A Glimpse into *Earth Systems and Climate Change*

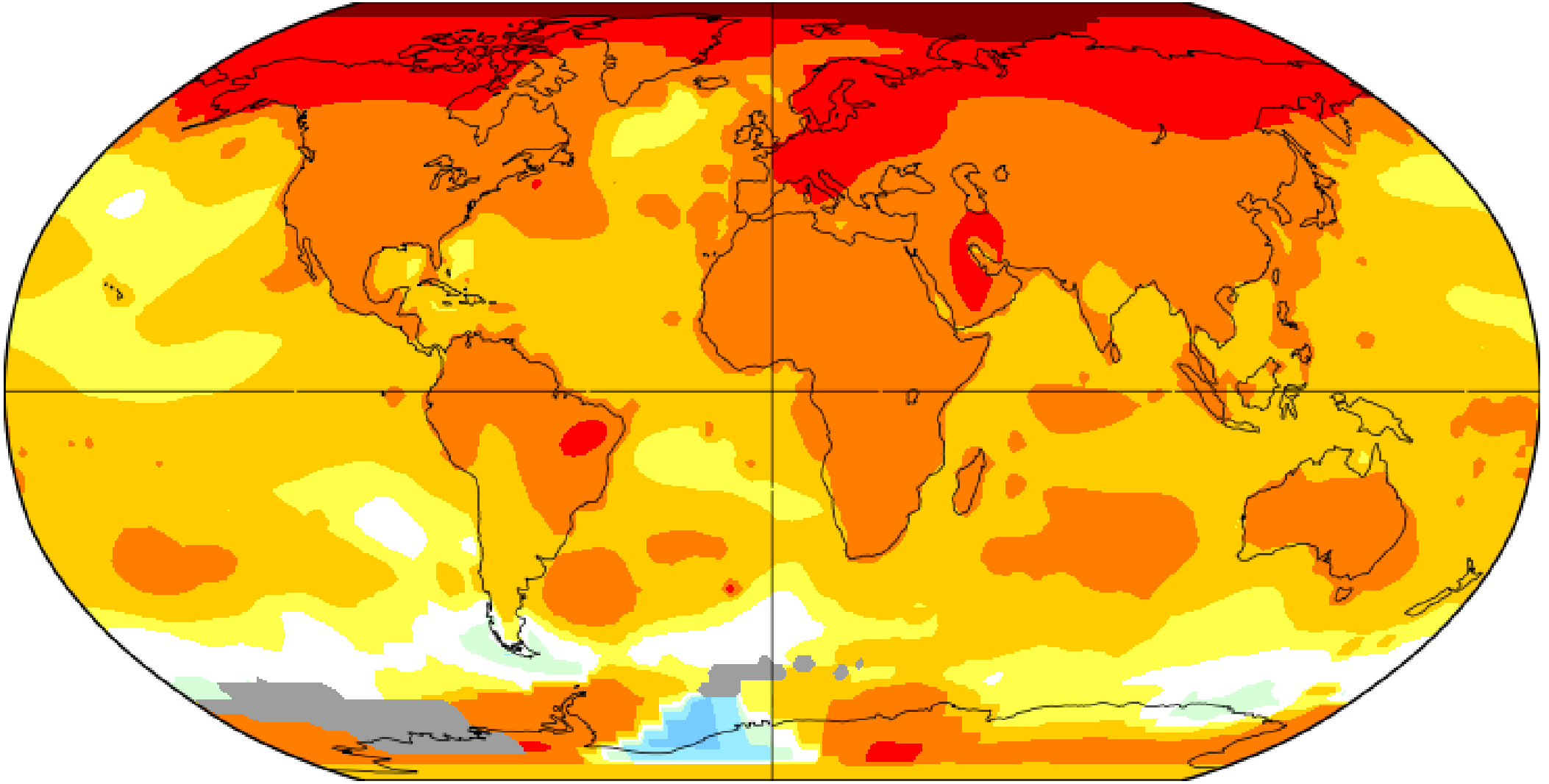
Dr. Bill Lukens
Department of Geology and Environmental Science
James Madison University

Objectives

1. How do we know climate is changing?
2. Are we humans to blame?
3. How did Covid lockdowns affect emissions?
4. What can we do about this?

Question 1: How do we know climate is changing?

Temperature change 1960-2019 **(The Instrument Record)**

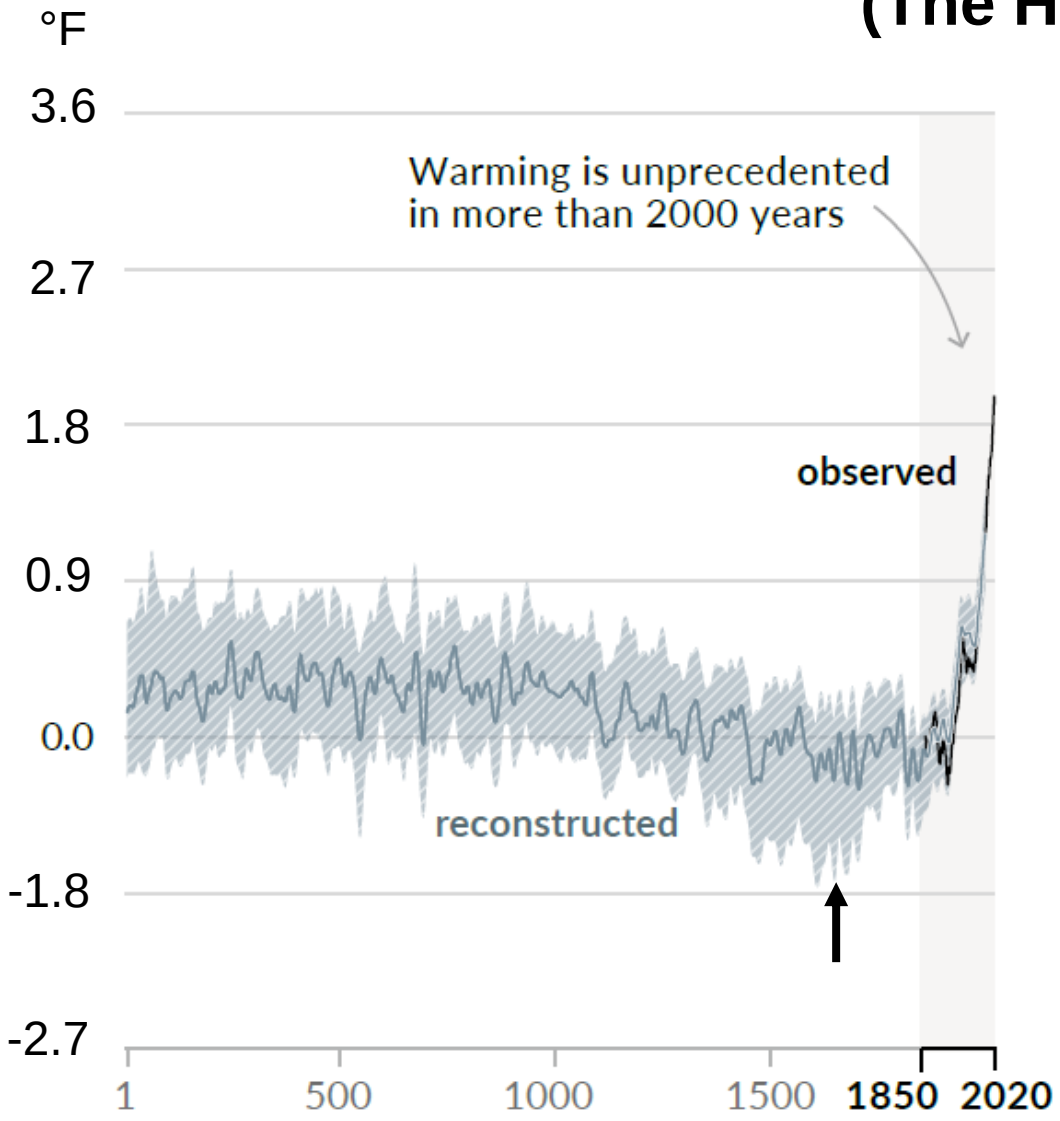


−4.1 −4.0 −2.0 −1.0 −0.5 −0.2 0.2 0.5 1.0 2.0 4.0 4.9 (°C)

-3.5 -1.0 1.0 3.5 9.0 (°F)

IPCC (2021)

Little Ice Age During the 15th-18th Centuries (The Historical Record)



IPCC (2021)

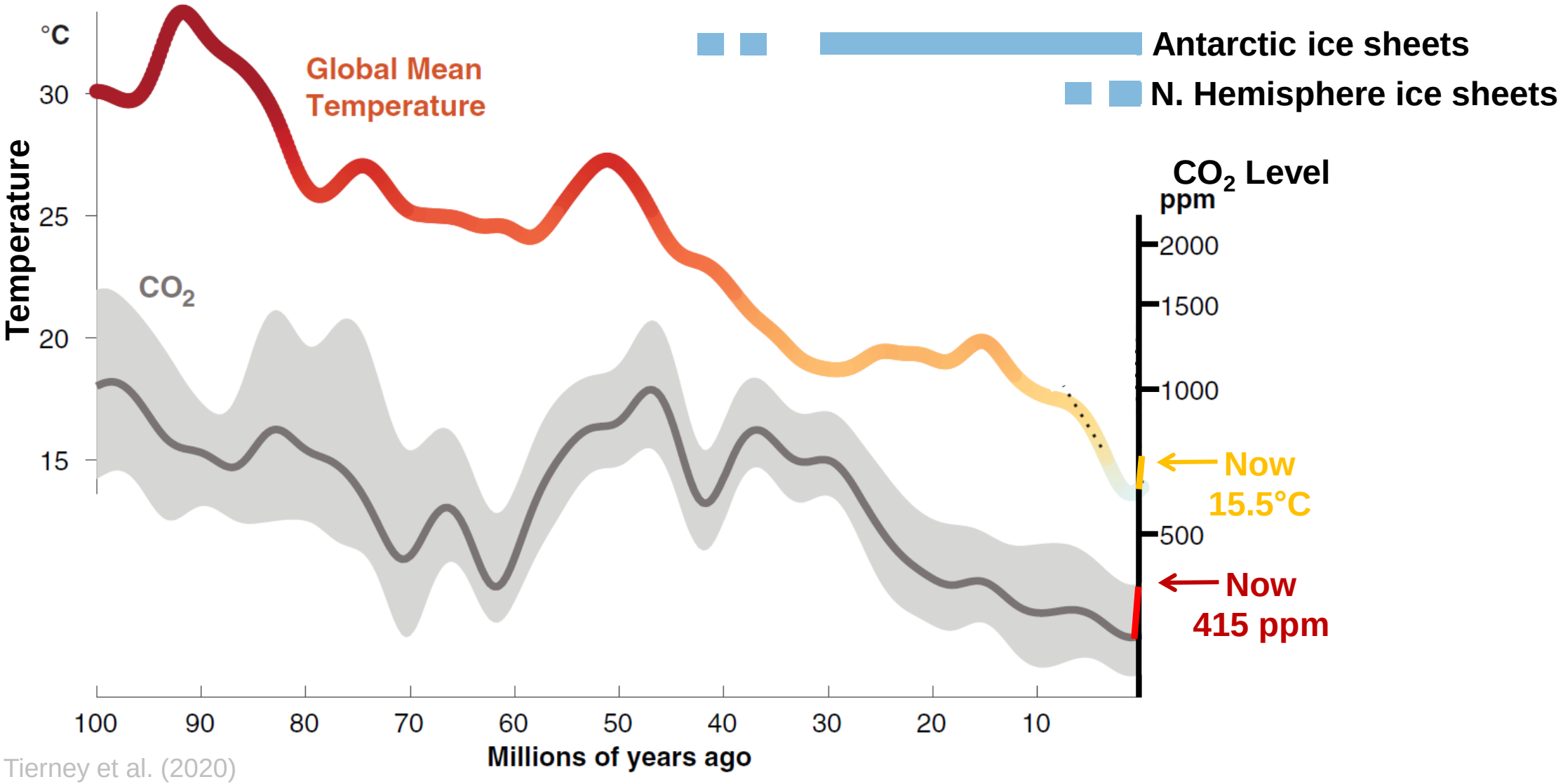
Washington Crossing the Delaware (E. Leutze, 1851)

Paleoclimate Perspectives from Earth's History

(The Geologic Record)

Over the last 100 million years:

- *CO_2 levels are typically higher than today*
- *Temperatures were much higher than today*



Tierney et al. (2020)

Paleoclimate Perspectives from Earth's History

(The Geologic Record)

What did ancient landscapes look like?

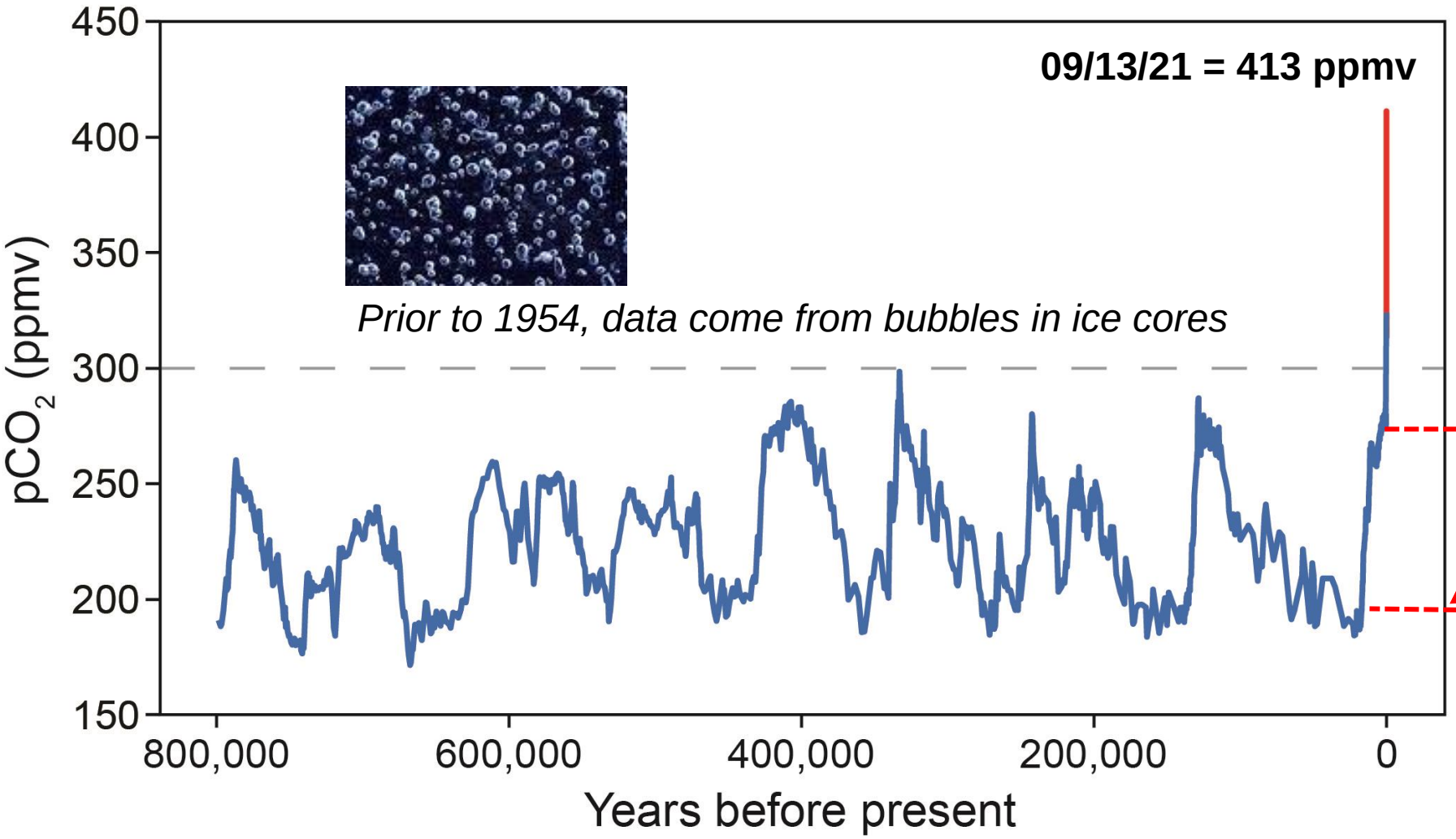
- *An analog is a representative example from a different time or place*
- *55 Million years ago, the Arctic Circle looked like South Carolina*
- *Thus, South Carolina is a modern analog for the Eocene Arctic*

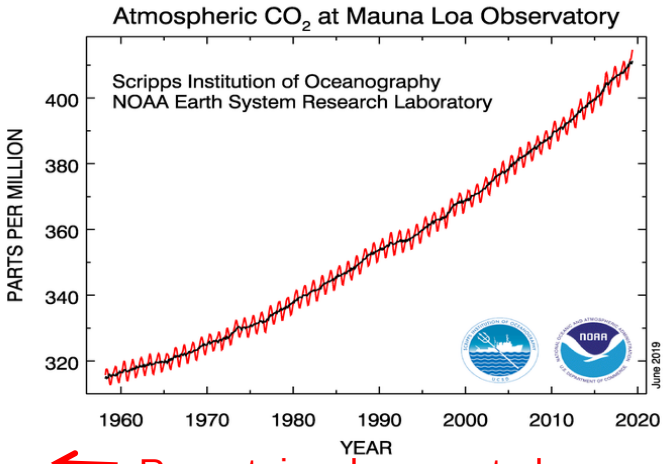
National Geographic

We are possibly on a pathway that would return us back to that climate state

Question 2: Are Humans to Blame?

Atmospheric CO_2 measurements: Long Term





Recent rise documented at Mauna Loa

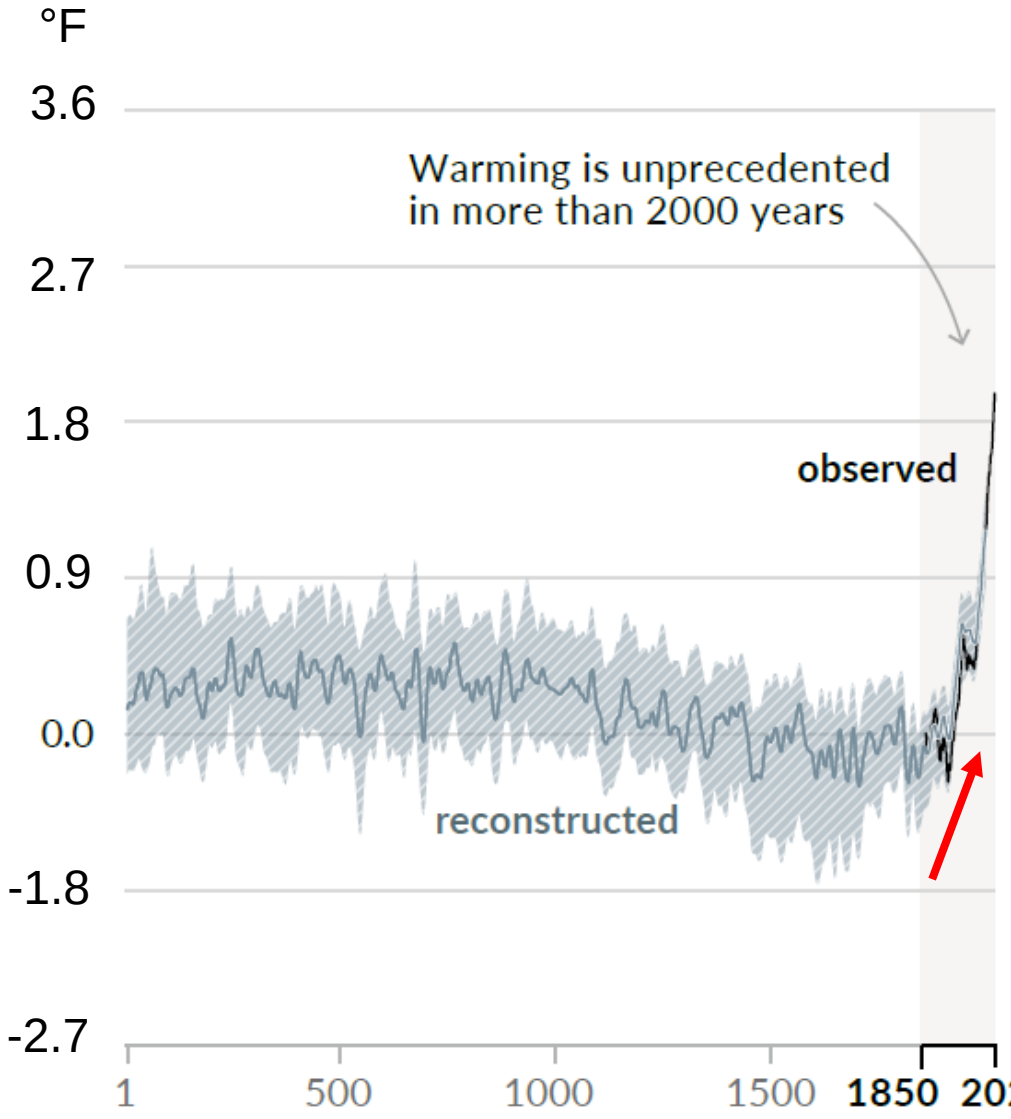
pre-industrial = 280 ppmv
(~ the year 1750)

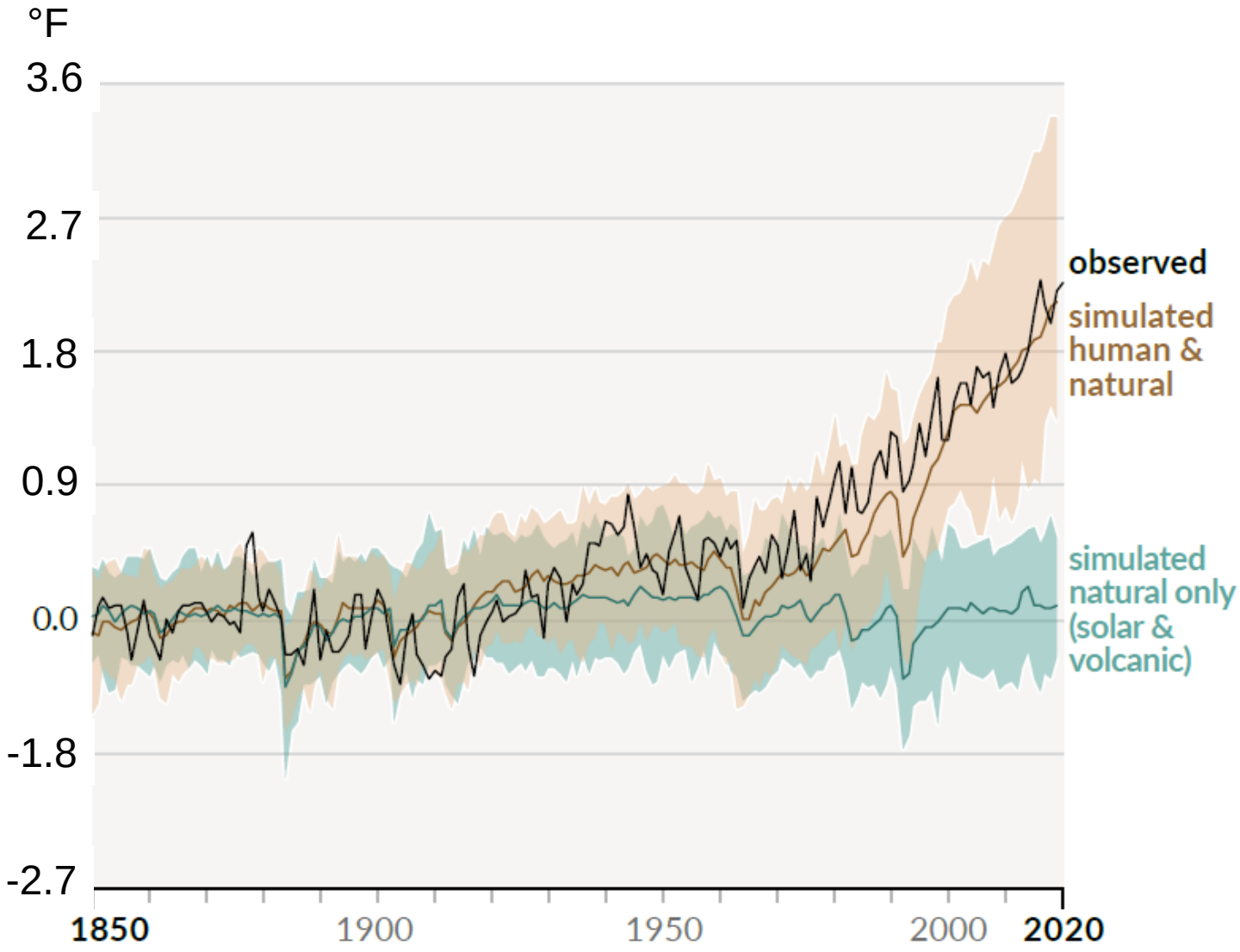
Last ice age = 180 ppmv
(~ 18-24 thousand years ago)

Mauna Loa data: Keeling and Keeling, 2018

Ice core data sources: Petit et al., 1999; Monnin et al., 2001; Pepin et al., 2001; Raynaud et al., 2005; Seigenthaler et al., 2005; Lüthi et al., 2008

Question 2: Are Humans to Blame?

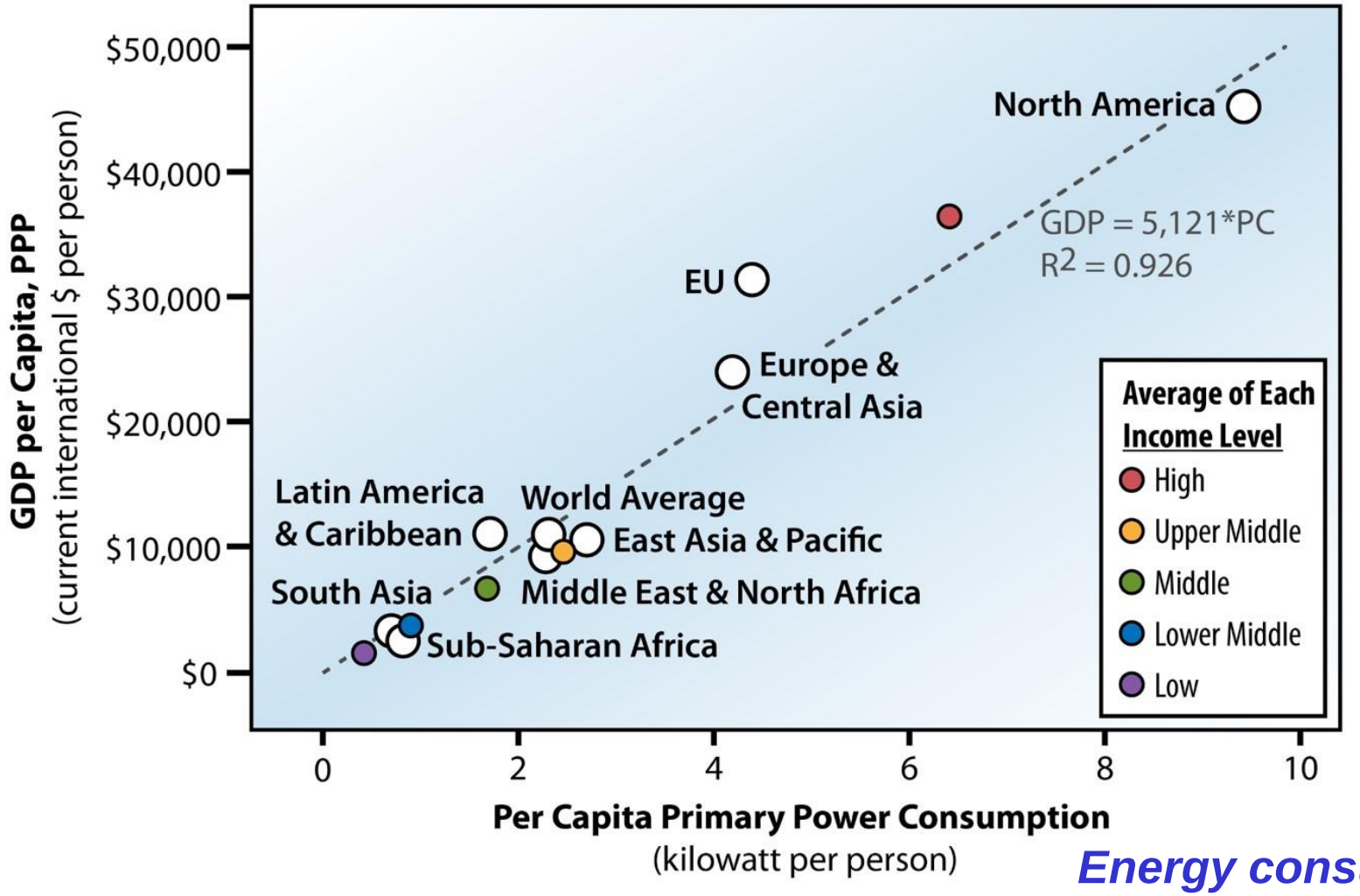




IPCC (2021)

Richer countries use more energy per person

Standard of living (income)



Energy consumed

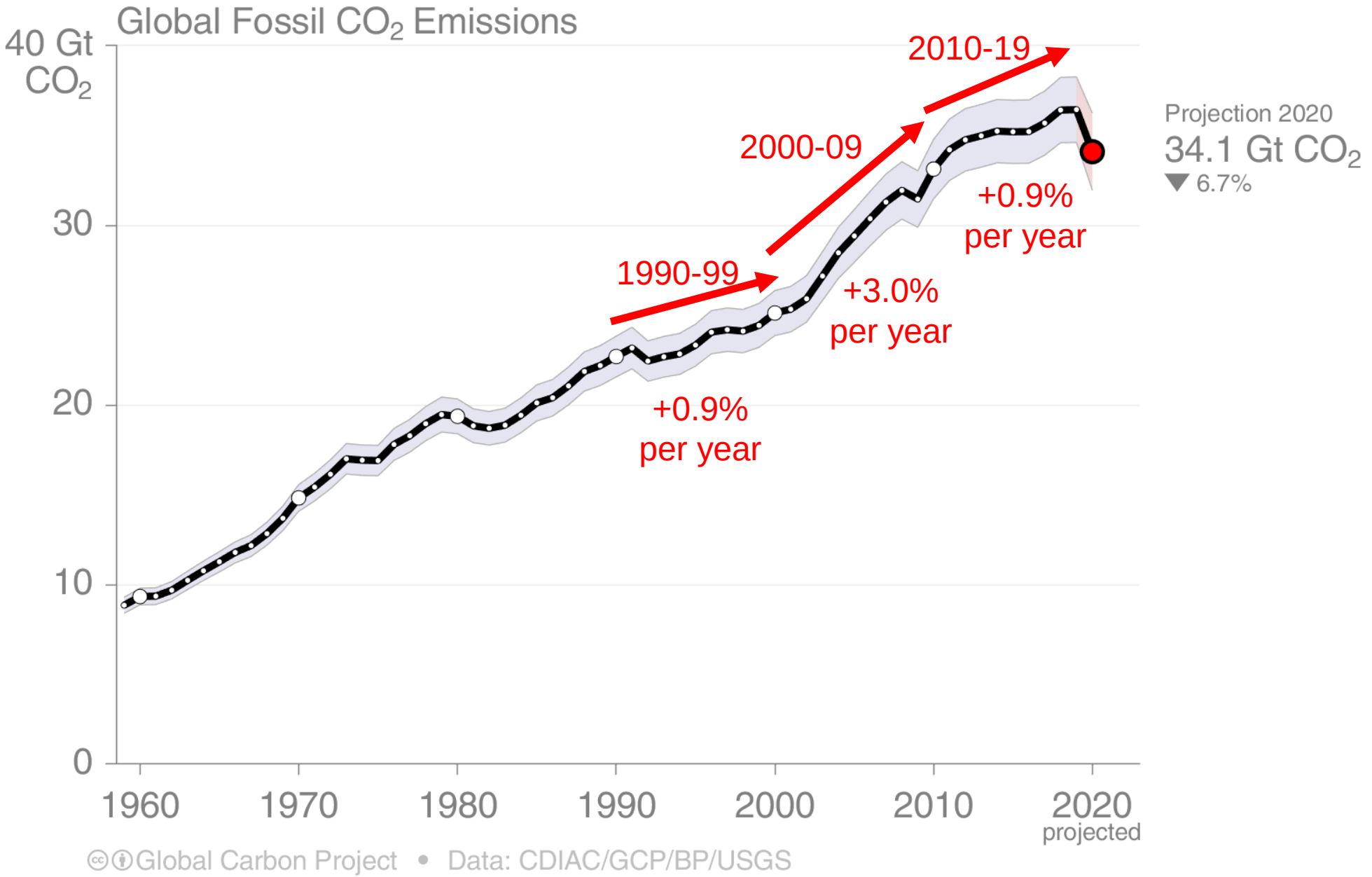
As less developed countries become more developed, with a higher standard of living, their energy consumption will increase

However, blaming a region like Sub-Saharan Africa ignores our current and historical role in changing Earth's atmosphere

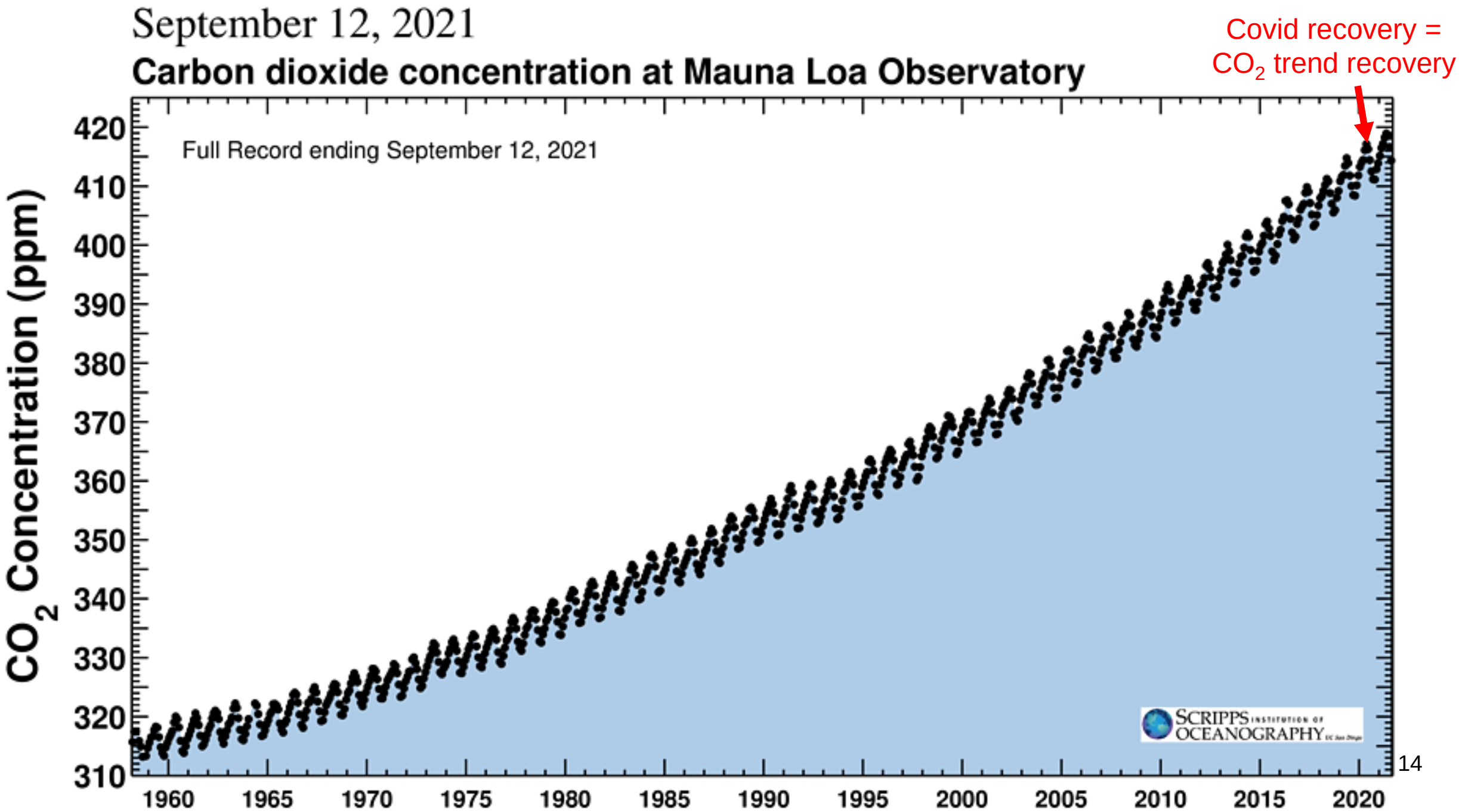
See http://www.ourenergypolicy.org/growing-poor-slowly-why-we-must-have-renewable-energy/
http://www.vjel.org/journal/VJEL10041.html

Question 3:
How did Covid lockdowns impact greenhouse gas emissions?

Effect of Covid lockdowns on Annual Emissions



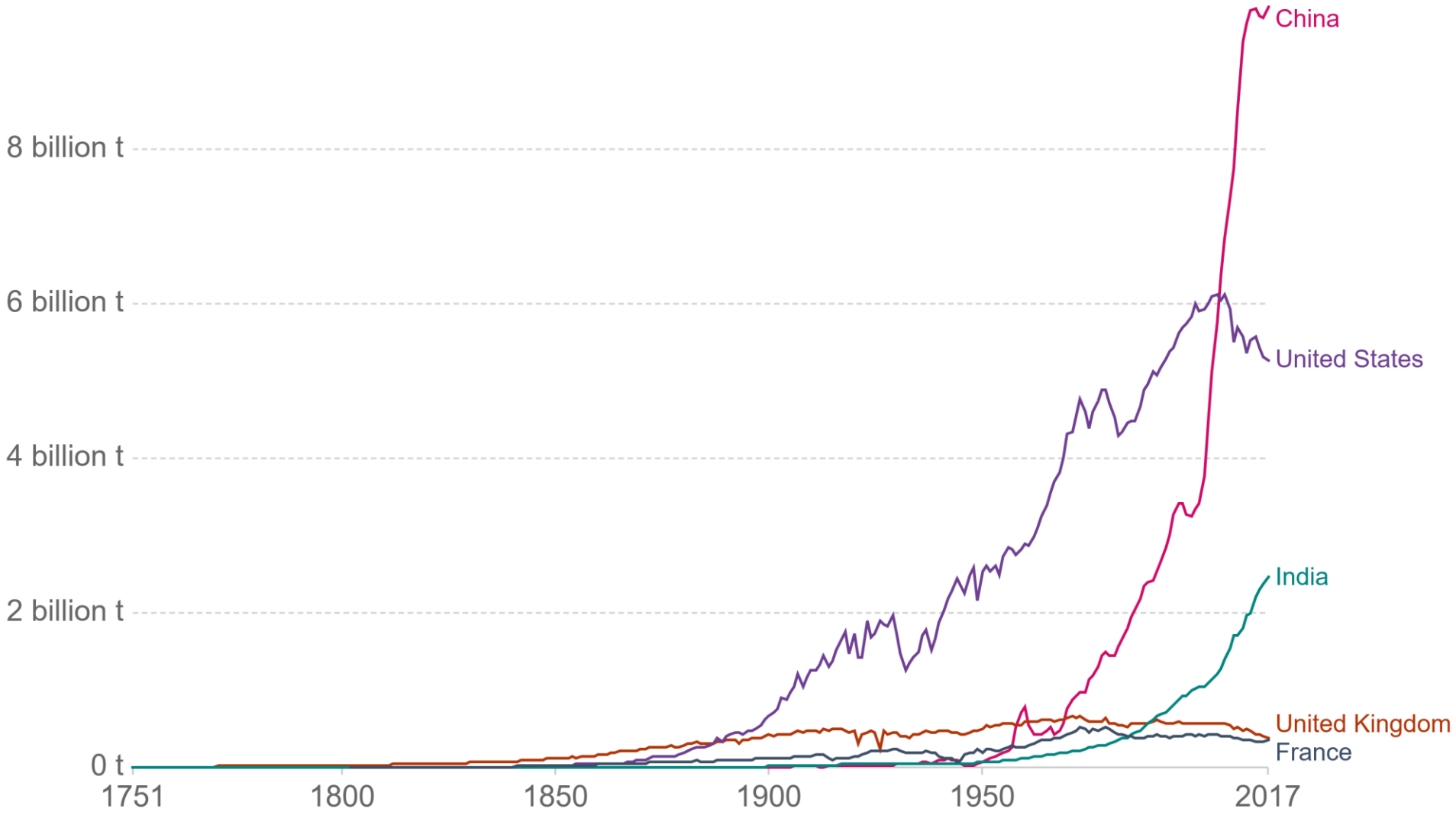
https://scrippsco2.ucsd.edu/



Annual CO_2 emissions (2018)

Carbon dioxide (CO_2) emissions from the burning of fossil fuels for energy and cement production. Land use change is not included.

Our World in Data

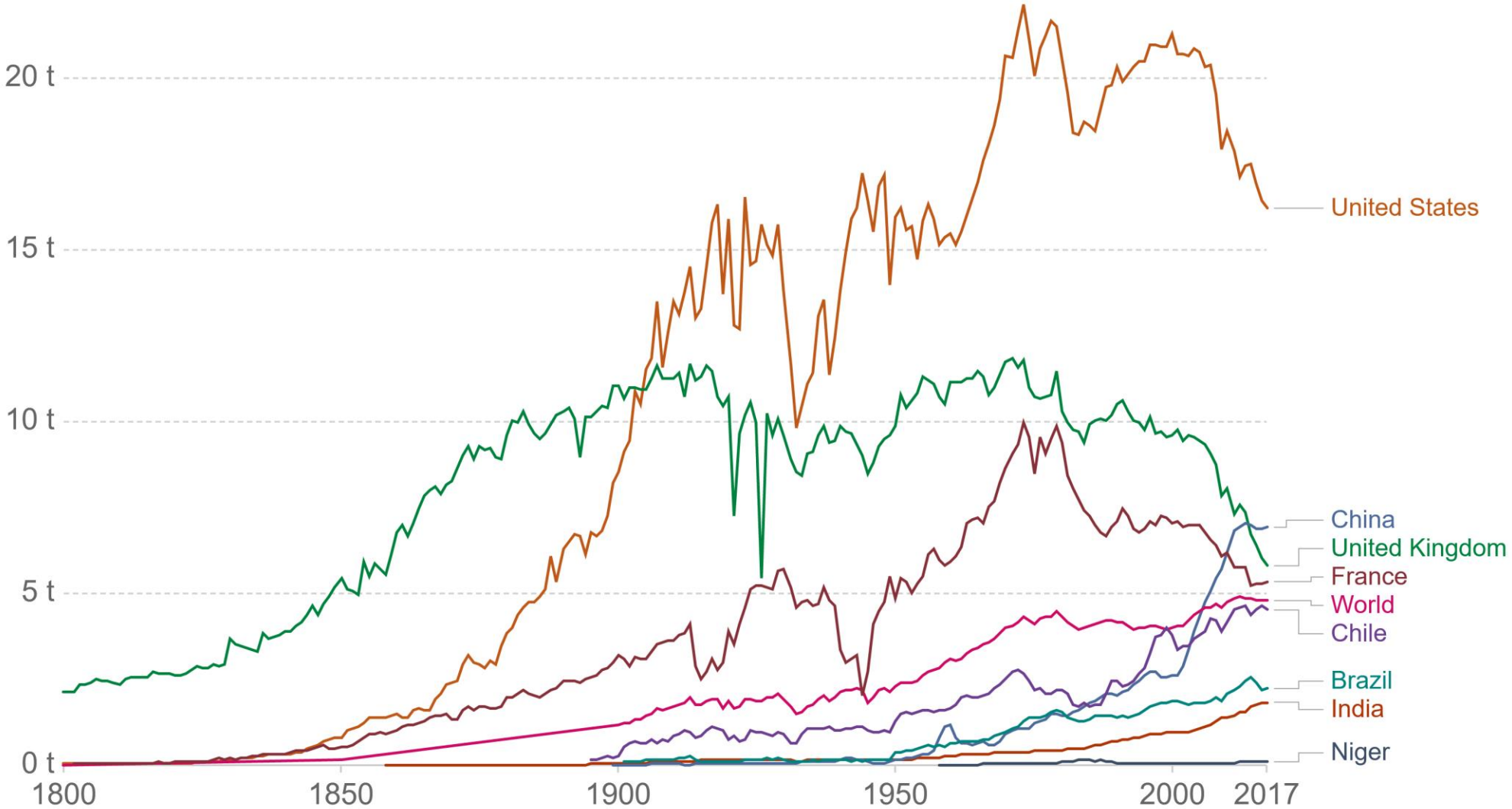


Source: Global Carbon Project; Carbon Dioxide Information Analysis Centre (CDIAC)
Note: CO_2 emissions are measured on a production basis, meaning they do not correct for emissions embedded in traded goods.
OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/ • CC BY

Per capita CO_2 emissions

Carbon dioxide (CO_2) emissions from the burning of fossil fuels for energy and cement production. Land use change is not included.

Our World in Data



Source: OWID based on CDIAC; Global Carbon Project; Gapminder & UN
Note: CO_2 emissions are measured on a production basis, meaning they do not correct for emissions embedded in traded goods.
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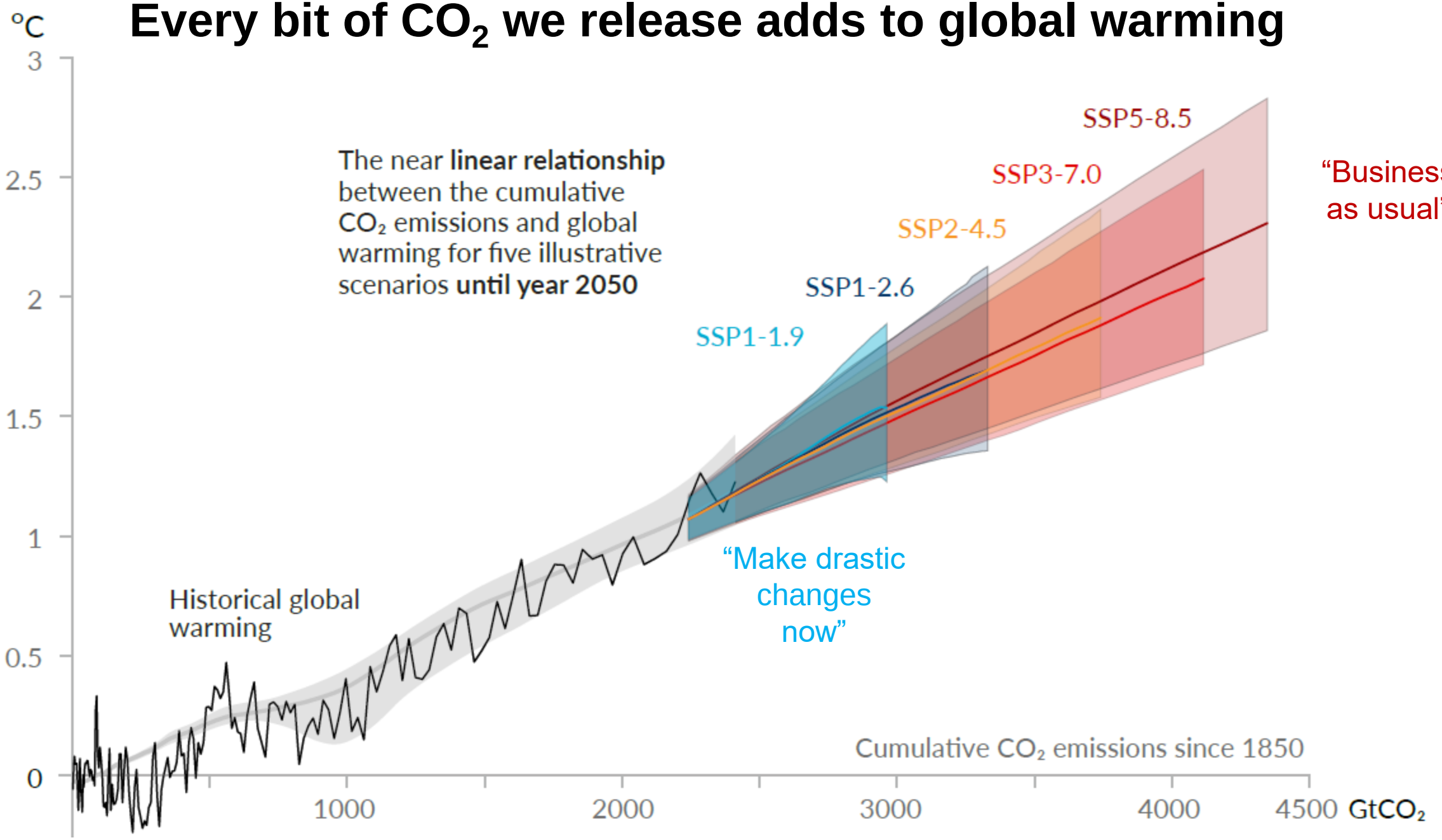
Question 4:
What can we do about it?

IPCC (2021)

Every bit of CO_2 we release adds to global warming



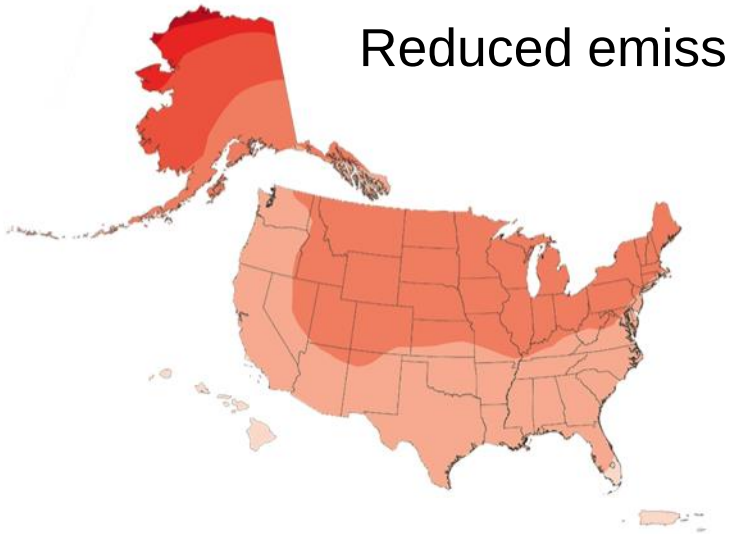
"Business as usual"

"Make drastic changes now"

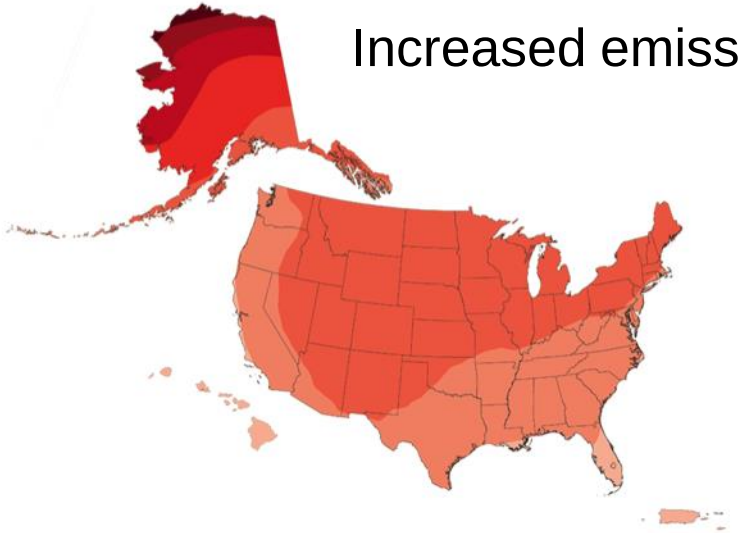
Temperature

Mid-21st Century

Reduced emissions

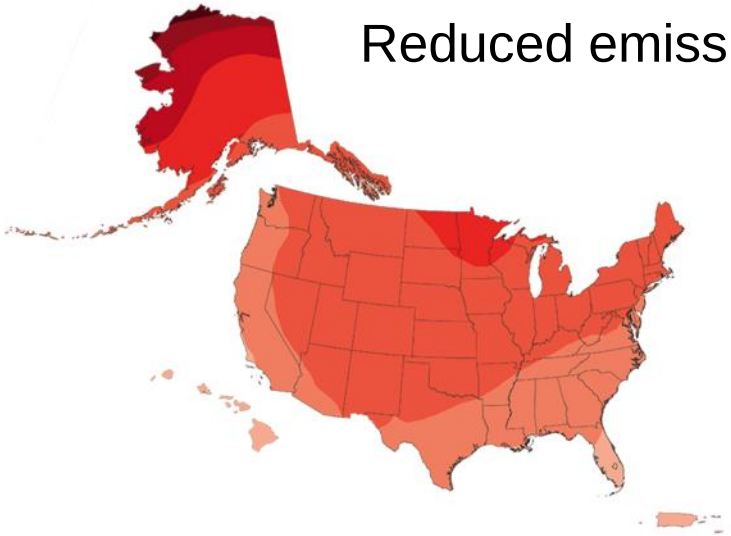


Increased emissions

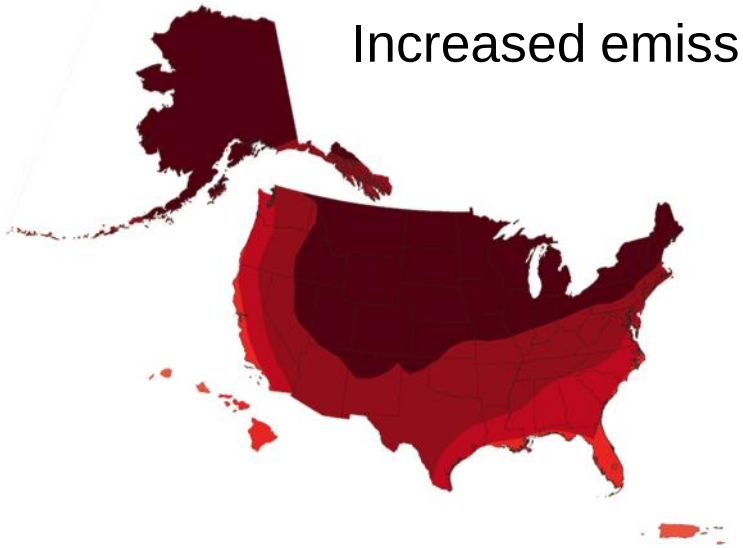


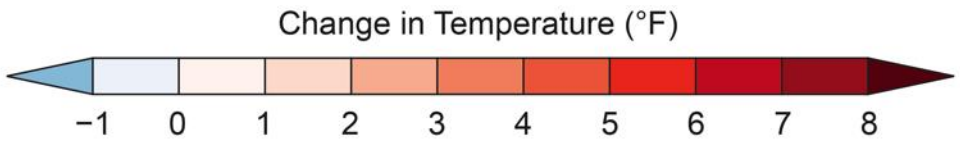
Late 21st Century

Reduced emissions



Increased emissions





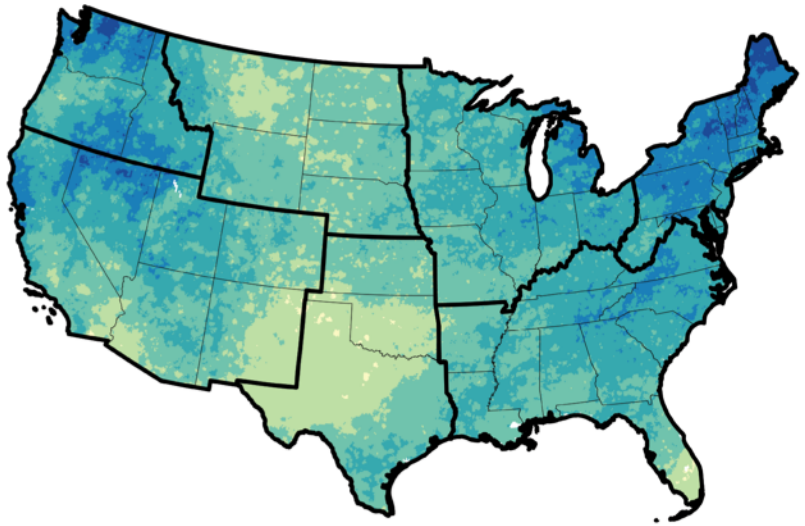
https://nca2018.globalchange.gov/

Rainfall

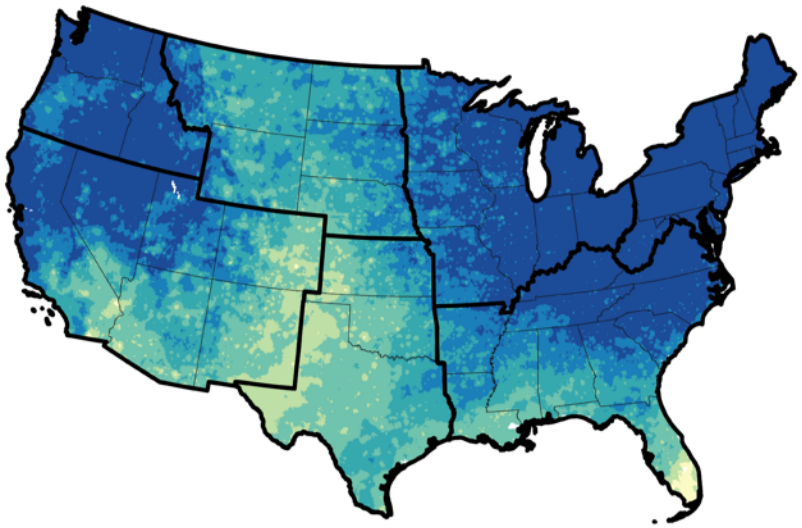
More of our rainfall budget will occur in extreme downpours

Projected Change in Total Annual Precipitation
Falling in the Heaviest 1% of Events by Late 21st Century

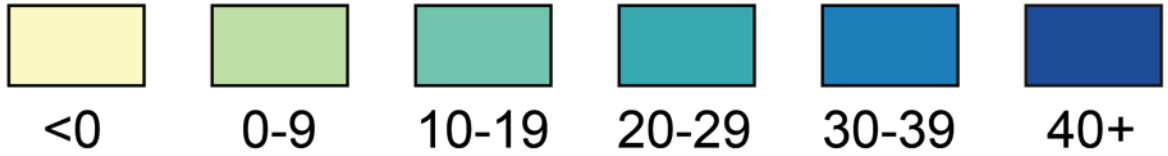
Reduced emissions



Increased emissions



Change (%)



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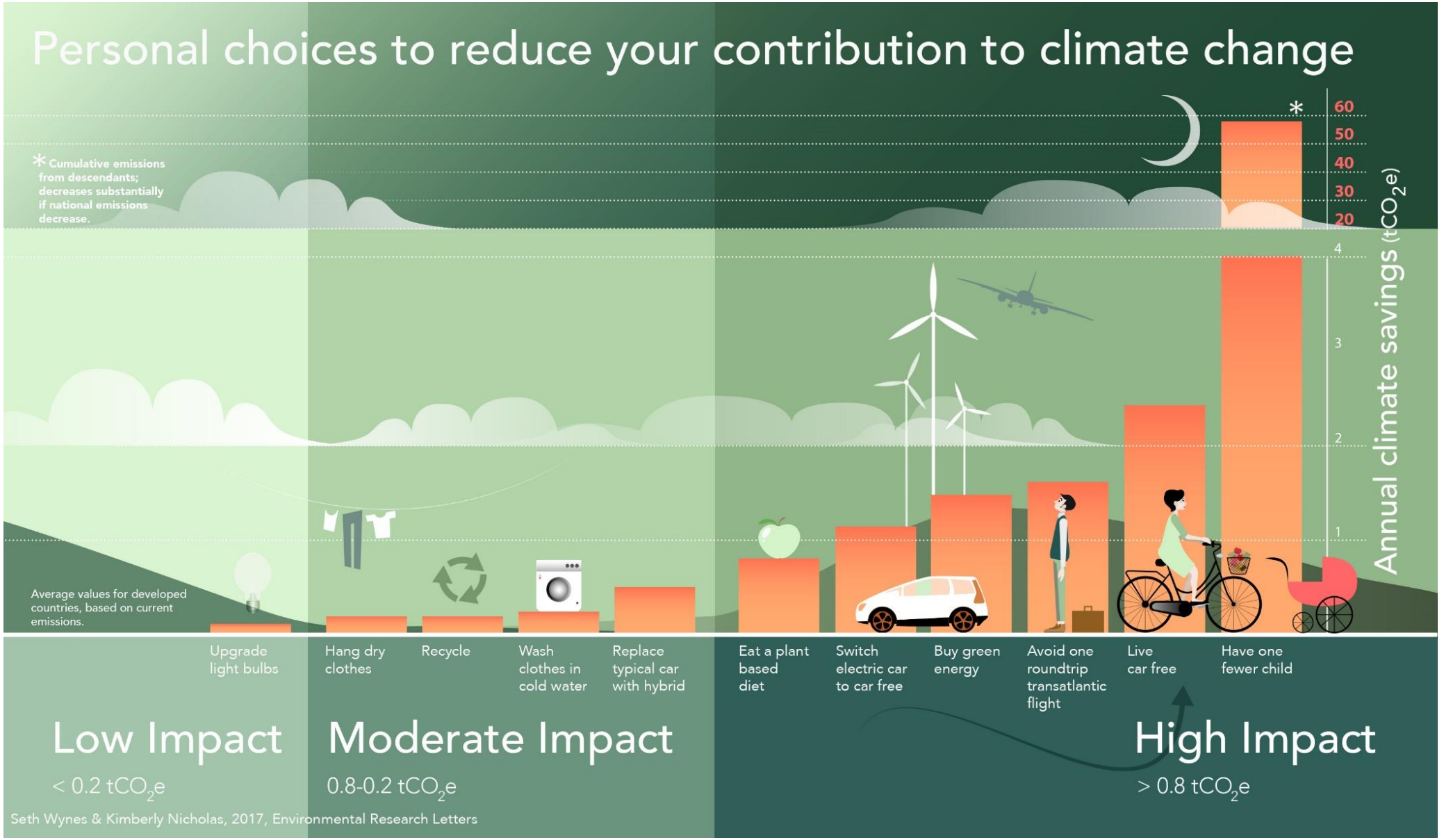
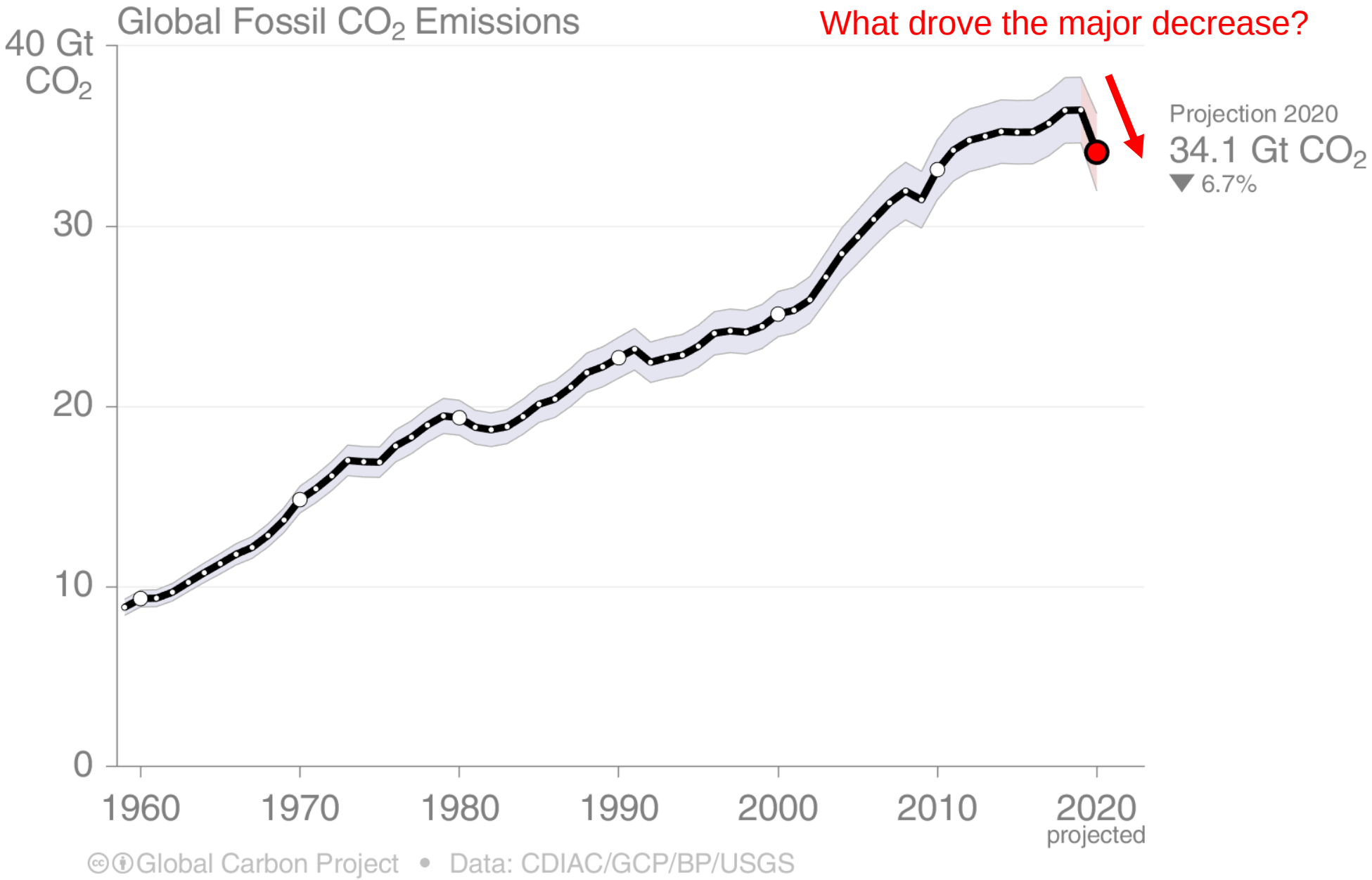
What can you do? *Mitigate and Adapt.*

Personal decisions matter….but policy changes by government and industry leaders are essential.



https://grist.org/briefly/groundbreaking-study-outlines-what-you-can-do-about-climate-change/

Effect of Covid lockdowns on Annual Emissions



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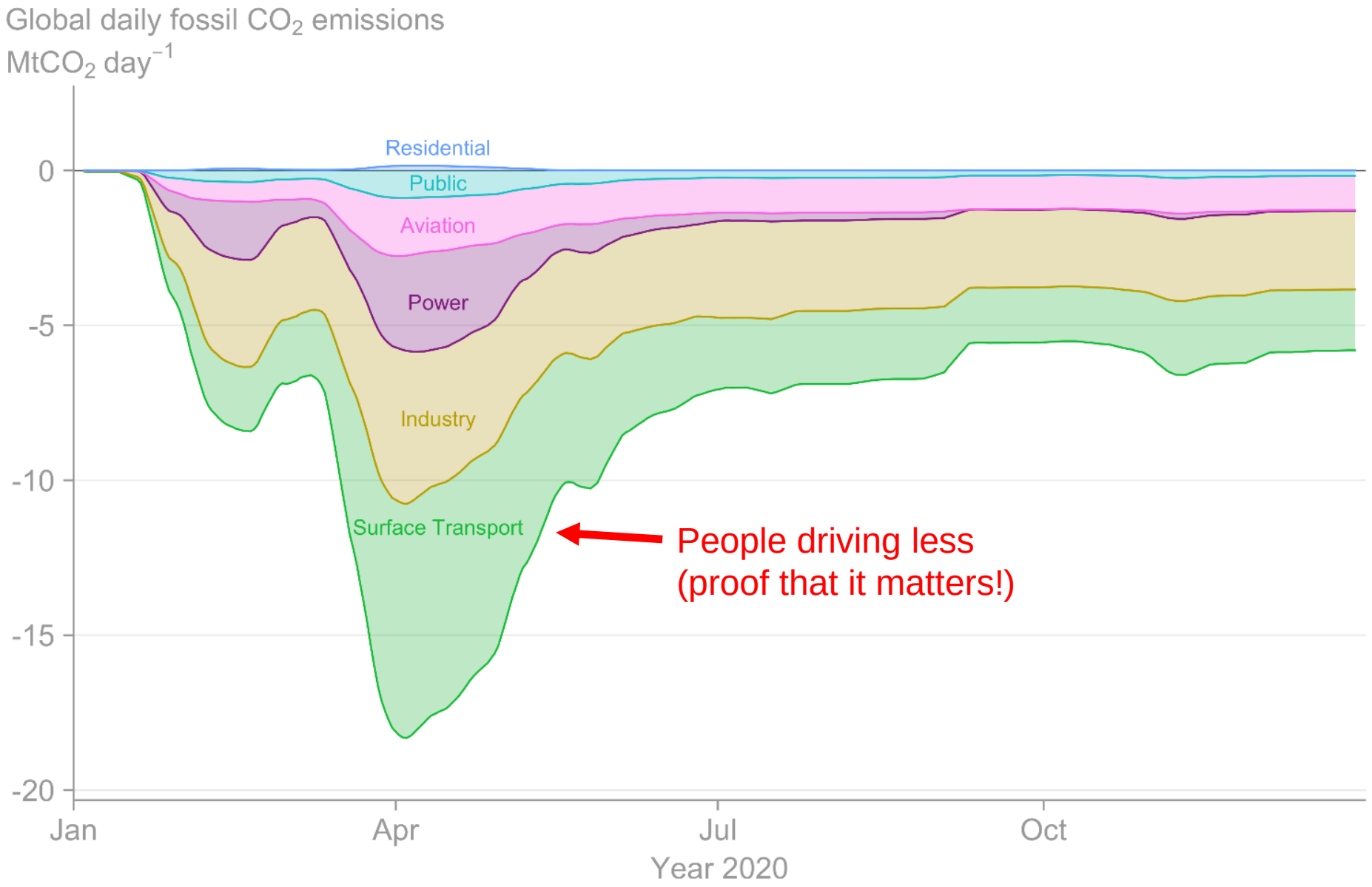

Thank you!

Dr. Bill Lukens

Department of
Geology and Environmental Science
James Madison University

lukenswe@jmu.edu
https://sites.google.com/view/lukenslabjmu

References for content in the talk:
IPCC, 2021: Summary for Policymakers. In: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.

Tierney, J. E., Poulsen, C. J., Montañez, I. P., Bhattacharya, T., Feng, R., Ford, H. L., ... & Zhang, Y. G. (2020). Past climates inform our future. *Science*, *370*(6517).

Here are some useful links that folks may be interested to explore:

Our World in Data (https://ourworldindata.org/),
Global Carbon Project (https://www.globalcarbonproject.org/),
Global CO2 Monitoring (https://gml.noaa.gov/ccgg/trends/),
Daily CO2 data (https://www.co2.earth/),
What Will Climate Feel Like in 60 Years App (https://fitzlab.shinyapps.io/cityapp/),
How Much Hotter is Your Hometown Than When You Were Born - NY Times (https://www.nytimes.com/interactive/2018/08/30/climate/how-much-hotter-is-your-hometown.html),
Realtime weather data - the Earth model (https://earth.nullschool.net/),
Climate Reanalyzer - puts today's weather conditions in perspective, every day (https://climatereanalyzer.org/)