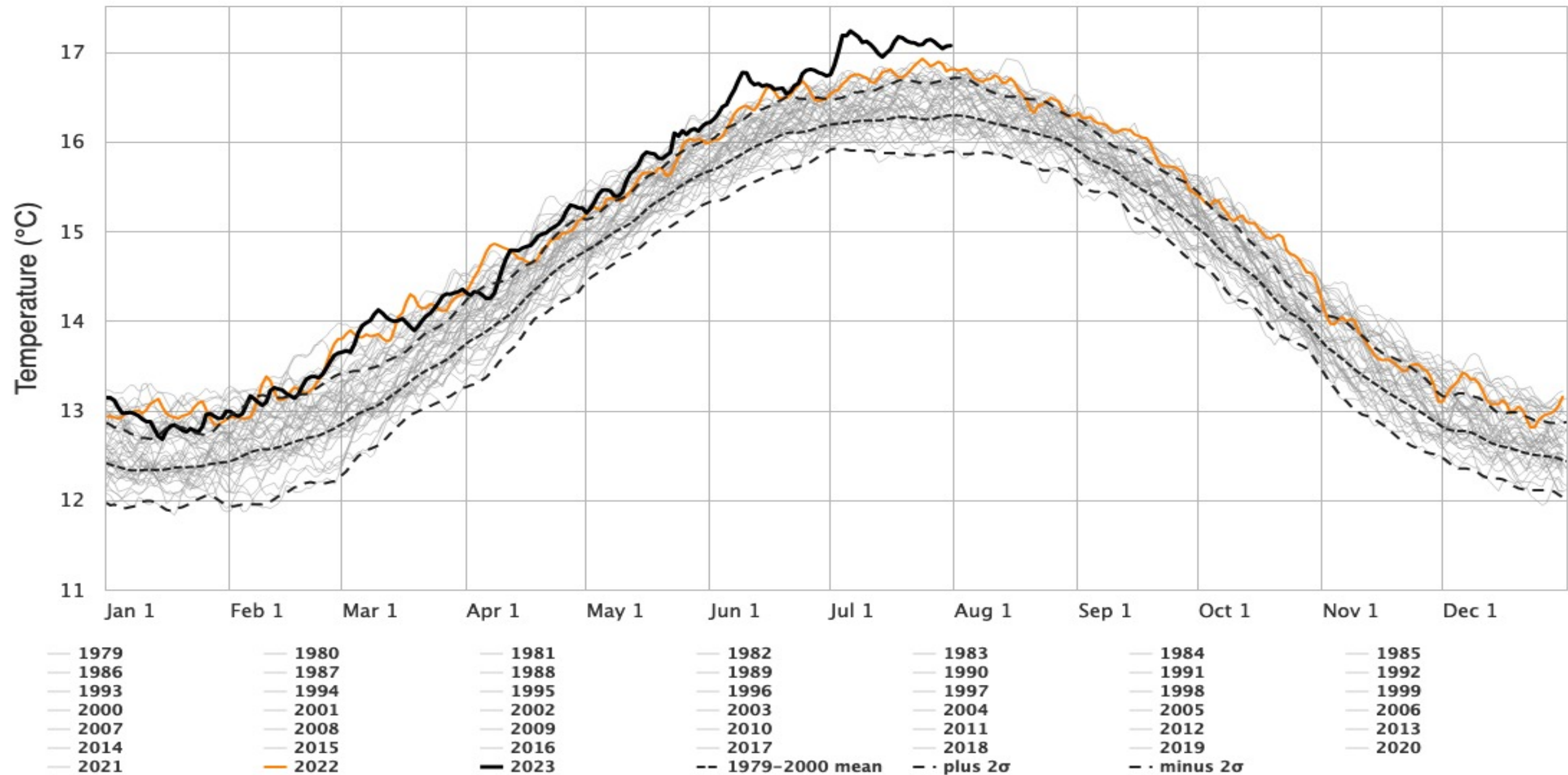
By Angela Fritz and Laura Paddison, CNN

Updated 11:33 AM EDT, Fri July 7, 2023



# 2m Temperature World (90°S–90°N, 0–360°E)

NCEP CFSV2/CFSR | ClimateReanalyzer.org, Climate Change Institute, University of Maine





LOG IN

SUBSCRIBE

Monday, July 17, 2023  
Today's eEdition

# THE SACRAMENTO BEE

Part of the McClatchy Media Network



[News](#) [Sports](#) [Politics](#) [Opinion](#) [Obituaries](#) • [Personal Finance](#) [Food & Drink](#) [Bee Curious](#) [Equity Lab](#) [Capitol Alert](#) [Detour](#) [Shopping](#)

WATER & DROUGHT

## California drought update: Map shows latest conditions as state braces for dangerous heat

BY BRIANNA TAYLOR

UPDATED JULY 13, 2023 1:30 PM





[SCIENCE](#)[CLIMATE](#)[NATURAL DISASTERS](#)

# California's deadly floods won't break the megadrought

Atmospheric rivers are dumping rain on California. That's not a good thing.

By Neel Dhanesha | [@neel\\_dhan](#) | [neel.dhanesha@vox.com](mailto:neel.dhanesha@vox.com) | Jan 6, 2023, 11:40am EST



SHARE



World

Africa

Americas

Asia

Australia

China

Europe

India

Middle East

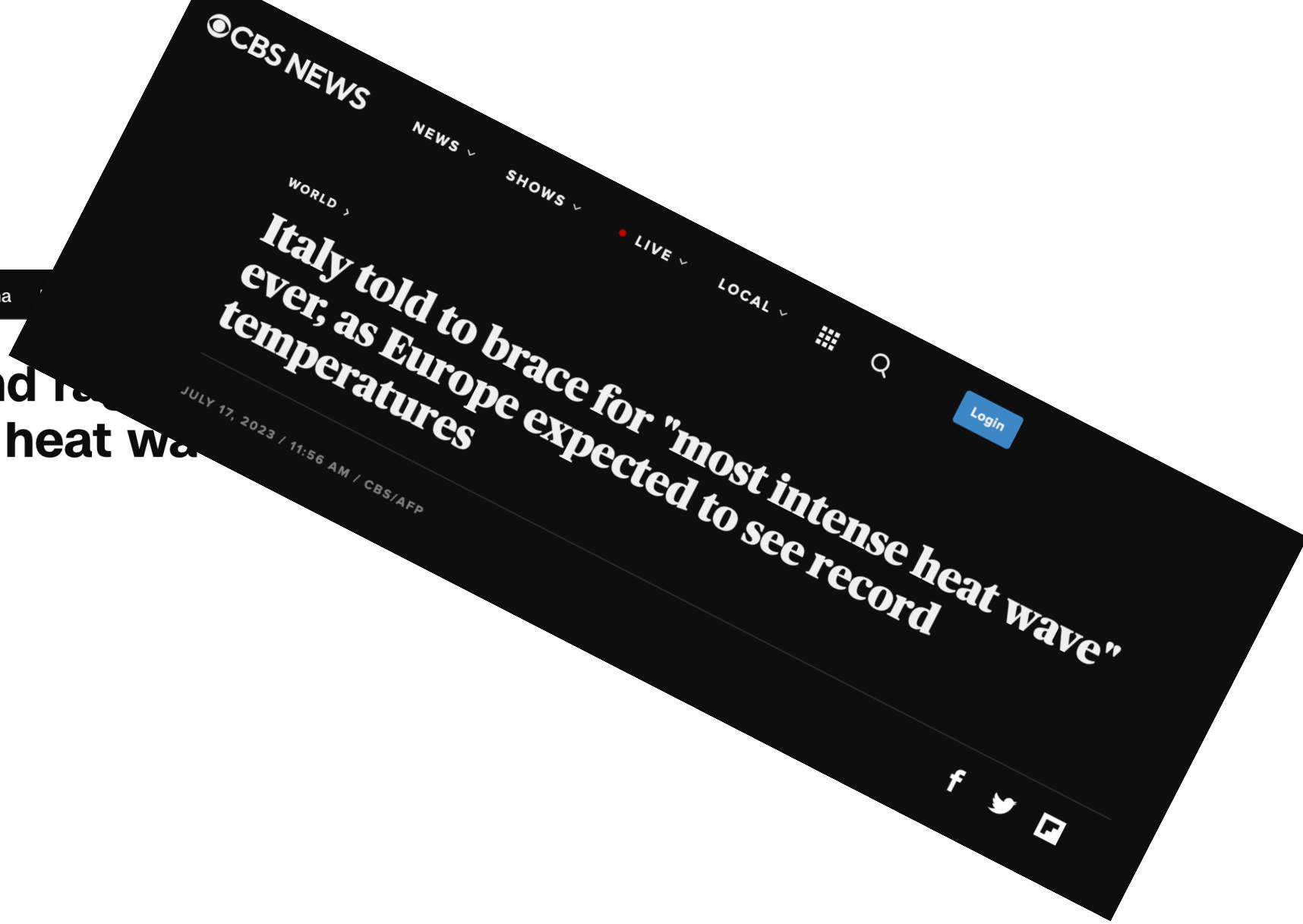
United Kingdom

# Soaring temperatures and raging fires: Europe faces its second heat wave in a week

By Laura Paddison, CNN

Updated 11:10 AM EDT, Mon July 17, 2023





# Soaring temperatures and record heat Europe faces its second heat wave

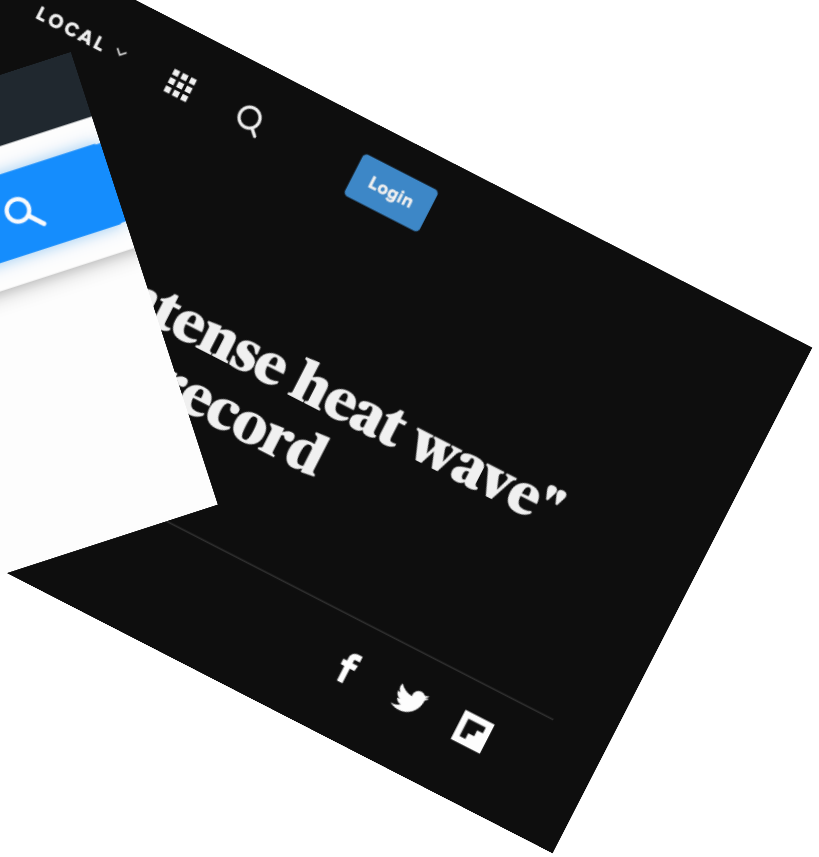
By Laura Paddison, CNN

Updated 11:10 AM EDT, Mon July 17, 2023



# Soaring temperatures and record heat in Europe faces its second heat wave

By Laura Paddison, CNN  
Updated 11:10 AM EDT, Mon July 17, 2023



News | Climate

# Extreme heat grips three continents as wildfires rage

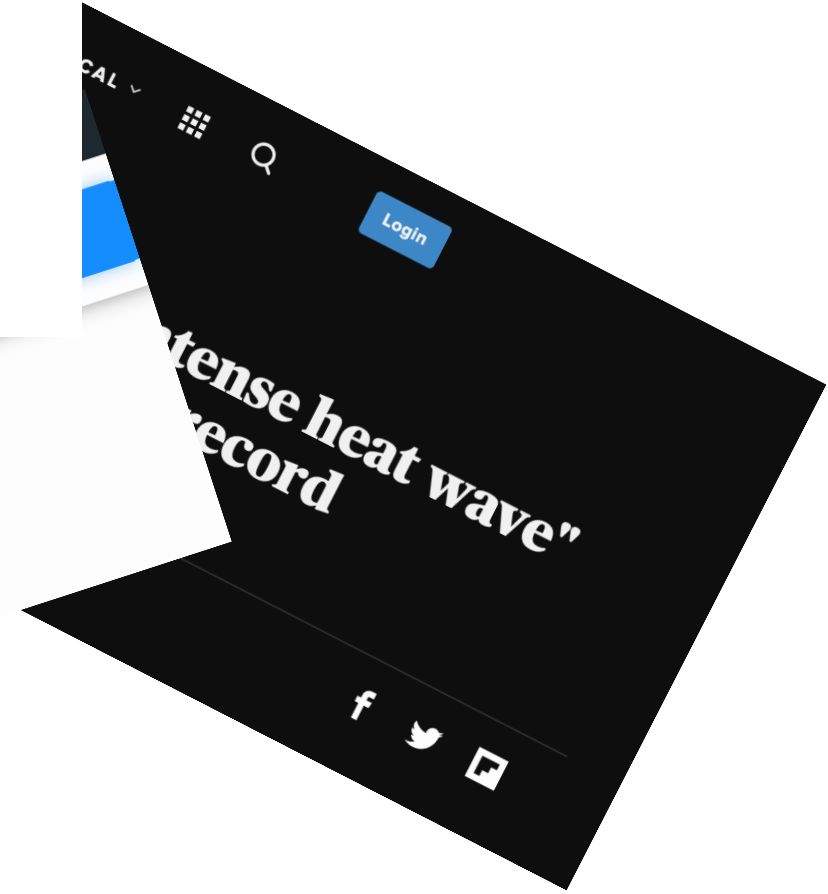
*Health alerts issued as scorching weather strikes three continents, threatening to topple temperature records.*

By Laura Paddison, CNN

Updated 11:10 AM EDT, Mon July 17, 2023



Soa  
Euro



News | Climate

# Extreme heat grips three continents as wildfires rage

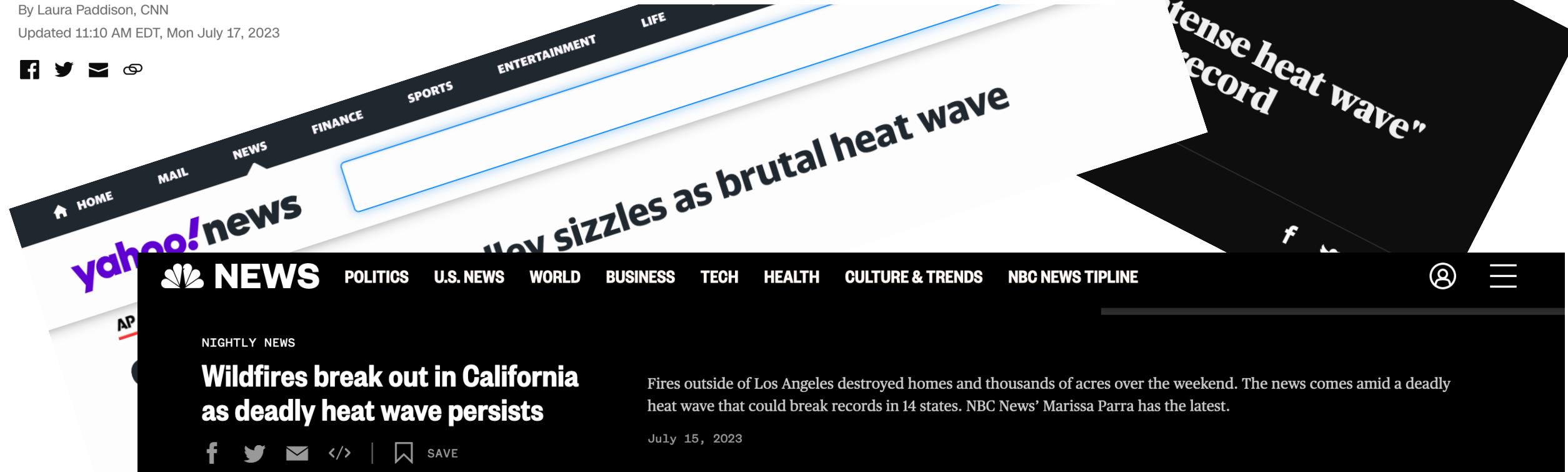
*Health alerts issued as scorching weather strikes three continents, threatening to topple temperature records.*

By Laura Paddison, CNN

Updated 11:10 AM EDT, Mon July 17, 2023

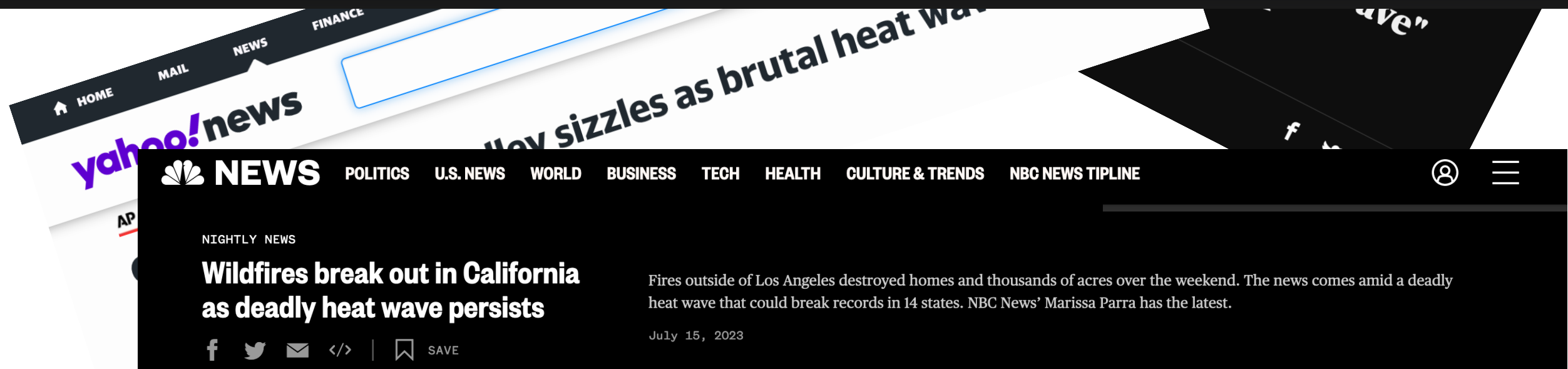


Soa  
Euro



U.S. NEWS

# US Southwest swelters under dangerous heat wave, with new records on track



HOME MAIL NEWS FINANCE

**yahoo!news**

... sizzles as brutal heat wave

... ve"

**NBC NEWS** POLITICS U.S. NEWS WORLD BUSINESS TECH HEALTH CULTURE & TRENDS NBC NEWS TIPLINE

NIGHTLY NEWS

## Wildfires break out in California as deadly heat wave persists

Fires outside of Los Angeles destroyed homes and thousands of acres over the weekend. The news comes amid a deadly heat wave that could break records in 14 states. NBC News' Marissa Parra has the latest.

July 15, 2023

f t e </> | SAVE

# Nearly 62,000 people died from record-breaking heat in Europe last summer. It's a lesson for the US, too



By [Rachel Ramirez](#), CNN

Updated 11:31 AM EDT, Fri July 14, 2023



**Wildfires break out in California as deadly heat wave persists**



SAVE

Fires outside of Los Angeles destroyed homes and thousands of acres over the weekend. The news comes amid a deadly heat wave that could break records in 14 states. NBC News' Marissa Parra has the latest.

July 15, 2023



# Catastrophic flooding swamped Vermont's capital as intense storms forced evacuations and closures in Northeast

By Nouran Salahieh and Lauren Mascarenhas, CNN

Updated 8:12 PM EDT, Wed July 12, 2023





ABC15 Arizona

@abc15

NEW HEAT RECORD 🌡️ The heat wave continues! Phoenix officially hit 118° today, breaking the previous daily record high of 116° set back in 2018. [bit.ly/44HnSgZ](https://bit.ly/44HnSgZ)



5:31 PM · Jul 25, 2023 · 33K Views

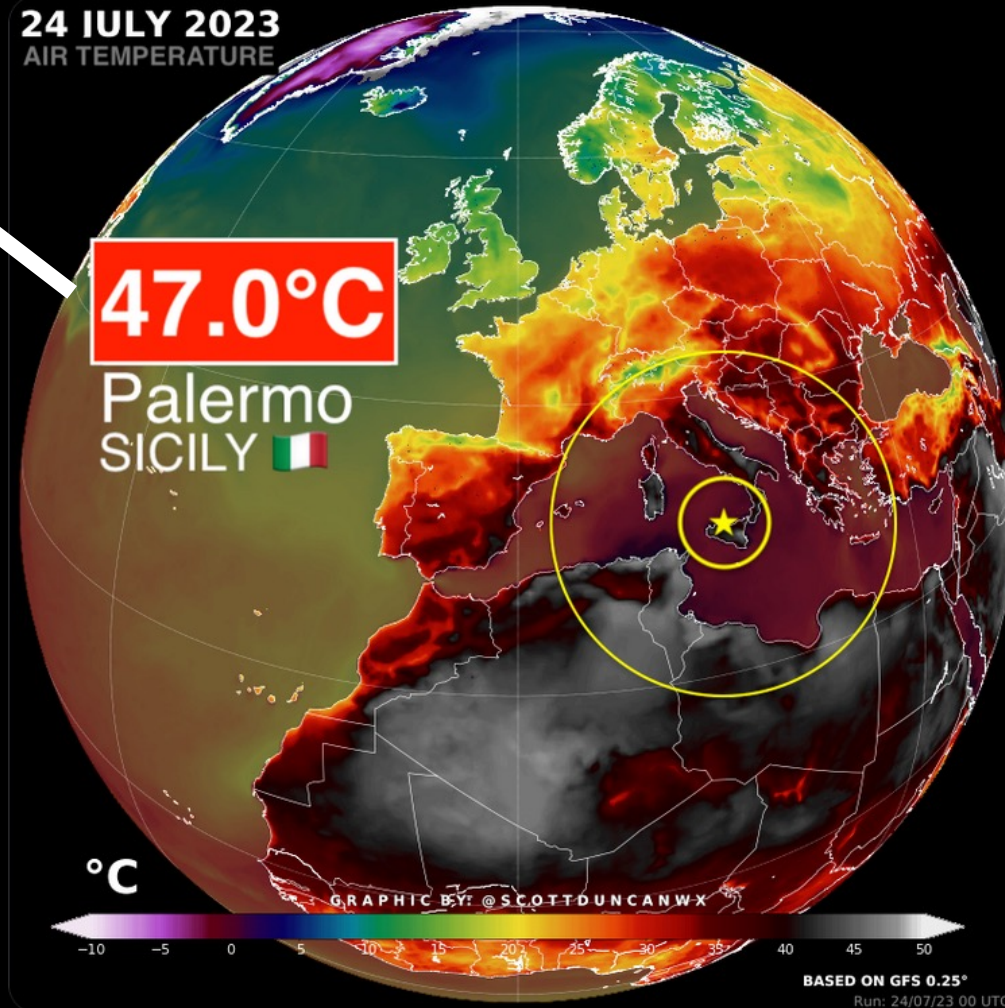
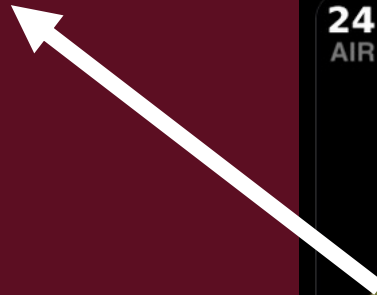


Scott Duncan  
@ScottDuncanWX

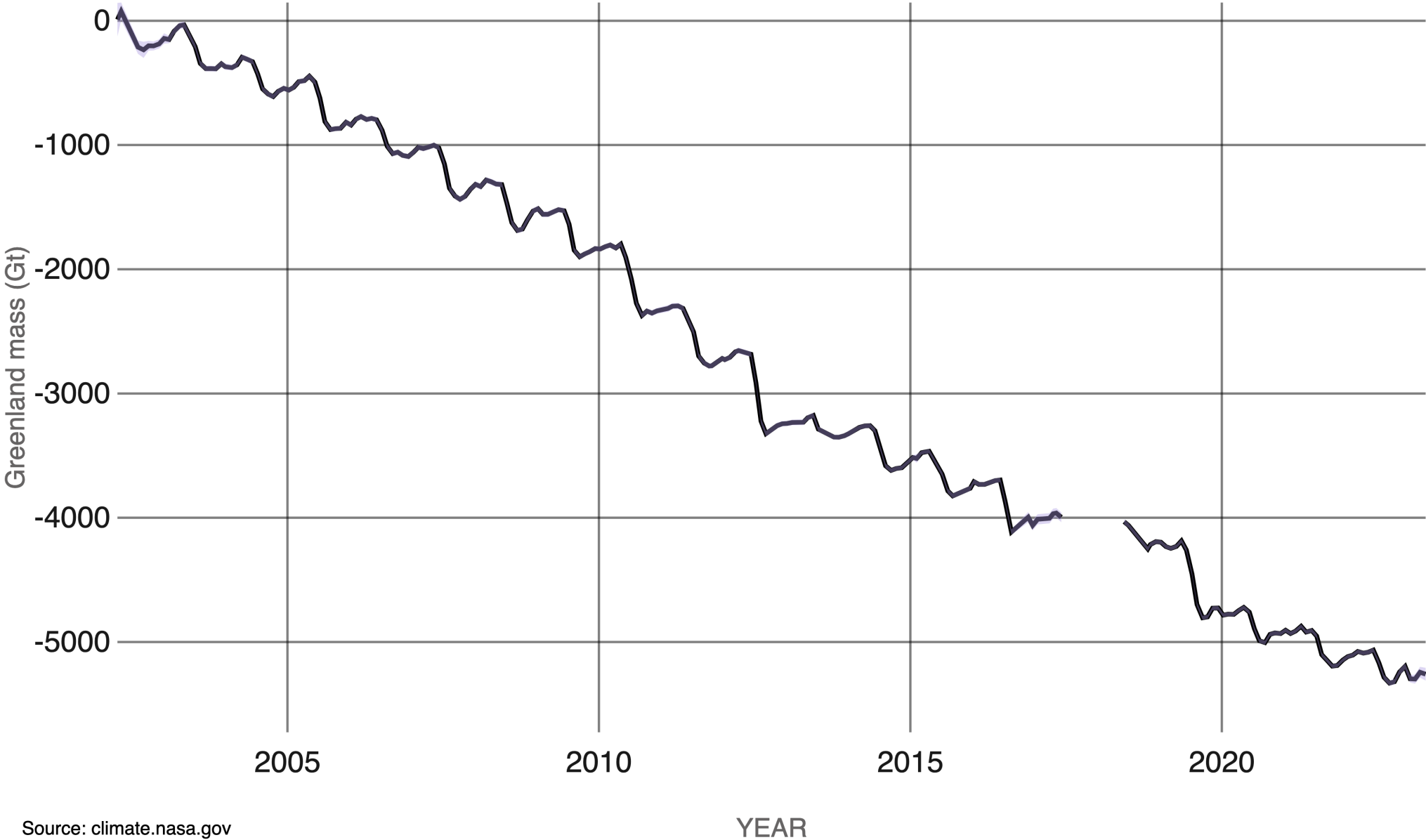
**BREAKING:** Palermo in Sicily has just obliterated its all-time heat record by over 2°C. The previous record was +44.8°C in August 1999.

The observatory has weather data dating back to 1791. This is a very significant record to fall by such an enormous margin.

116.6°F

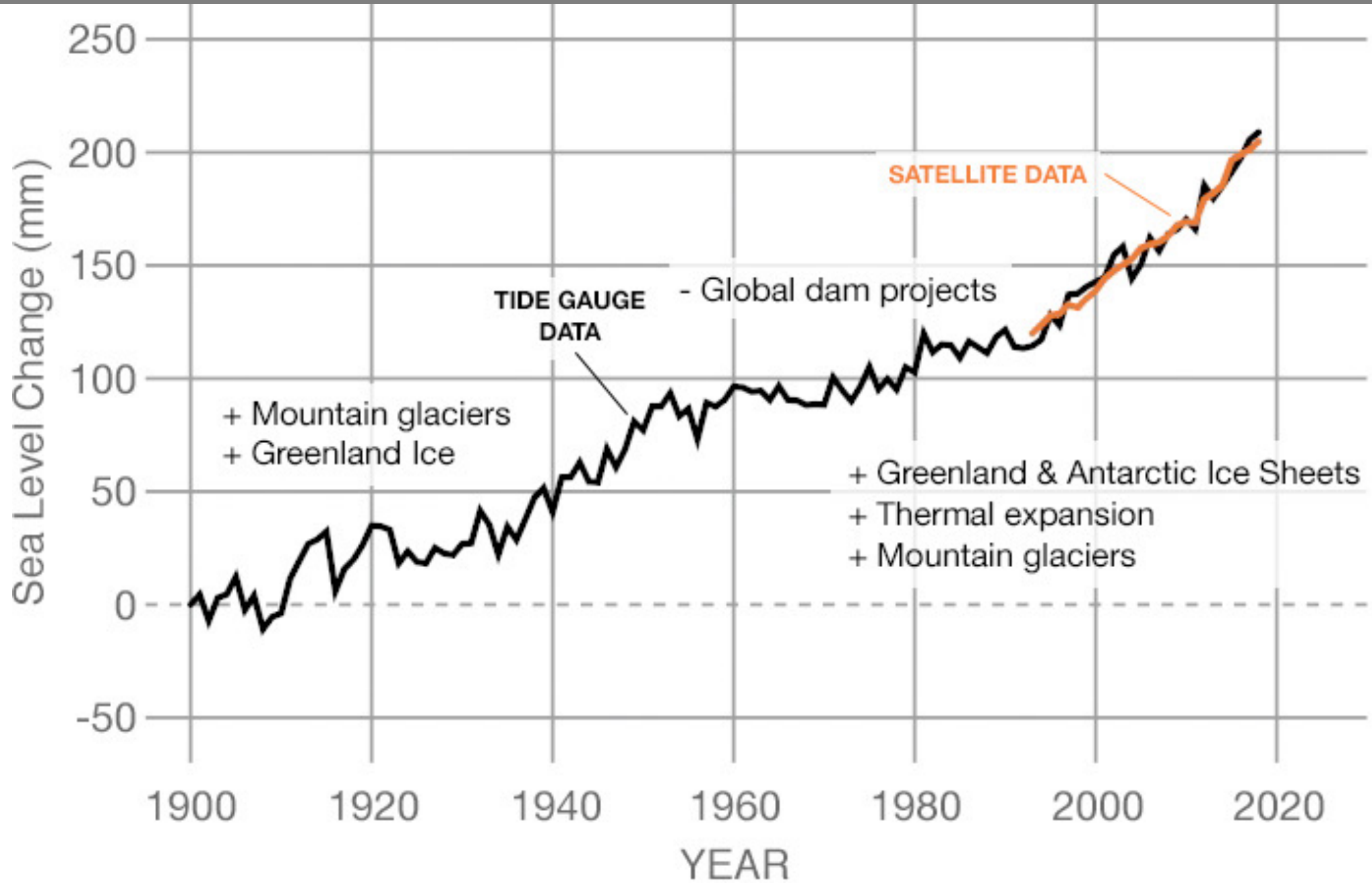


# Greenland Ice Mass



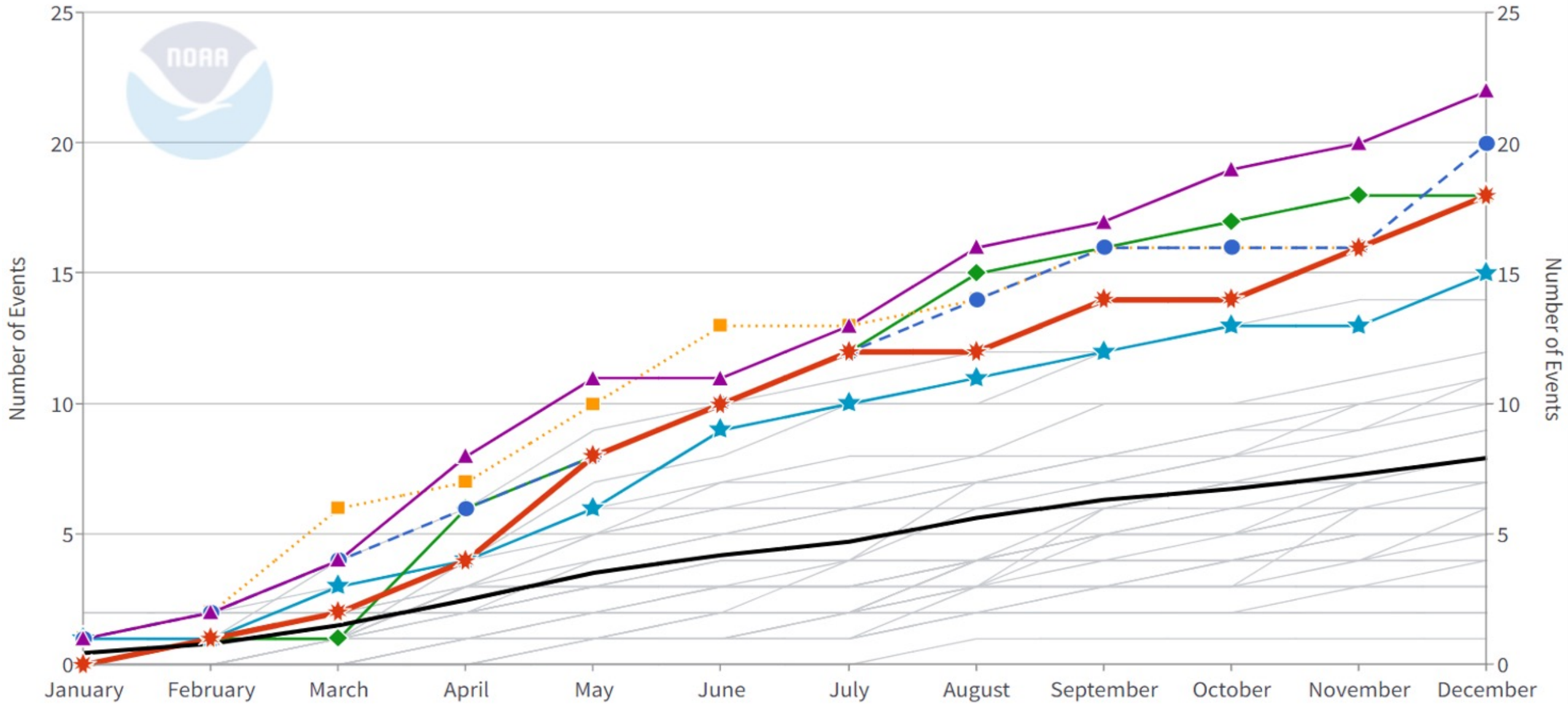
Source: [climate.nasa.gov](https://climate.nasa.gov)

# Sea Levels

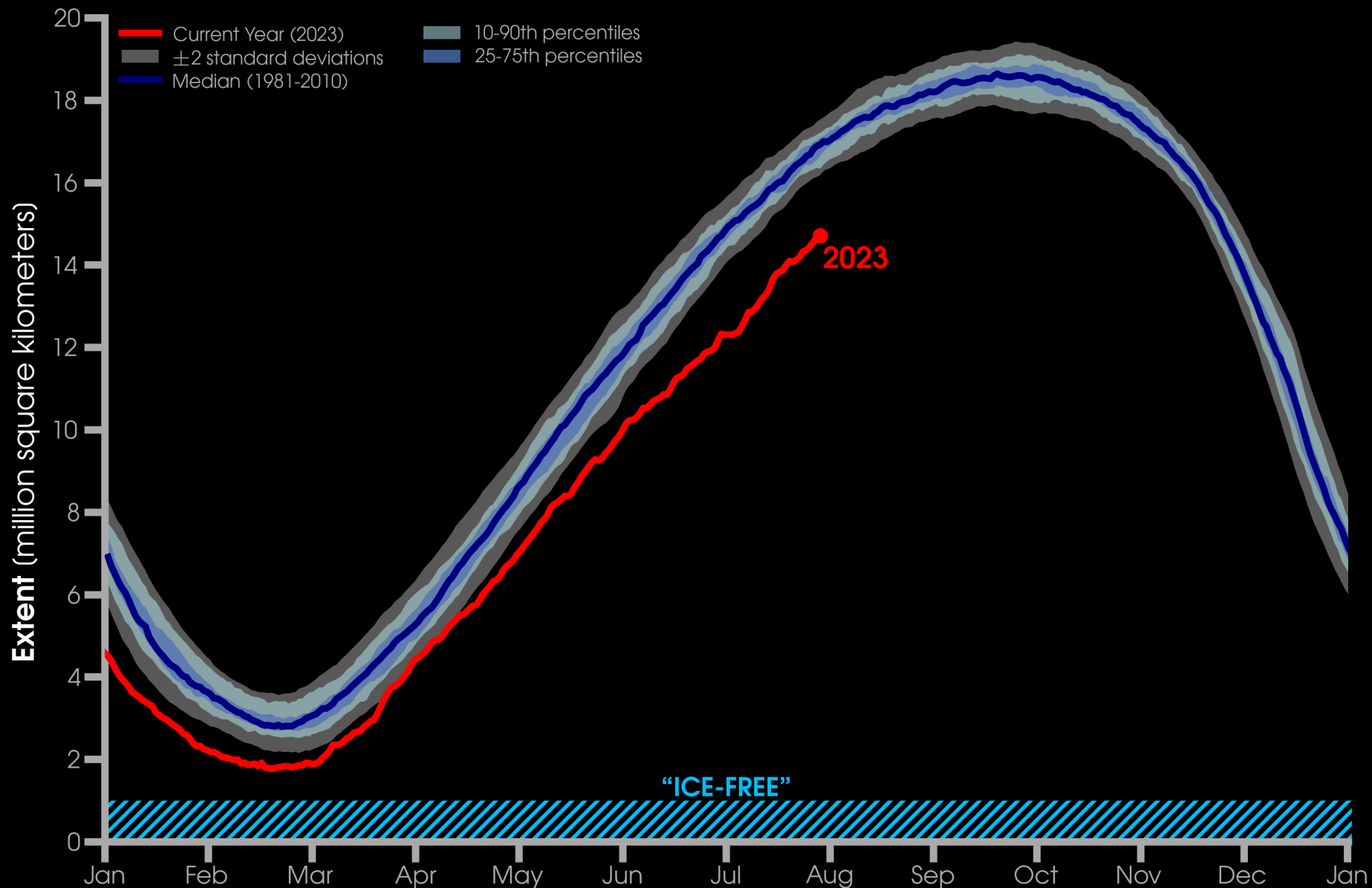


# 1980-2022 United States Billion-Dollar Disaster Event Count (CPI-Adjusted)

★ 2018 (15)    ◆ 2011 (18)    ■ 2017 (18)    ● 2021 (20)    ▲ 2020 (22)    ☆ 2022 (18)    — Average (7.9)



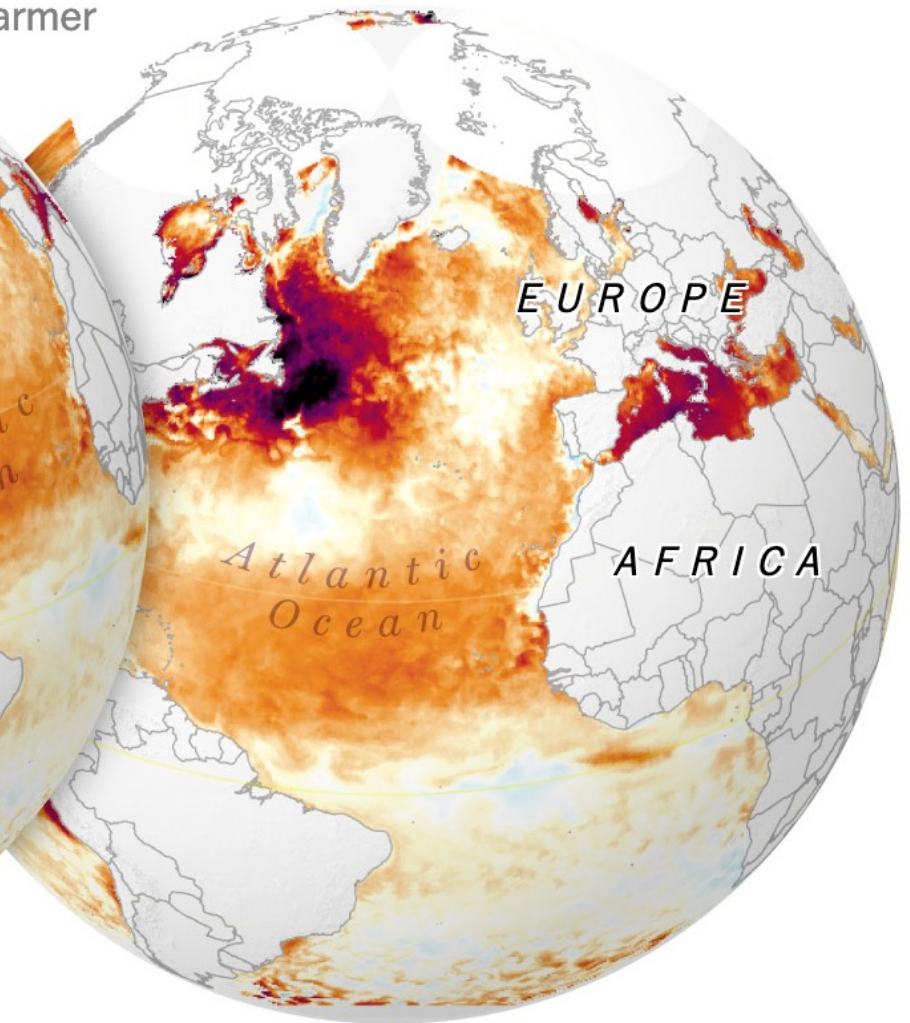
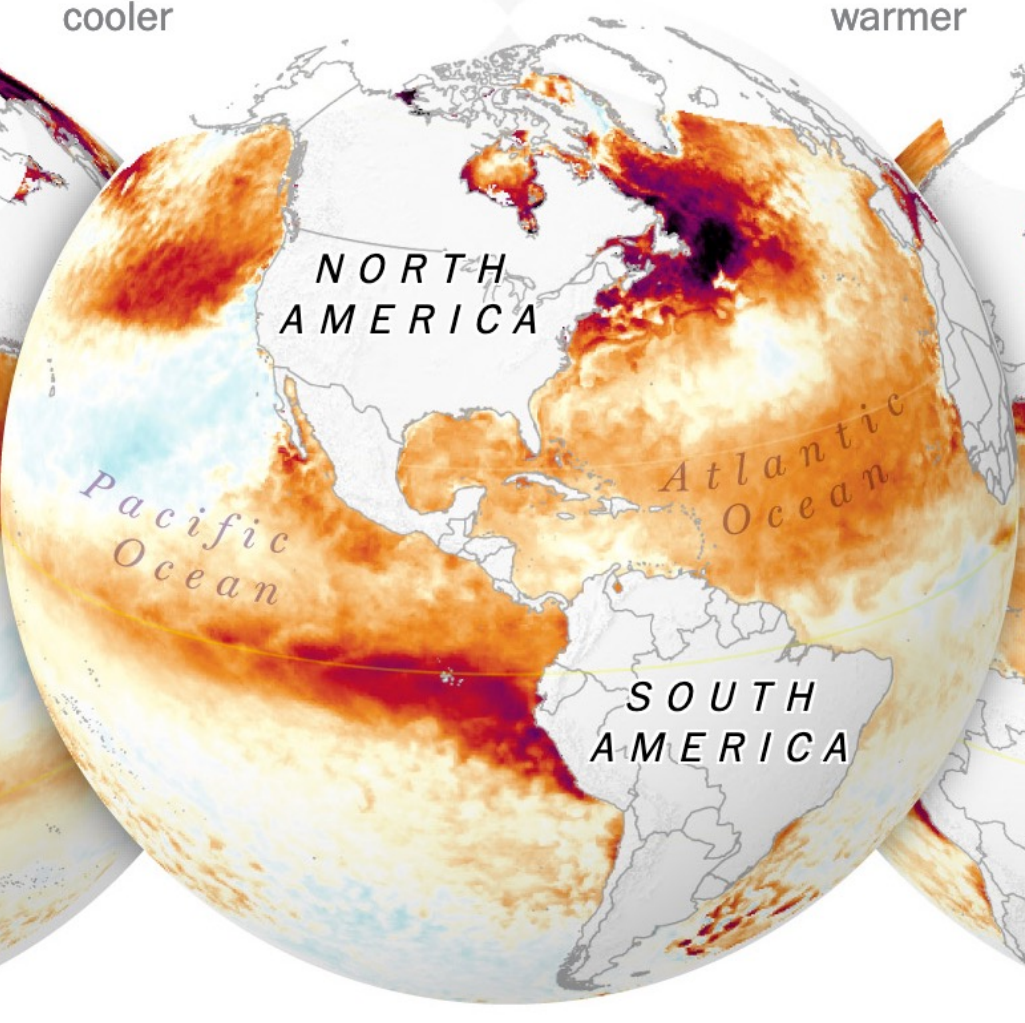
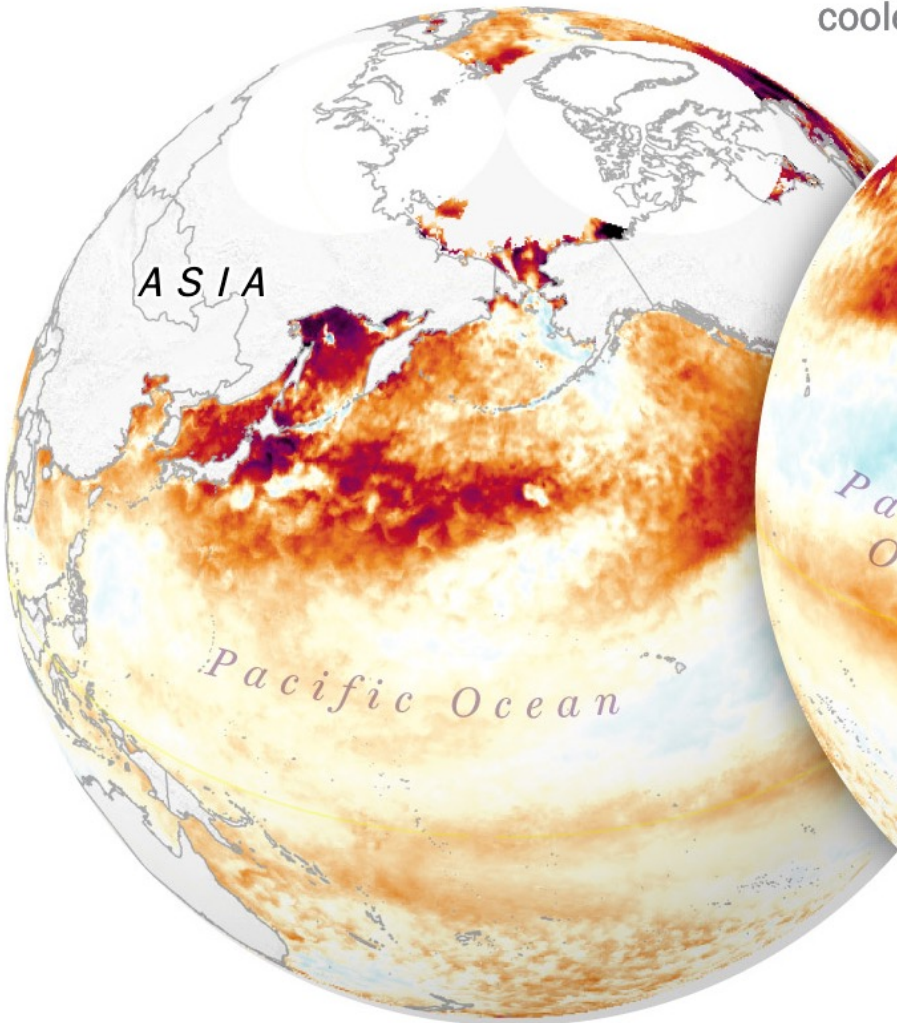
# ANTARCTIC SEA ICE



DATA: National Snow & Ice Data Center, Boulder CO (Sea Ice Index v3; 1979-2023\*)  
SOURCE: <ftp://sidacs.colorado.edu/DATASETS/NOAA/G02135/>

GRAPHIC: Zachary Labe (@ZLabe)

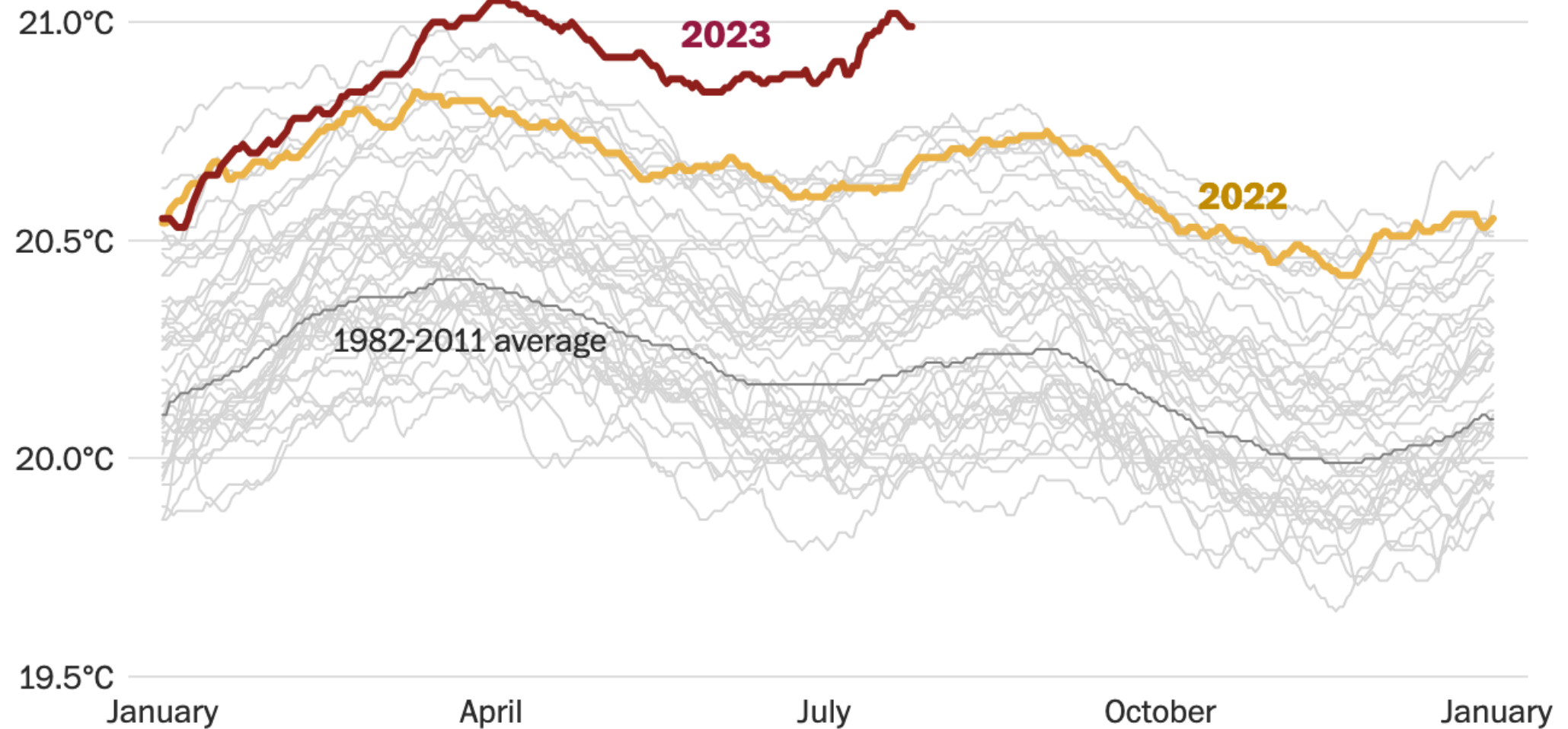
# Sea surface temperature anomaly



Data is as of July 24



# Average daily ocean surface temperature since 1981



The sea surface temperatures shown include data from 60°S to 60°N across all longitudes.

Source: [NOAA Optimum Interpolation Sea Surface Temperature \(OISST\) version 2.1](#), [ClimateReanalyzer.org](#), [Climate Change Institute](#), [University of Maine](#)

# Sea surface temperature anomaly

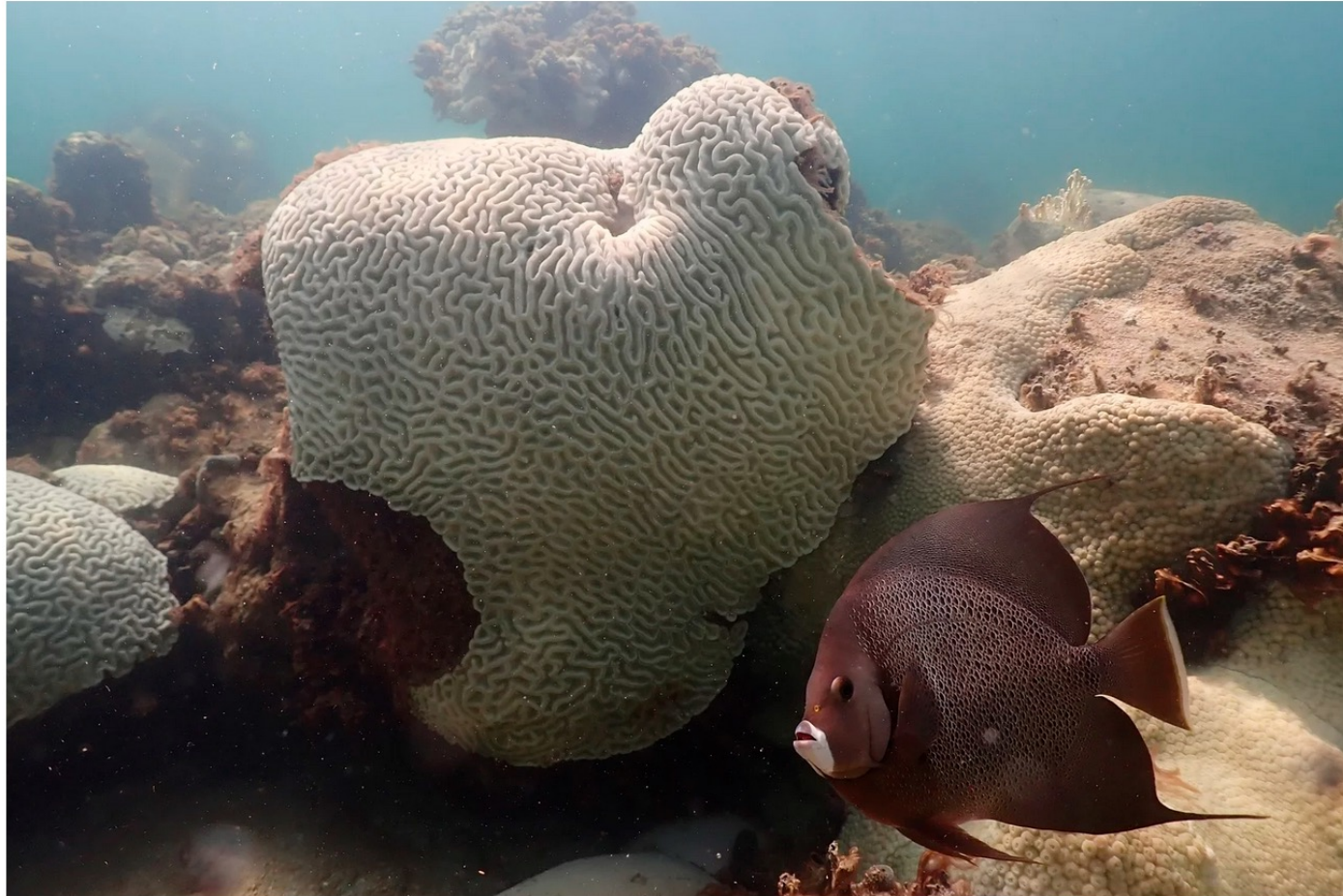


CLIMATE

# With Florida ocean temperatures topping 100, experts warn of damage to marine life

July 26, 2023 · 12:57 PM ET

By [Joe Hernandez](#)



In this image provide by NOAA, a fish swims near coral showing signs of bleaching at Cheeca Rocks off the coast of Islamorada, Fla., on July 23.

[blank]

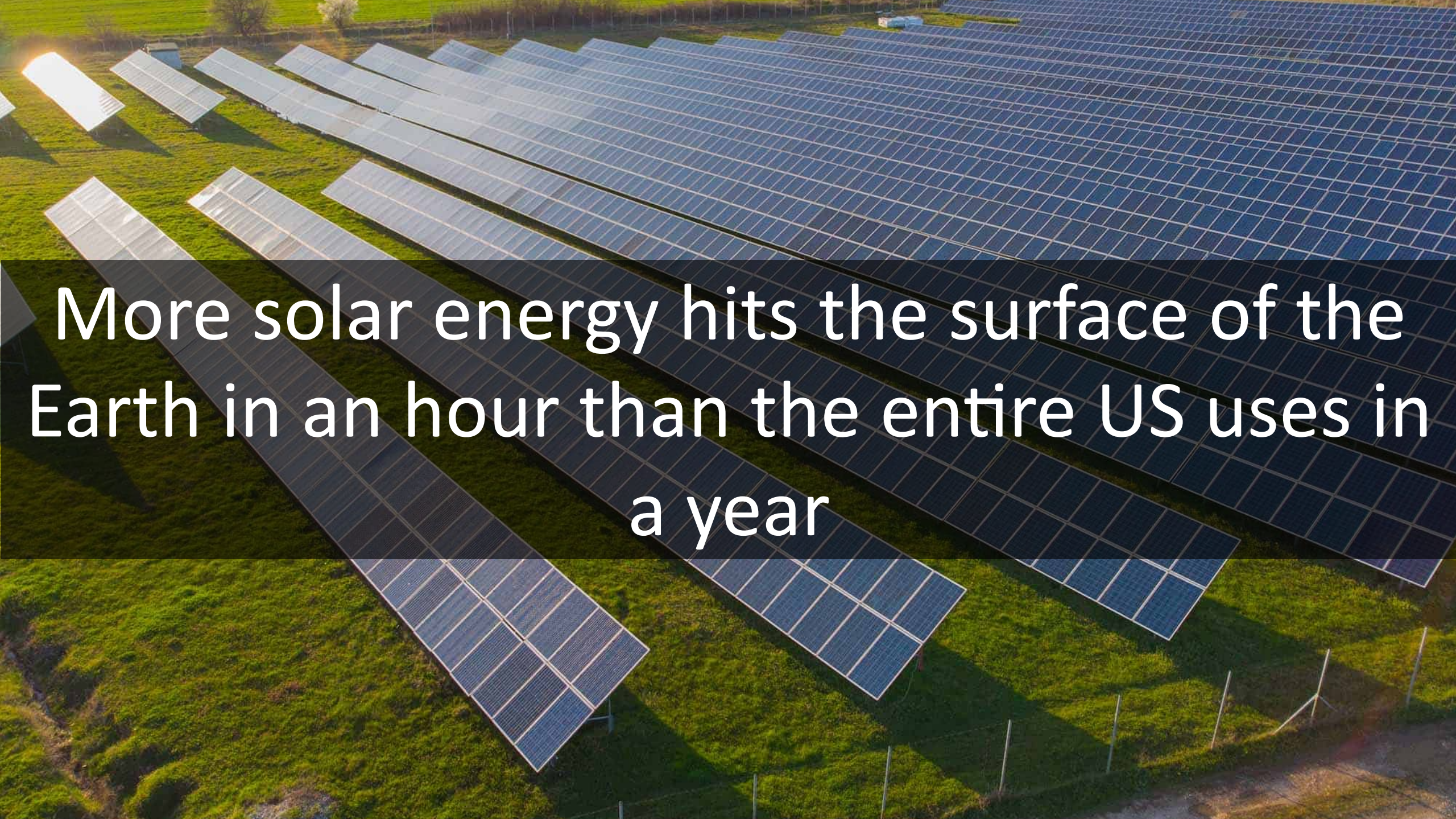
Is there good news?

# Brazil Amazon deforestation drops 34% under Lula, but El Niño is stoking the risk of forest fires



By Euronews Green with AP • Updated: 07/07/2023

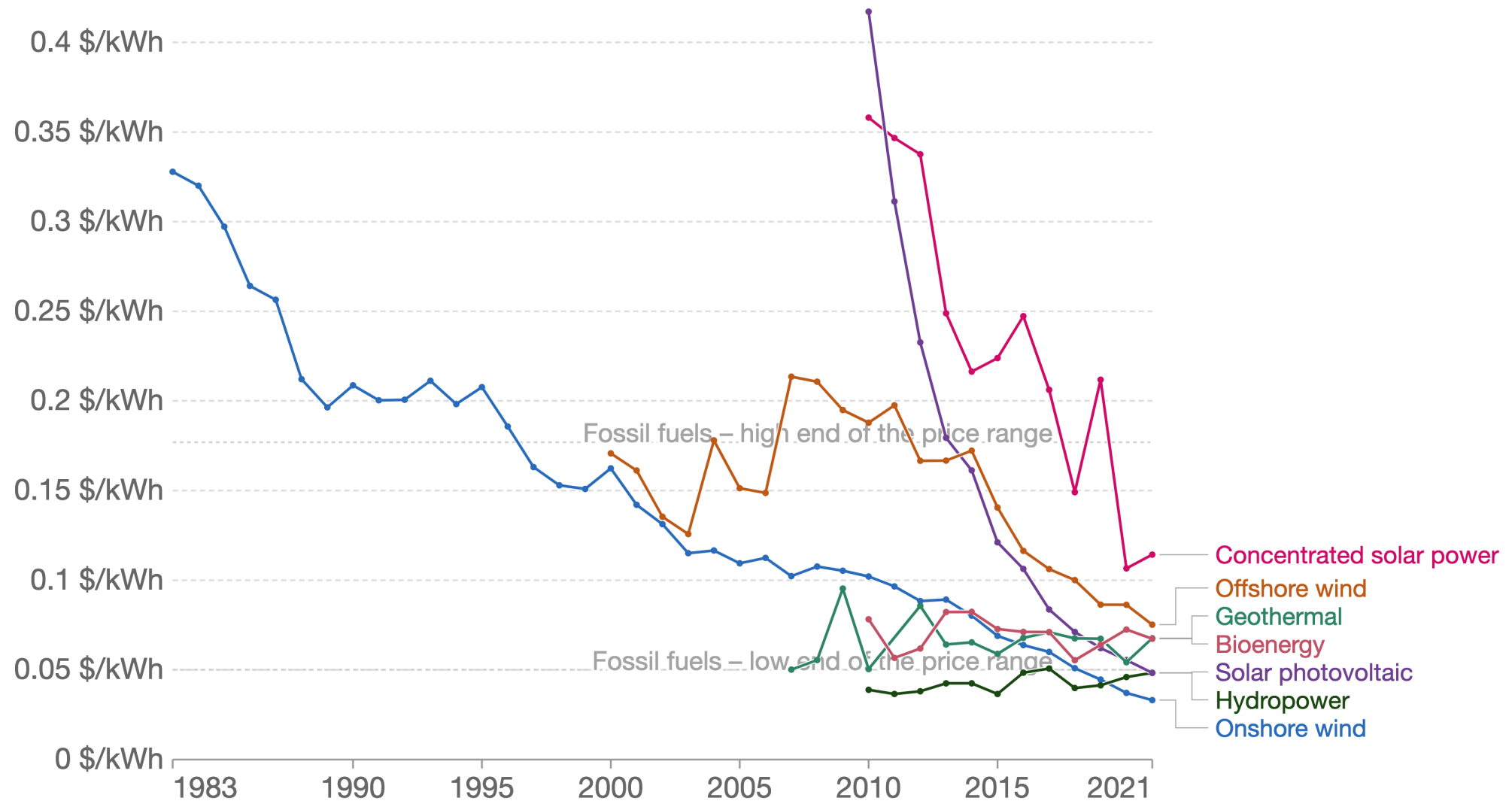
**It follows four years of rising destruction in the critical rainforest under Bolsonaro, but experts know “the fight isn’t over”.**



More solar energy hits the surface of the Earth in an hour than the entire US uses in a year

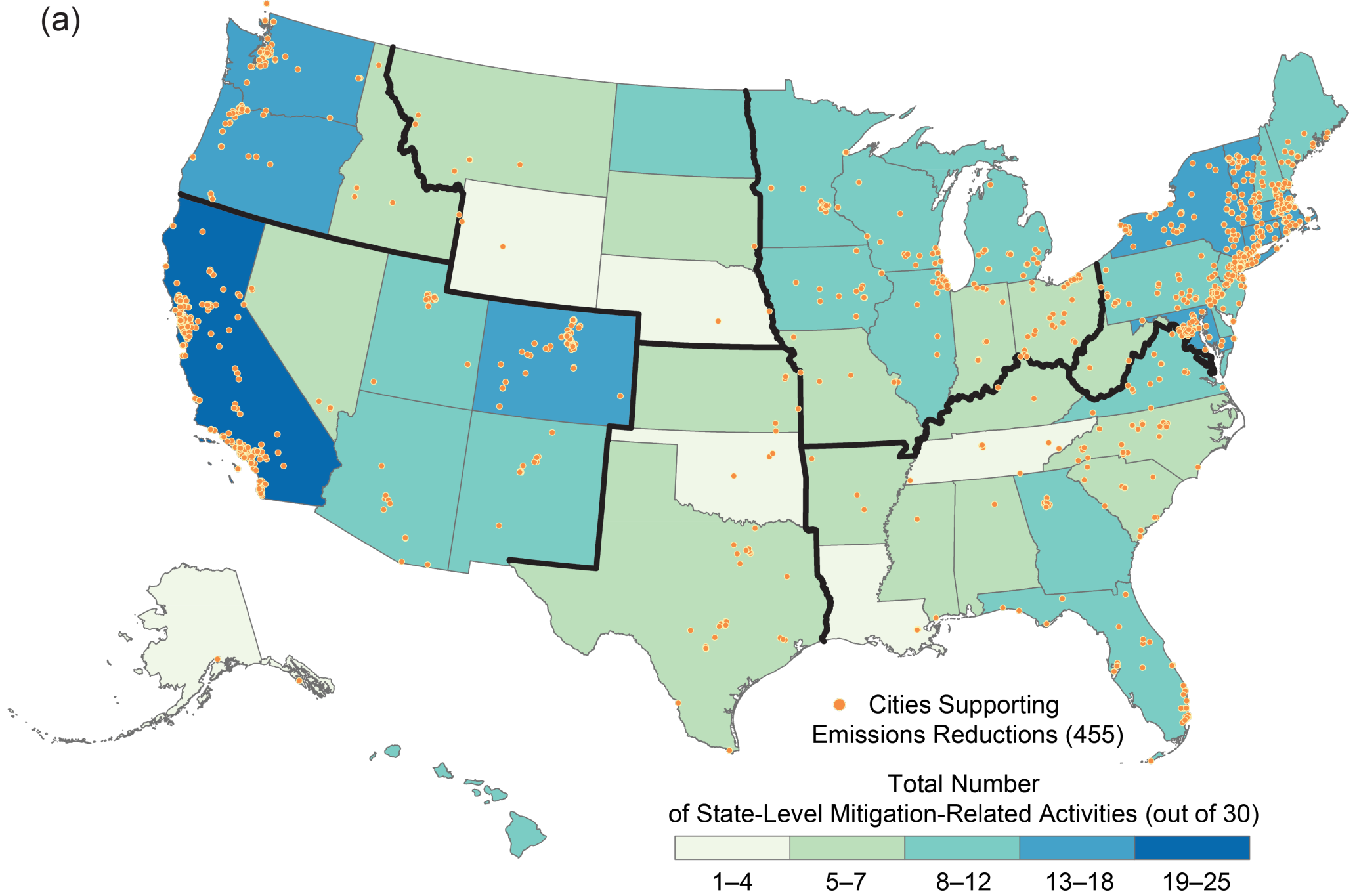
# Levelized cost of energy by technology, World

The average cost per unit of energy generated across the lifetime of a new power plant. This data is expressed in US dollars per kilowatt-hour, adjusted for inflation.





(a)



(b)

## Global coalition to cut methane formed

The U.S., European Commission, Australia, South Korea and Japan are joining forces to cut methane emissions. Methane, a potent greenhouse gas, is responsible for almost one-third of global heating since the industrial revolution, making efforts to limit its emissions crucial in the fight against climate.

And coming early next year, a new satellite will help spot methane leaks.



## US solar jobs trending upward

The executive summary from the Interstate Renewable Energy Council shows a 3.5% increase in solar job growth since 2021, demonstrating a positive trend in the renewable energy sector.

The report showcases a remarkable surge in employment opportunities within the solar industry, highlighting its significant contribution to the U.S. job market and sustainable economic development.



## Egypt Set to Build Largest Wind Farm in Africa



 Egypt Set To Build Largest Wind Farm In Africa. Source: Unsplash

Fisher Brown  
Fri 14 Jul 2023

## Egypt Set to Build Largest Wind Farm in Africa

## Heat pumps avoided 8m tonnes of CO2 emissions in Europe last year: Which country sold the most?



By [Rosie Frost](#) • Updated: 20/02/2023

Europe's 20 million heat pumps now avoid emissions the equivalent of the entirety of Greece.

## Global coalition to cut methane formed

The U.S., European Commission, South Korea and Japan are joining cut methane emissions. Methane, greenhouse gas, is responsible for one-third of global heating since industrial revolution, making efforts to cut its emissions crucial in the fight against climate.

And coming early next year, a new agreement will help spot methane leaks.



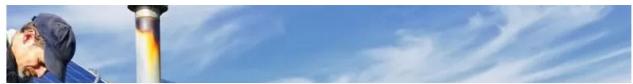
### Egypt Set in Africa



Egypt Set To Build Largest Wind Farm In Africa. Source: Unsplash

### Egypt Set to Build Largest Wind Farm in Africa

Fisher Brown  
Fri 14 Jul 2023



## US solar jobs trending upward

Executive summary from the Renewable Energy Council shows a 3.5% increase in solar job growth in 2021, demonstrating a positive trend in the renewable energy sector.

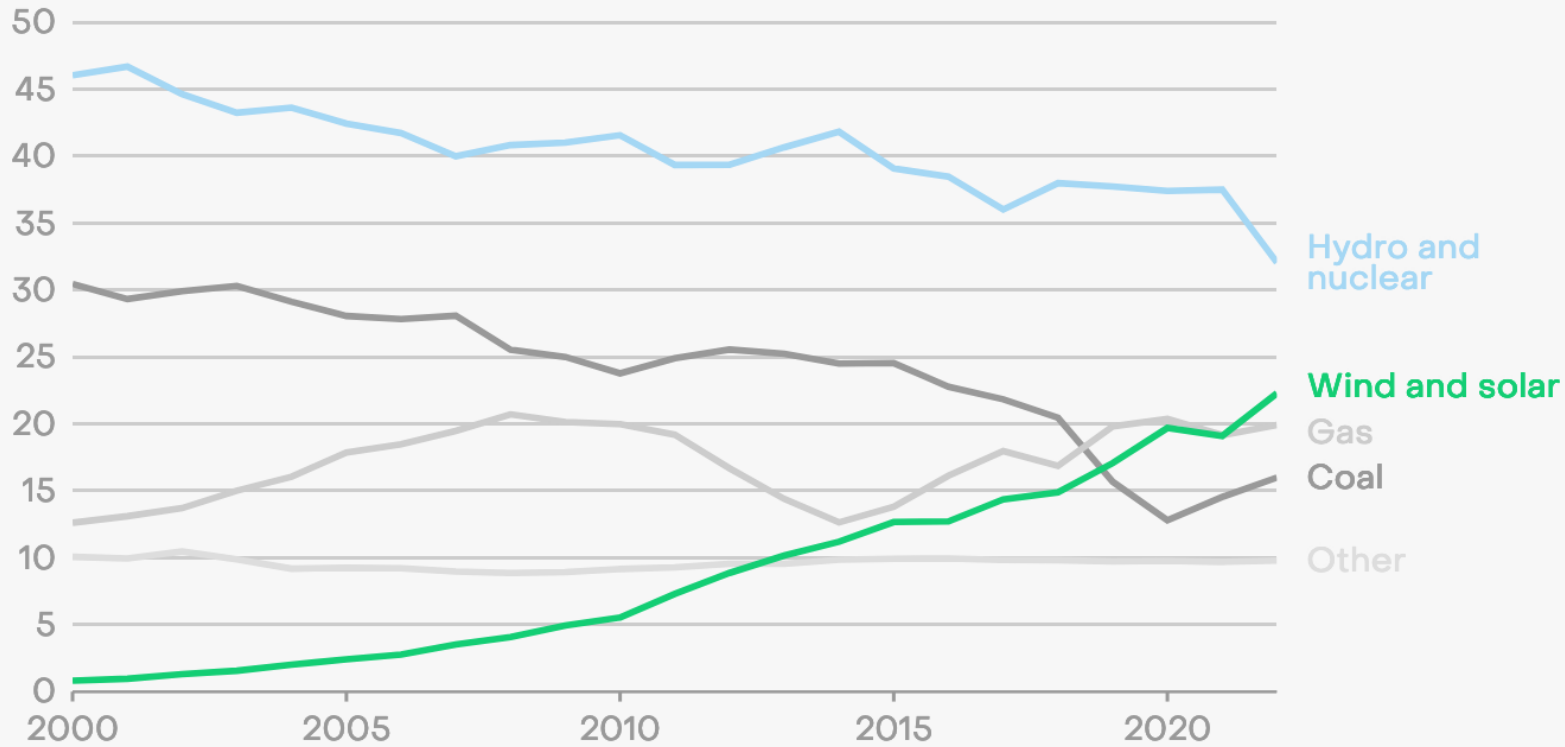
The report showcases a remarkable surge in employment opportunities within the industry, highlighting its significant contribution to the U.S. job market and overall economic development.

### 2021 Top CO2 emitting country



# EU wind and solar generated more than gas for the first time

## Share of electricity generation (%)



Source: Annual electricity data, Ember  
'Other' includes bioenergy, other fossil fuels and other renewables



By Rosie Frost • Updated: 20/02/2023

Europe's 20 million heat pumps now avoid emissions the equivalent of the entirety of Greece.

# Demand for electric cars is booming, with sales expected to leap 35% this year after a record-breaking 2022

News  
26 April 2023



# Paris to Make Seine Swimmable Again After a Century

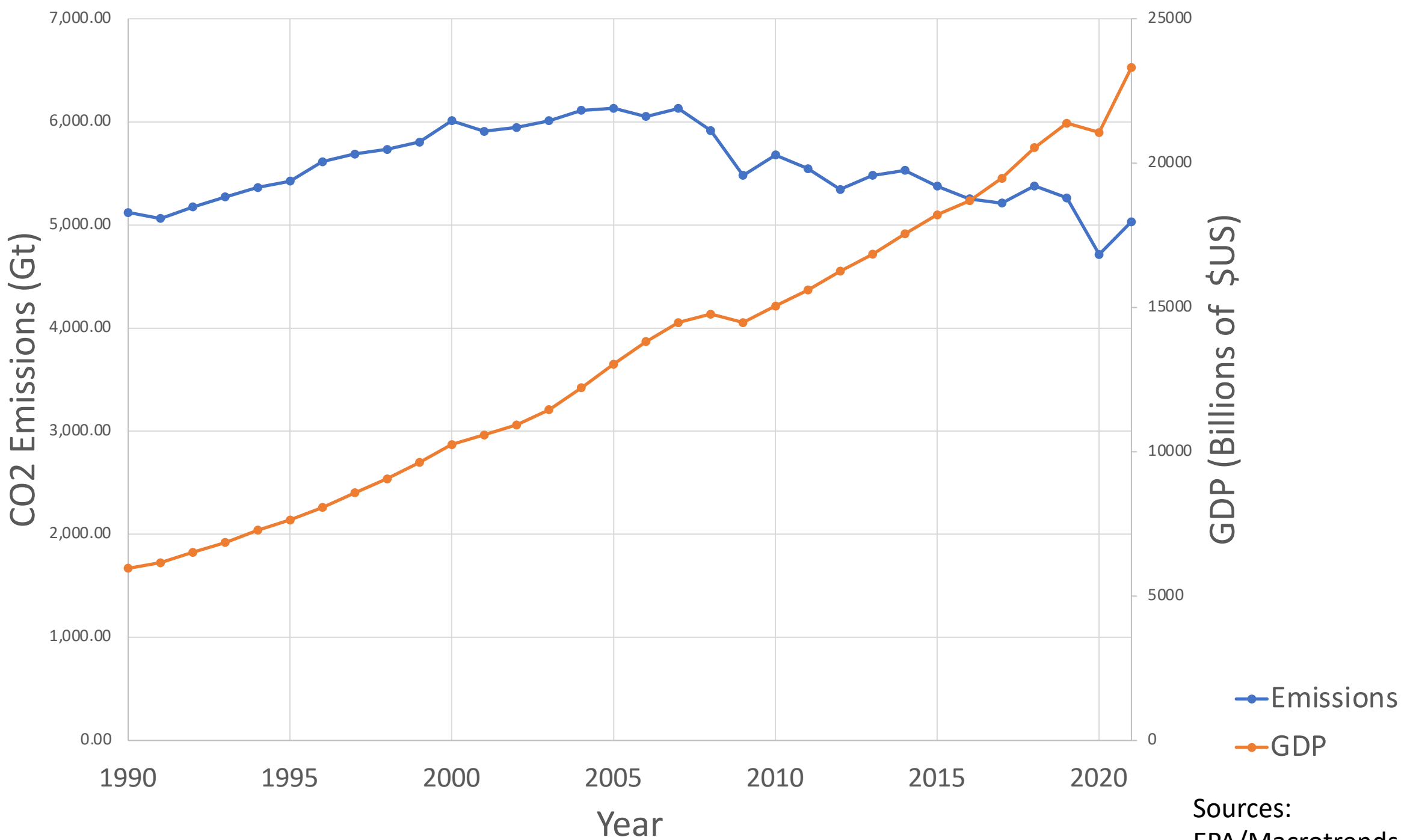


By: [Cristen Hemingway Jaynes](#)

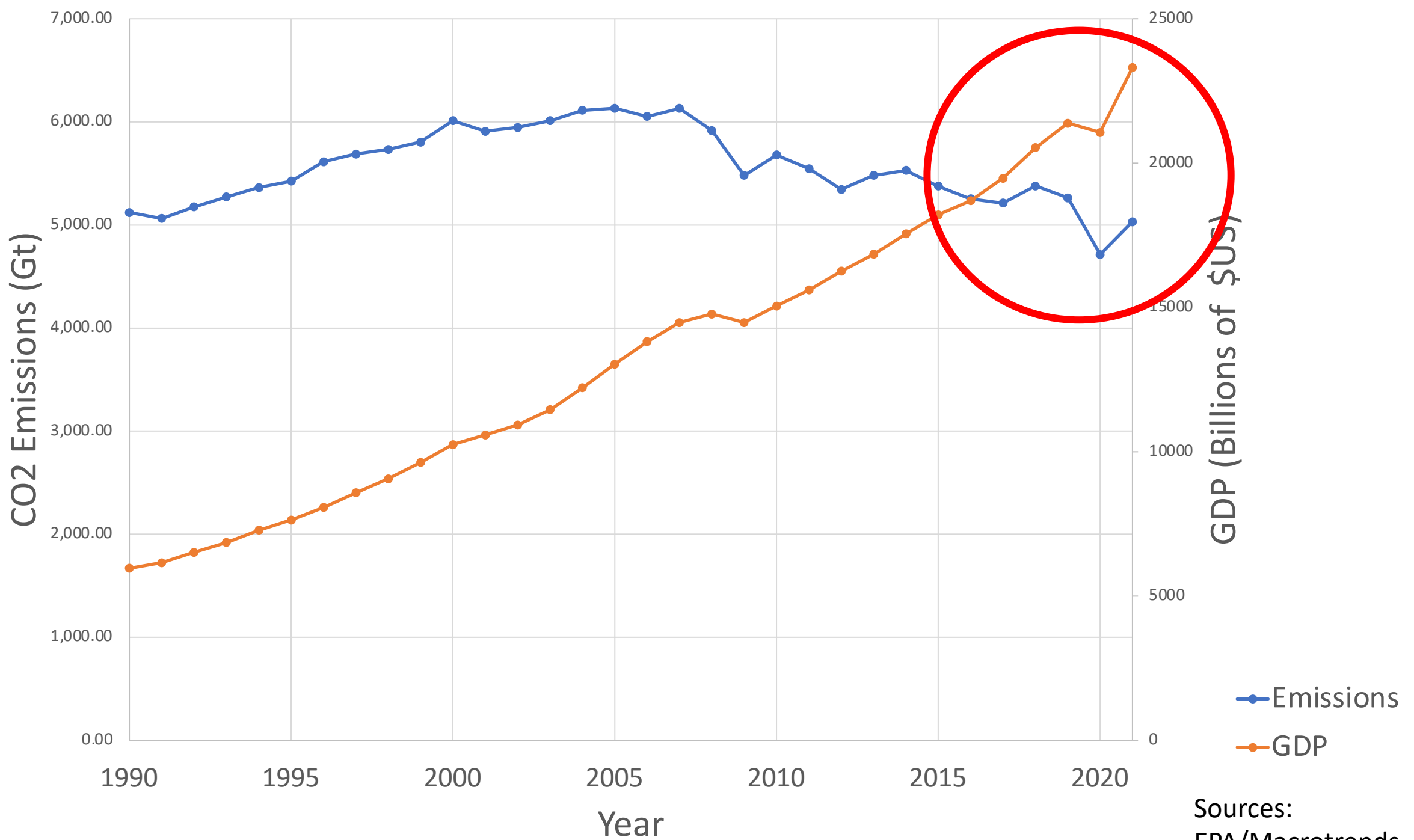
Published: July 25, 2023

Edited by [Chris McDermott](#)





Sources:  
EPA/Macrotrends



Sources:  
EPA/Macrotrends



Voting



Lower Consumption



Less air travel



Plant based diet



Donations



Educating Others



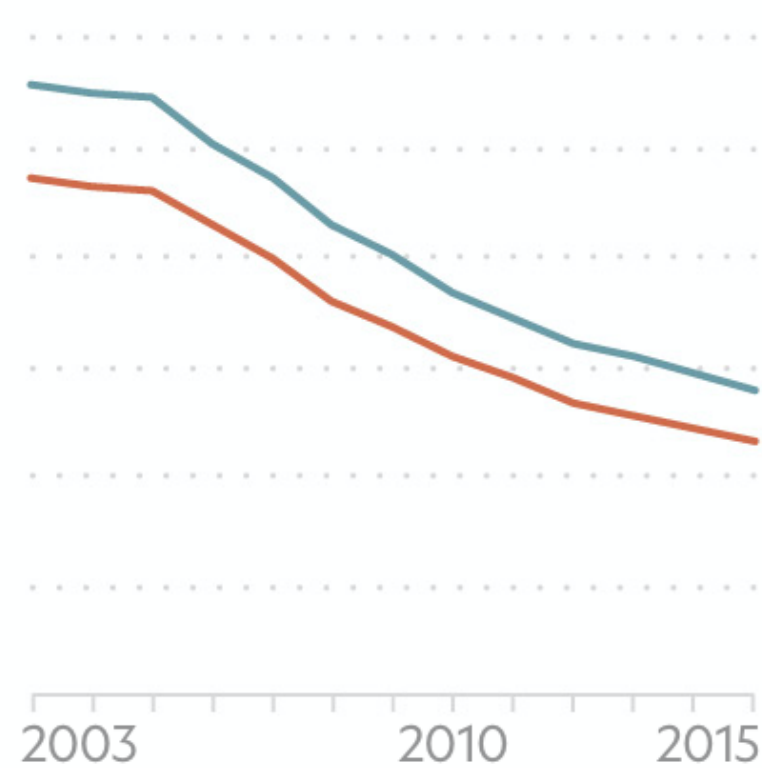
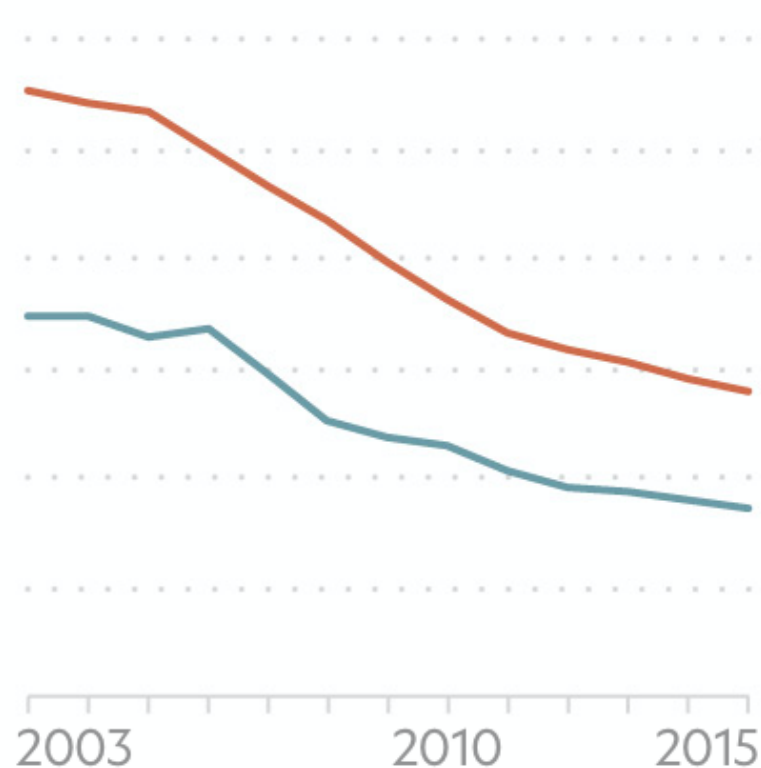
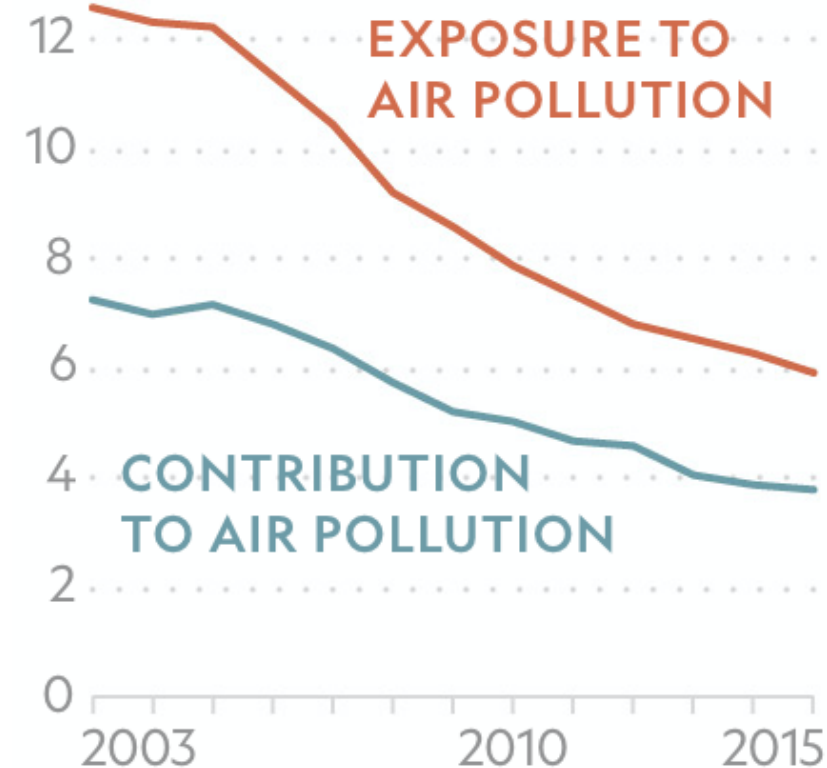


# Average per person contribution and exposure to air pollution by race/ethnicity\*

**Black**                      **Hispanic**                      **White/Other**

Pollution concentration (PM2.5)

14 micrograms per cubic meter



\*Group population-adjusted

Taylor Maggiacomo, NGM Staff

Sources: Jason Hill, University of Minnesota; Chris Tessum, University of Illinois

COP21/CMP11

# Paris France



SECRETAIRE EXECUTIVE CCNUCC

PRESIDENT

SECRE

Subscribe

Latest Issues

SCIENTIFIC  
AMERICAN®

Sign In | Newsletters

SHARE

LATEST

E&E NEWS

CLIMATE CHANGE

# Global Carbon Removal Efforts Are Off Track for Meeting Climate Goals

Carbon removal is an “unavoidable” part of global climate action, but a new report finds that current efforts aren’t enough to meet the warming limits set by the Paris climate agreement

---

By Chelsea Harvey, E&E News on January 19, 2023

CLIMATE SCIENCE  
HELP 5¢



THE DOCTOR  
IS 



Contact:

[cpe28@cornell.edu](mailto:cpe28@cornell.edu)

[www.climatecolin.com](http://www.climatecolin.com)



[@climate\\_colin](https://twitter.com/climate_colin)

**CornellEngineering**  
Earth and Atmospheric Sciences

**Cornell CALS**  
College of Agriculture and Life Sciences



Northeast Regional Climate Center