

Climate Change 101

Nashville Youth Climate Summit

Jonathan Gilligan

Saturday, February 8 2020

What Is Climate Change?

What Is Climate?

- Weather is what is happening now
 - Temperature, wind, rain, clouds, etc.
- Climate describes patterns of weather over several decades:
 - Average temperature
 - Range of variation (hottest, coldest, etc.)
 - How likely is it to rain on an average day?
- **Climate** is what you expect.
Weather is what you get.



Photo credit: Mabel Amber, Pexels



Photo credit: Genaro Servín, Pexels

Climate vs. Weather

- Predicting weather is hard:
 - Will it rain on Feb. 5, 2025?
- Predicting climate is much easier:
 - On average, will **February** be colder than **July** from 2025–2055?
 - On average, will **Texas** be hotter than **Alaska** from 2025–2055?
- A few unusually hot or cold days doesn't prove or disprove climate change.
 - Climate change means *a consistent pattern* of changing weather over 30 years or more.

The Greenhouse Effect

Light and the Atmosphere

- Light has different wavelengths (like colors)
- Everything gives off light
- Visible light and ultraviolet light are *shortwave*
 - Very hot things
 - Sun is almost 10,000° F
 - Light bulbs are about 5,000° F
- Infrared light is *longwave*
 - Cooler things
 - Earth is about 68° F on average



Photo credit: Burak K, Pexels



Photo credit: Yongrow Medical

The Greenhouse Effect

- The atmosphere is transparent to shortwave light.
 - That's why we can see!
- **Greenhouse gases** are opaque to longwave light.
 - Carbon dioxide, water vapor, methane, ...
- Shortwave sunlight brings heat to the surface
- Longwave light takes heat away
 - Greenhouse gases block longwave light & trap heat
- **The natural greenhouse effect is good**
 - Without the greenhouse effect, all water on earth would be frozen
 - *Life would be impossible*
- **Fossil fuels** put extra greenhouse gases in the atmosphere
 - Stronger greenhouse effect
 - *The earth gets hotter*

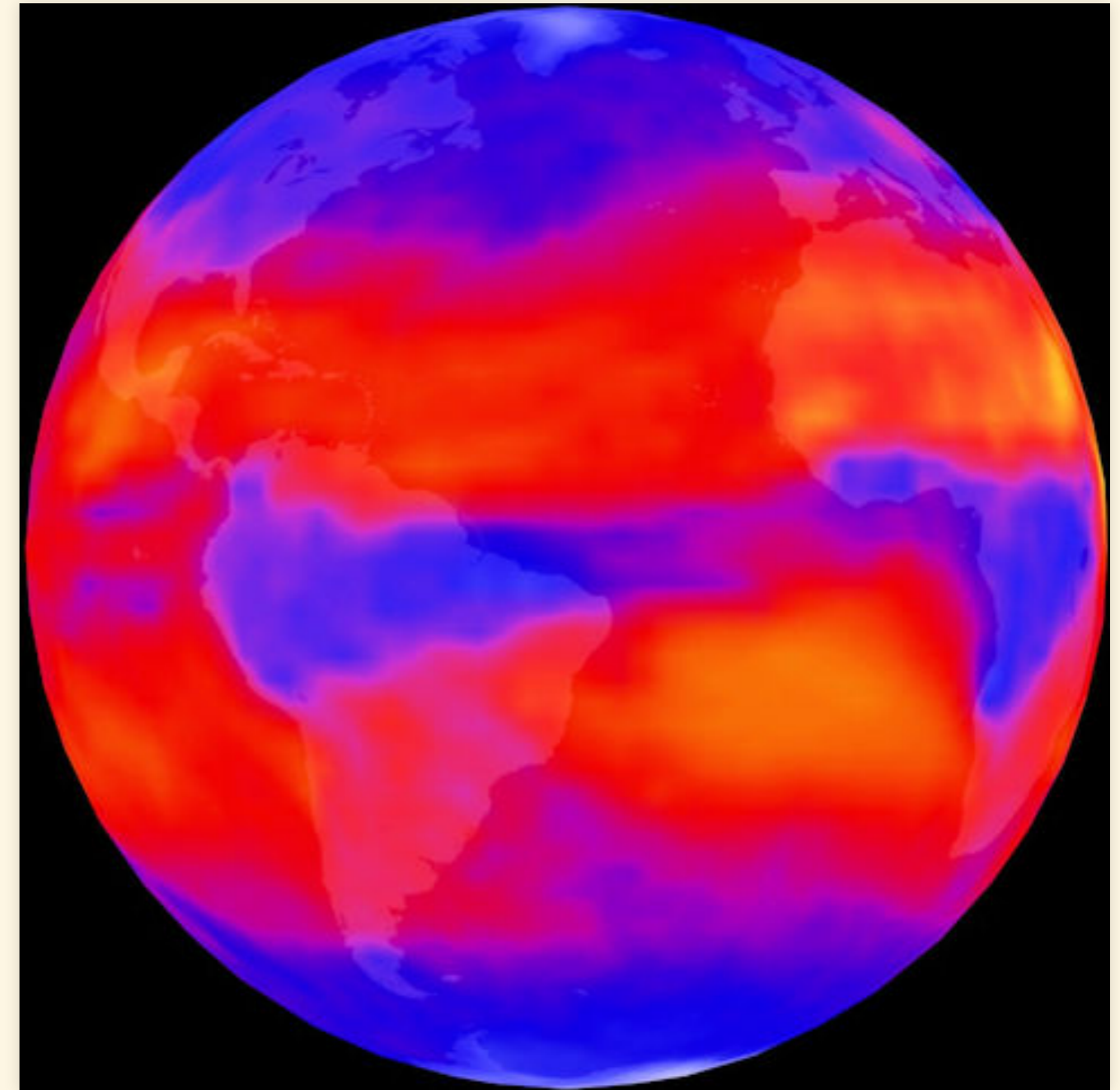


Photo credit: NASA Terra/CERES mission

History of Climate Science

Greenhouse Effect (1820s)

Joseph Fourier

THE
AMERICAN
JOURNAL OF SCIENCE, &c.

ART. I.—*General Remarks on the Temperature of the Terrestrial Globe and the Planetary Spaces*; by BARON FOURIER.*

Translated from the French, by MR. EBENEZER BURGESS, of Amherst College.

THE question of terrestrial temperature, one of the most remarkable and difficult in natural philosophy, involves very different elements which require to be considered in a general light. I have thought it would be useful to have condensed in a single essay, all the results of this theory. The analytical details here admitted, are found in works which I have already published. I was specially desirous of presenting to philosophers, in a concise table, a complete view of the phenomena and the mathematical relations which exist between them.



Greenhouse Gases (1860s)

John Tyndall

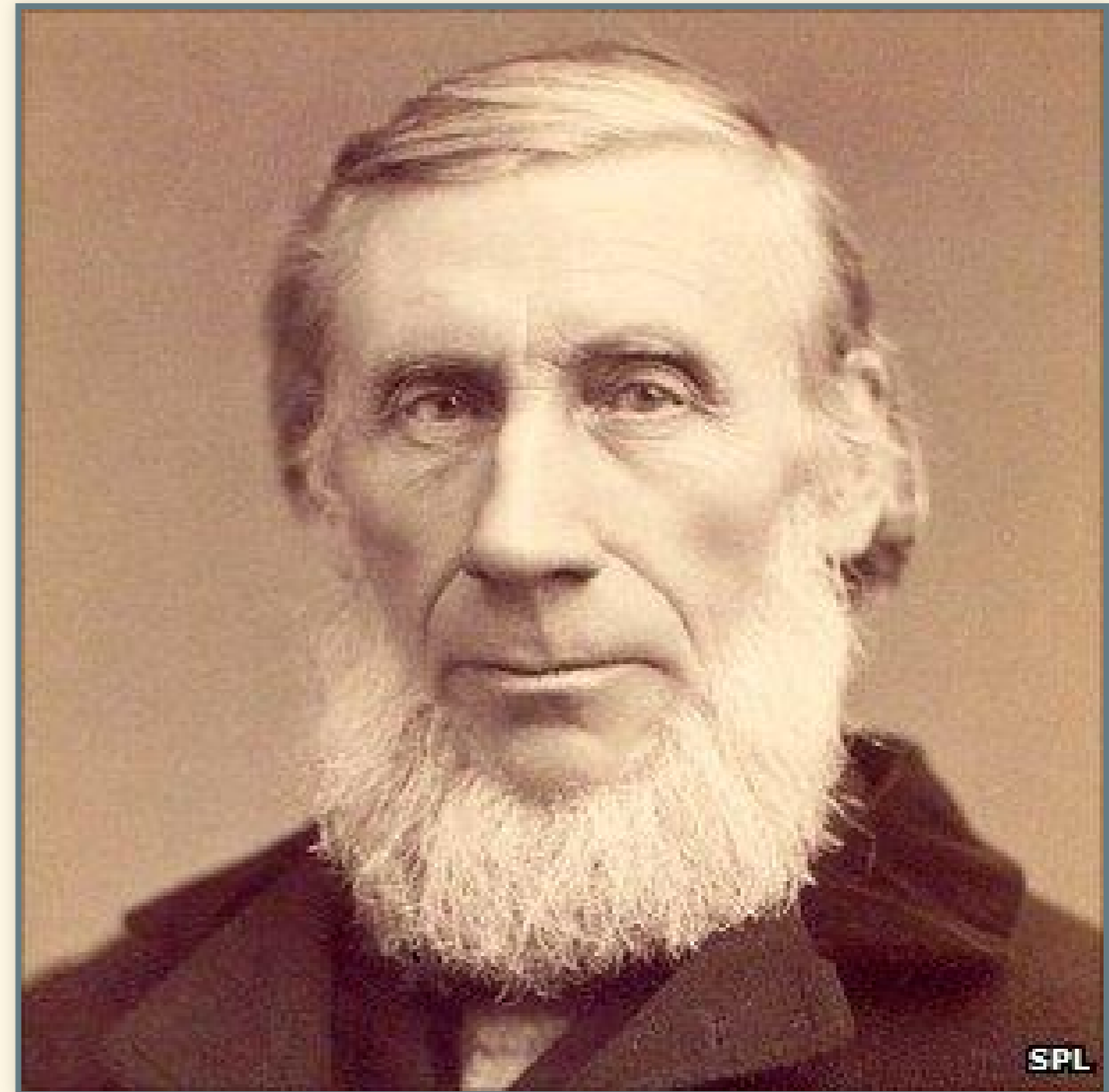
CONTRIBUTIONS
TO
MOLECULAR PHYSICS
IN THE DOMAIN OF
RADIANT HEAT.

A SERIES OF MEMOIRS PUBLISHED IN THE 'PHILOSOPHICAL TRANSACTIONS'
AND 'PHILOSOPHICAL MAGAZINE,' WITH ADDITIONS.

BY
JOHN TYNDALL, LL.D. F.R.S.
PROFESSOR OF NATURAL PHILOSOPHY IN THE ROYAL INSTITUTION.

LONDON:
LONGMANS, GREEN, AND CO.
1872.

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Global Warming (1896)

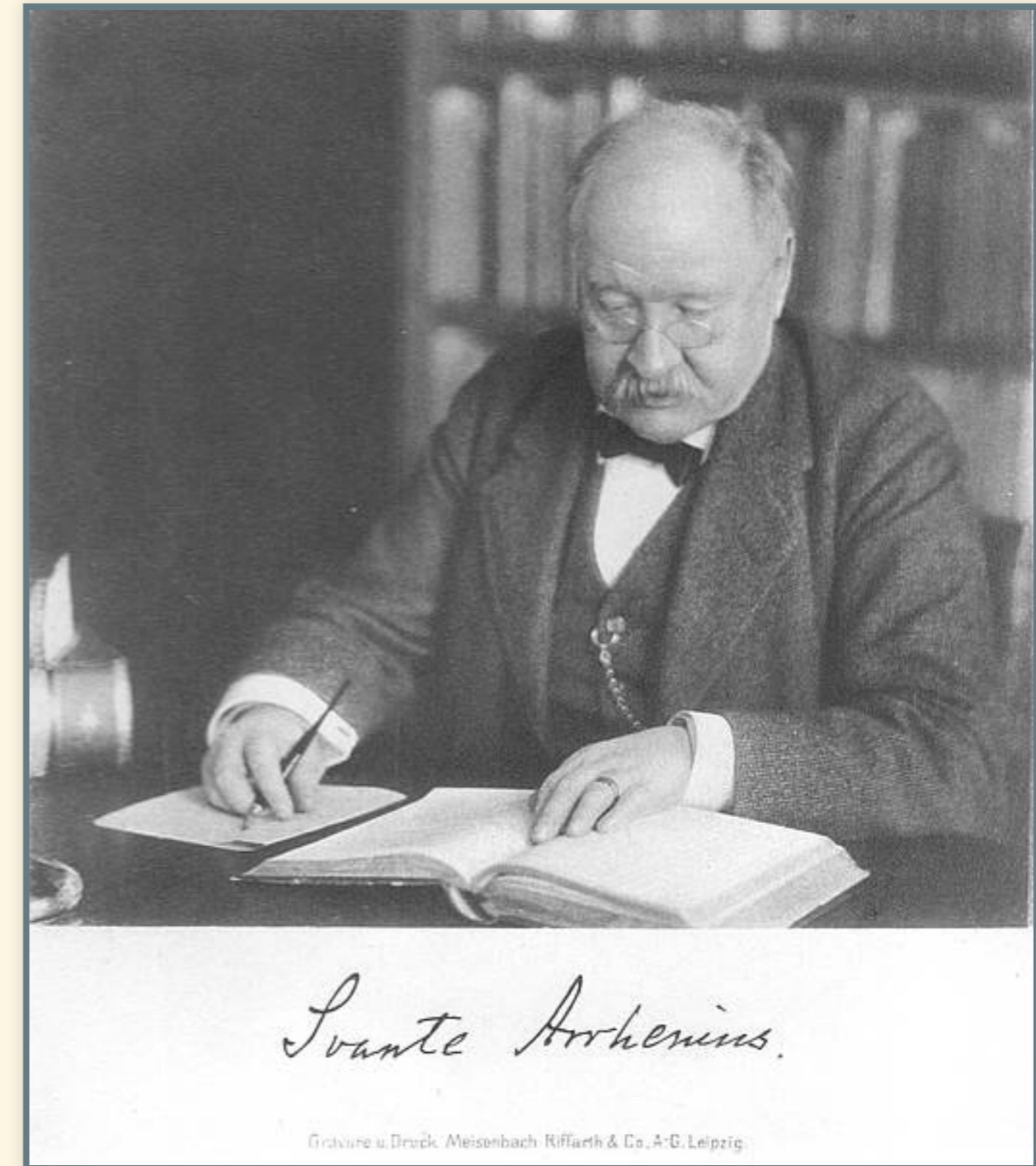
Svante Arrhenius

THE
LONDON, EDINBURGH, AND DUBLIN
PHILOSOPHICAL MAGAZINE
AND
JOURNAL OF SCIENCE.

[FIFTH SERIES.]

APRIL 1896.

XXXI. *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground.* By Prof. SVANTE ARRHENIUS*.



Modern Theory of Greenhouse Effect (1956)

The Carbon Dioxide Theory of Climatic Change

By GILBERT N. PLASS

The Johns Hopkins University, Baltimore, Md.¹

(Manuscript received August 9 1955)

Abstract

The most recent calculations of the infra-red flux in the region of the 15 micron CO_2 band show that the average surface temperature of the earth increases 3.6°C if the CO_2 concentration in the atmosphere is doubled and decreases 3.8°C if the CO_2 amount is halved, provided that no other factors change which influence the radiation balance. Variations in CO_2 amount of this magnitude must have occurred during geological history; the resulting temperature changes were sufficiently large to influence the climate. The CO_2 balance is discussed. The CO_2 equilibrium between atmosphere and oceans is calculated with and without CaCO_3 equilibrium, assuming that the average temperature changes with the CO_2 concentration by the amount predicted by the CO_2 theory. When the total CO_2 is reduced below a critical value, it is found that the climate continuously oscillates between a glacial and an inter-glacial stage with a period of tens of thousands of years; there is no possible stable state for the climate. Simple explanations are provided by the CO_2 theory for the increased precipitation at the onset of a glacial period, the time lag of millions of years between periods of mountain building and the ensuing glaciation, and the severe glaciation at the end of the Carboniferous. The extra CO_2 released into the atmosphere by industrial processes and other human activities may have caused the temperature rise during the present century. In contrast with other theories of climate, the CO_2 theory predicts that this warming trend will continue, at least for several centuries.

Gilbert Plass



Media Coverage (NY Times 1956)

SCIENCE IN REVIEW

By WALDEMAR KAEMPFERT

New York Times (1857-Current file); Oct 28, 1956; ProQuest Historical Newspapers The New York Times (1851 - 2003)
pg. 191

SCIENCE IN REVIEW

Warmer Climate on the Earth May Be Due To More Carbon Dioxide in the Air

By WALDEMAR KAEMPFERT

The general warming of the climate that has occurred in the last sixty years has been variously explained. Among the explanations are fluctuations in the amount of energy received from the sun, changes in the amount of volcanic dust in the atmosphere and variations in the average elevation of the continents.

starches) causes a large loss of carbon dioxide, but the balance is restored by processes of respiration and decay of plants and animals.

Despite nature's way of maintaining the balance of gases the amount of carbon dioxide in the atmosphere is being artificially increased as we burn coal, oil and wood for industrial purposes. This

President's Council of Advisers on Science & Tech (1965)

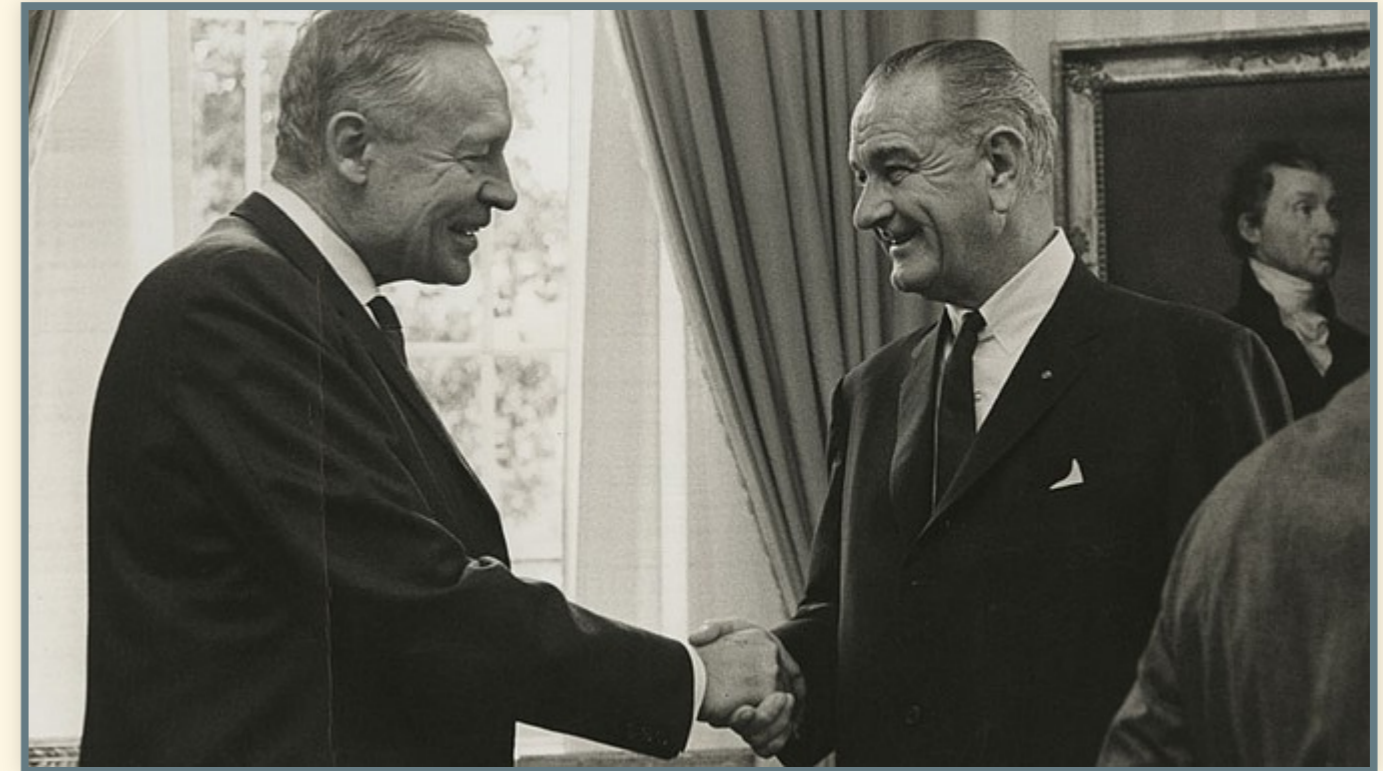
Roger Revelle and Lyndon B. Johnson

RESTORING THE QUALITY OF OUR ENVIRONMENT



*Report of The
Environmental Pollution Panel
President's Science Advisory Committee*

THE WHITE HOUSE
NOVEMBER 1965



The climatic changes that may be produced by the increased CO₂ content could be deleterious from the point of view of human beings.

Recognition of Great Severity (1975)

Climatic Change: Are We on the Brink of a Pronounced Global Warming?

Abstract. If man-made dust is unimportant as a major cause of climatic change, then a strong case can be made that the present cooling trend will, within a decade or so, give way to a pronounced warming induced by carbon dioxide. By analogy with similar events in the past, the natural climatic cooling which, since 1940, has more than compensated for the carbon dioxide effect, will soon bottom out. Once this happens, the exponential rise in the atmospheric carbon dioxide content will tend to become a significant factor and by early in the next century will have driven the mean planetary temperature beyond the limits experienced during the last 1000 years.

WALLACE S. BROECKER

SCIENCE, VOL. 189

8 AUGUST 1975

National Academies Report (1979)

Jule G. Charney

Carbon Dioxide and Climate: A Scientific Assessment

Report of an Ad Hoc Study Group on Carbon Dioxide and Climate
Woods Hole, Massachusetts
July 23–27, 1979
to the
Climate Research Board
Assembly of Mathematical and Physical Sciences
National Research Council

NATIONAL ACADEMY OF SCIENCES
Washington, D.C. 1979



The conclusions of this brief but intense investigation may be comforting to scientists but disturbing to policymakers. If carbon dioxide continues to increase, the study group finds no reason to doubt that climate changes will result and no reason to believe that these changes will be negligible. The conclusions of prior studies have been generally reaffirmed. However, the study group points out that the ocean, the great and ponderous flywheel of the global climate system, may be expected to slow the course of observable climatic change. A wait-and-see policy may mean waiting until it is too late.

What Does Science Know?

What Does Science Know?

- Carbon dioxide in the atmosphere has risen by almost 50% since people started using fossil fuels
 - Chemical analysis of the atmosphere proves that the rise in carbon dioxide is almost entirely caused by burning fossil fuels.
 - The amount of carbon dioxide in the atmosphere is the highest it's been in 3 to 5 million years.
- The earth's average temperature has risen by 2.2° F since the late 19th century.
 - Human activity caused almost all of this warming.

Studying Ancient Climates

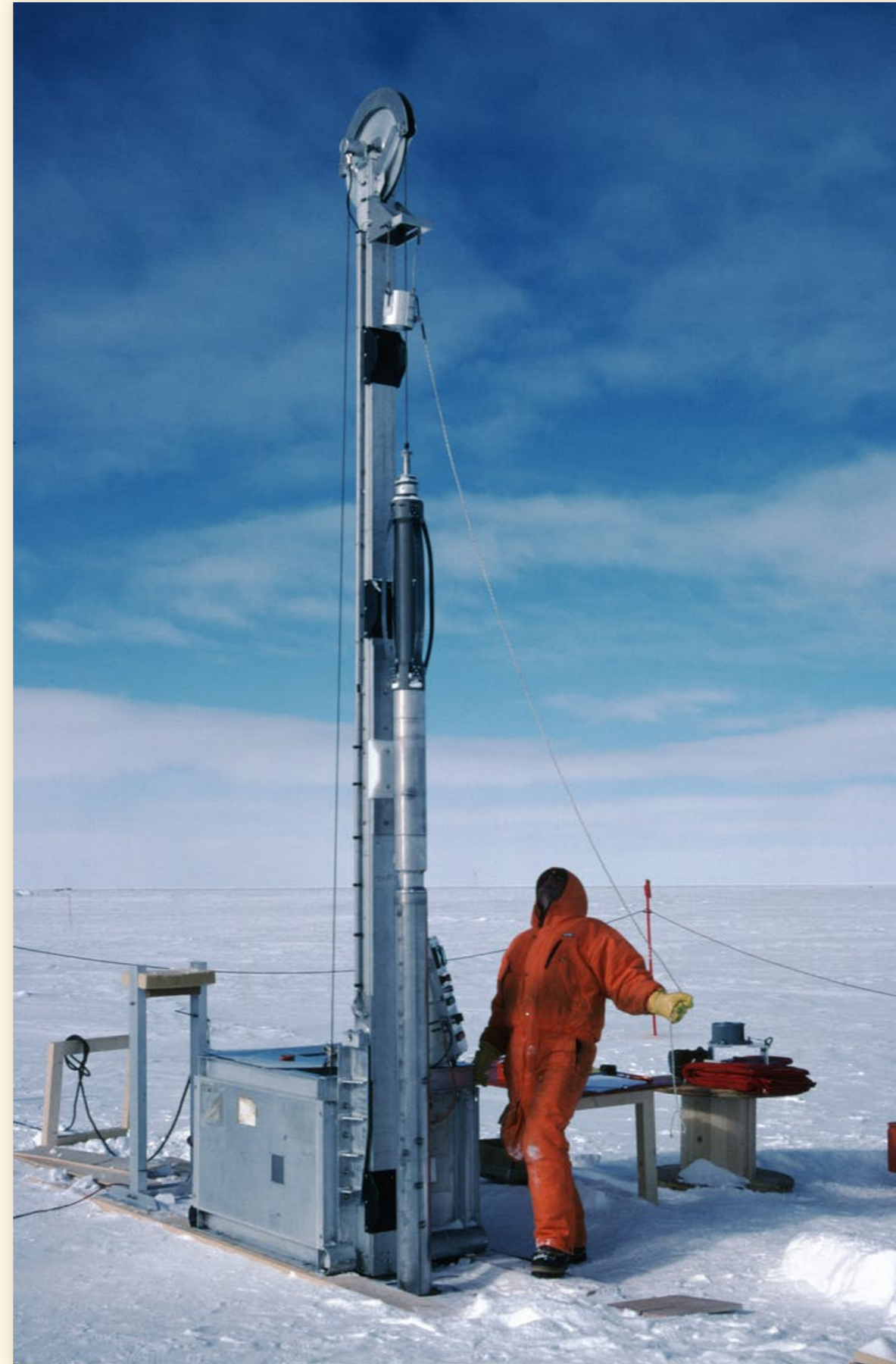


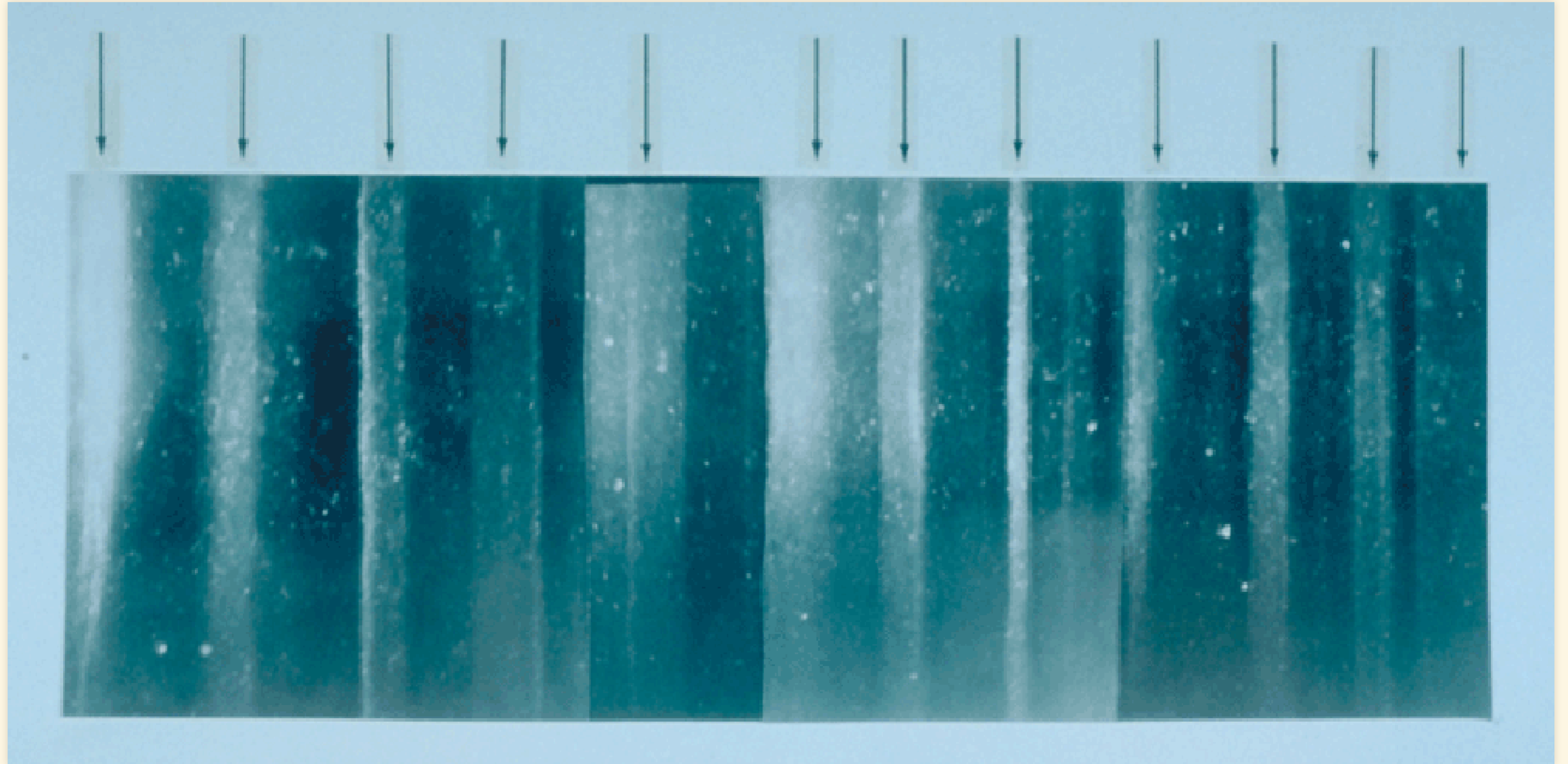
Image Credit: R Mulvaney/British Antarctic Survey

Ice Cores



Image credits: Pete Bucktrout/British Antarctic Survey

Inside the Ice Core



Inside the Ice Core

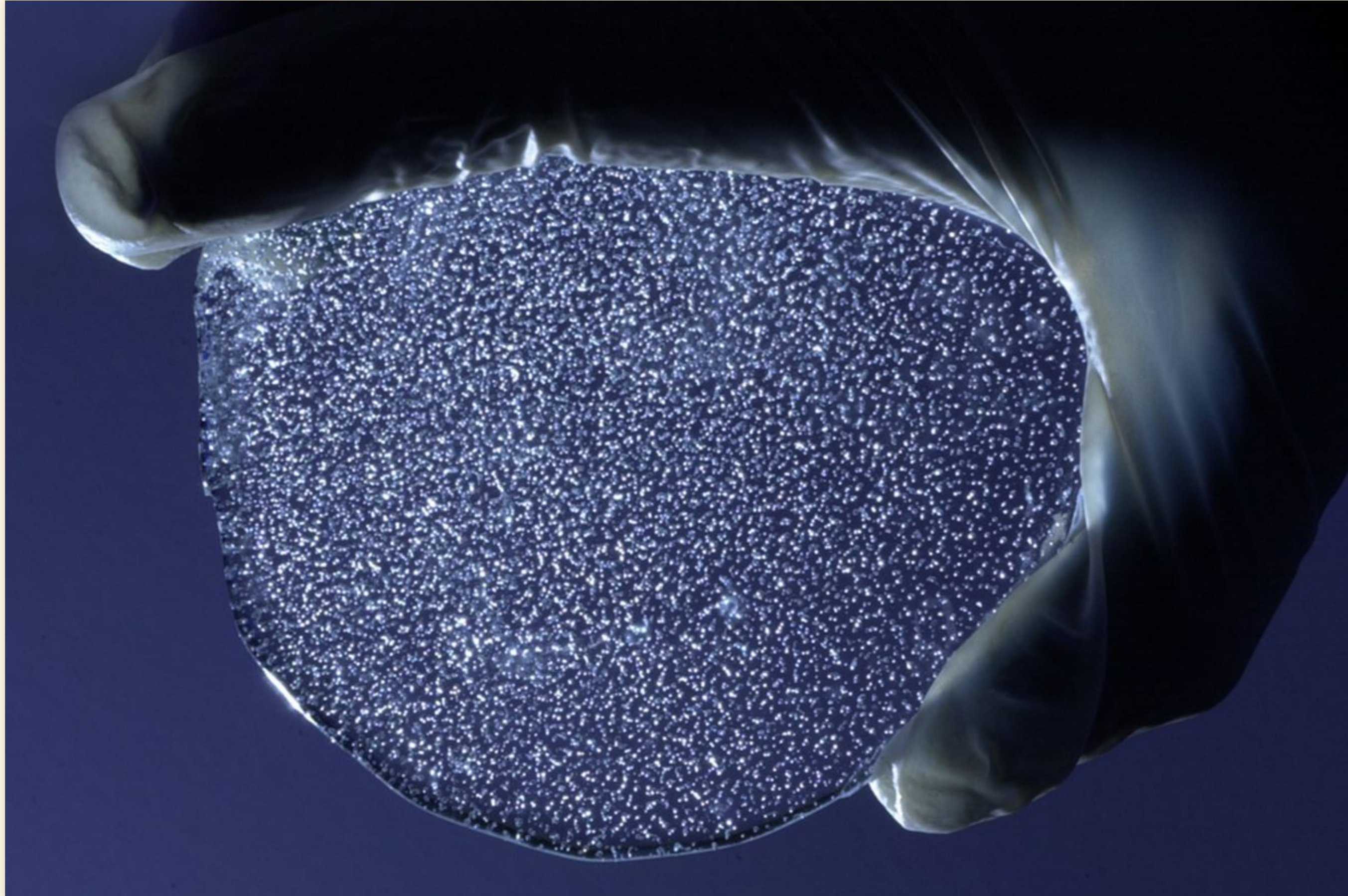


Image credit: Pete Bucktrout/British Antarctic Survey

Ice Ages



Image credit: Ron Blakey

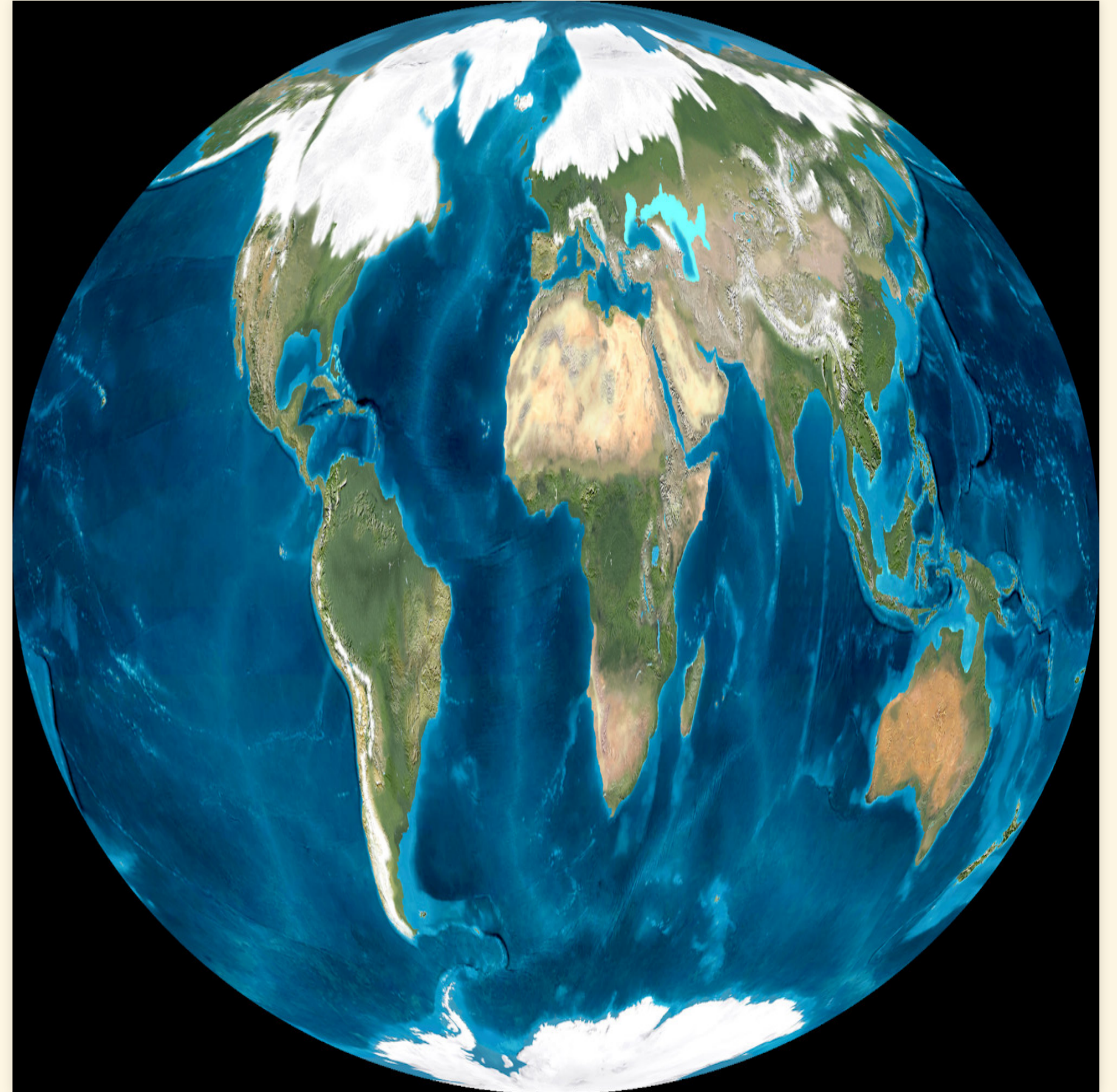


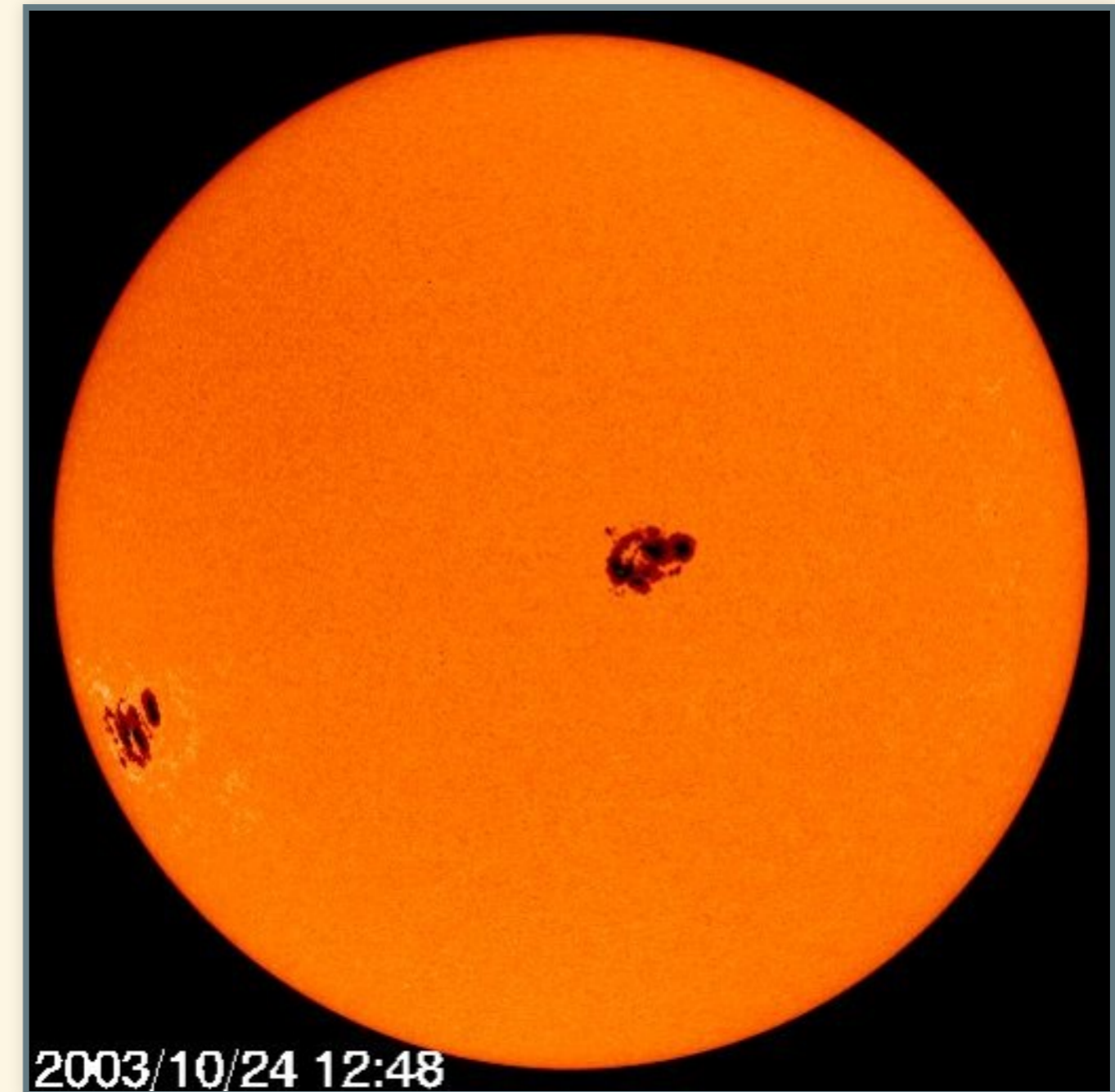
Image credit: Ron Blakey

What Scientists Have Learned

- Climate has changed throughout Earth's history
- Those changes were mostly caused by natural changes in carbon dioxide
- If carbon dioxide did not cause climate change, the Ice Ages could not happen

Could Something Else Be Causing Global Warming

- Some people say changes in the sun are causing warming, not greenhouse gases.
- Different causes produce different patterns of climate change
 - Compare patterns to find the true cause
 - Example: Greenhouse gases:
 - Nights warm faster than days
 - Winter warms faster than summer
 - Observed patterns match greenhouse theory.
 - No other theory matches patterns nearly as well.
- ***Once you eliminate the impossible, whatever remains, no matter how improbable, must be the truth.***
— Sherlock Holmes



Climate Change and People's Lives

- Extreme heat waves are now 50 times more frequent than they used to be.
 - Six of the ten deadliest heat waves in history happened since 2000.
 - 2003 European heat wave: 70,000 deaths
 - 2010 Russian heat wave: 50,000 deaths
 - A record-setting heat wave, combined with drought caused Australian wildfires.



Sea-Level Rise

- Sea level rise is causing increasing flooding in coastal cities
 - “King tides” in Miami are flooding the city even in good weather.
 - When hurricanes come, storm surges are higher and more destructive



Winter Temperatures

- Cold winters are important
 - Freezing temperatures kill pests
 - Many trees need cold winters to tell them to reset for growing in the spring
 - Peach trees need more than 800 hours below 40° F to make good fruit
 - The winter of 2016–2017 had less than 500 “cold-soaking” hours in Georgia
 - 85% of the Georgia peach crop was lost.



Summer Temperatures

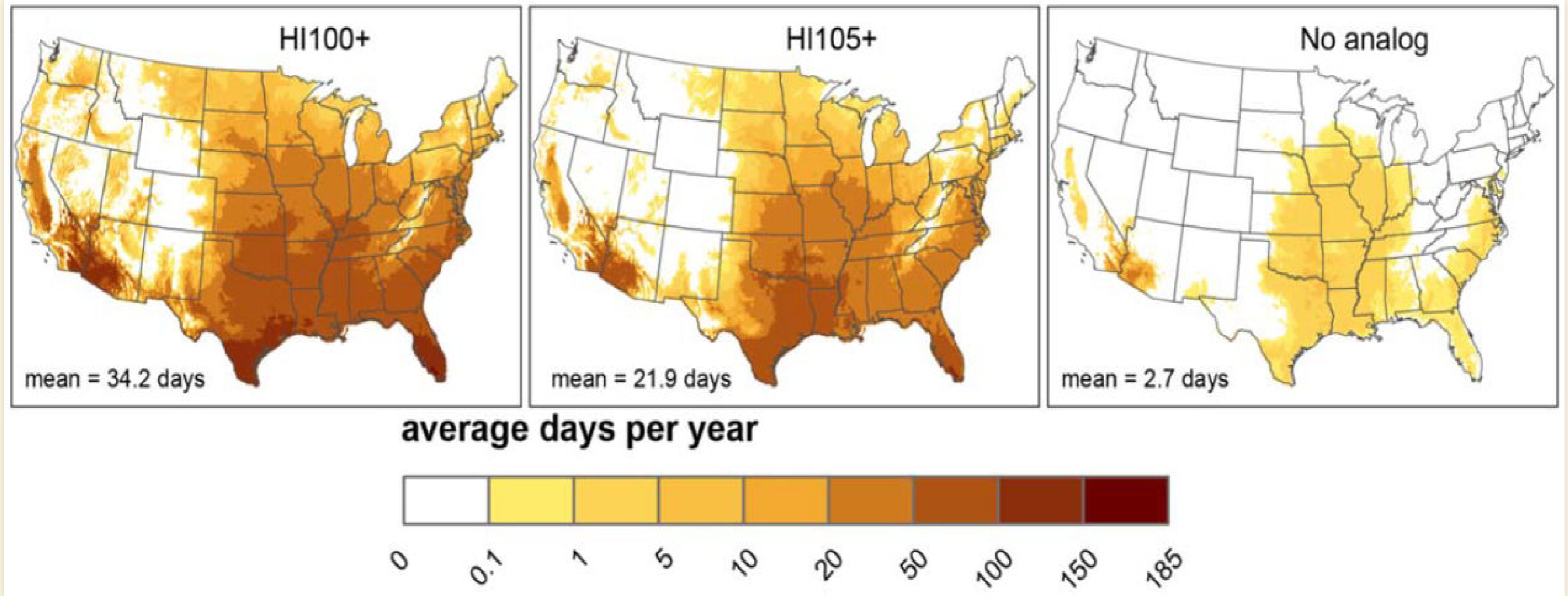
- In the South, many people work outside
 - Construction, farming, logging, etc.
 - Summer heat waves could make it dangerous to be physically active outdoors
 - Loss of working hours, lower economic productivity, less money



What Does the Future Hold?

Future Projections for the U.S.

- Extreme heat in 2070-2099 even with serious emission reductions.



Football Practice in Heat

Football practice health/safety rules:

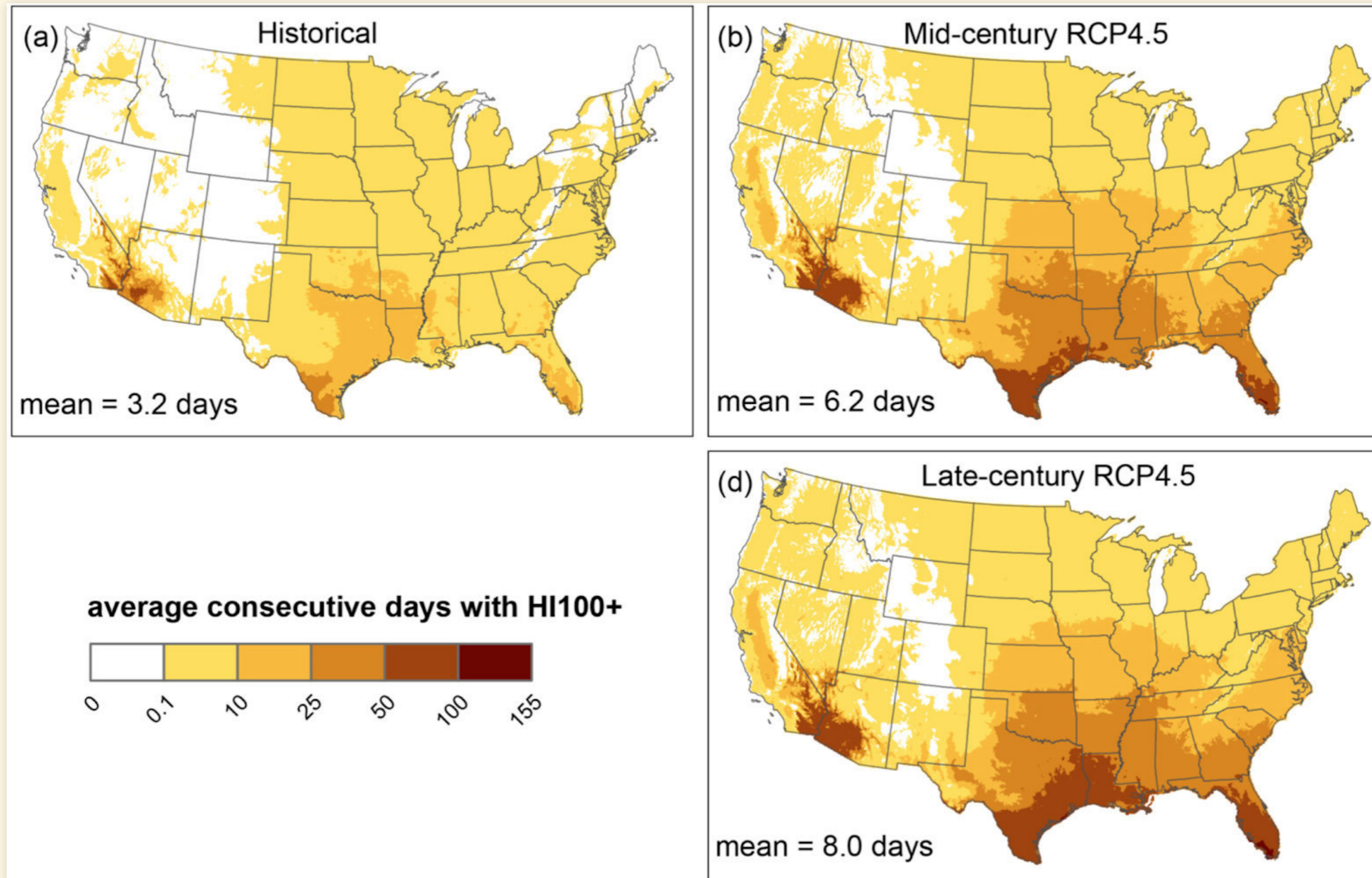
- Heat index of 104 or more is considered **dangerous**
 - Constant observation and supervision for overheating
 - No pads or equipment
 - 5 minutes mandatory rest and water break every 15 minutes
- After 2070:
 - Average of 3 weeks per year in US
 - 2 months per year in most of South and Midwest



Photo credit: Nathaniel Rutherford/RTI

Severe Heat Waves

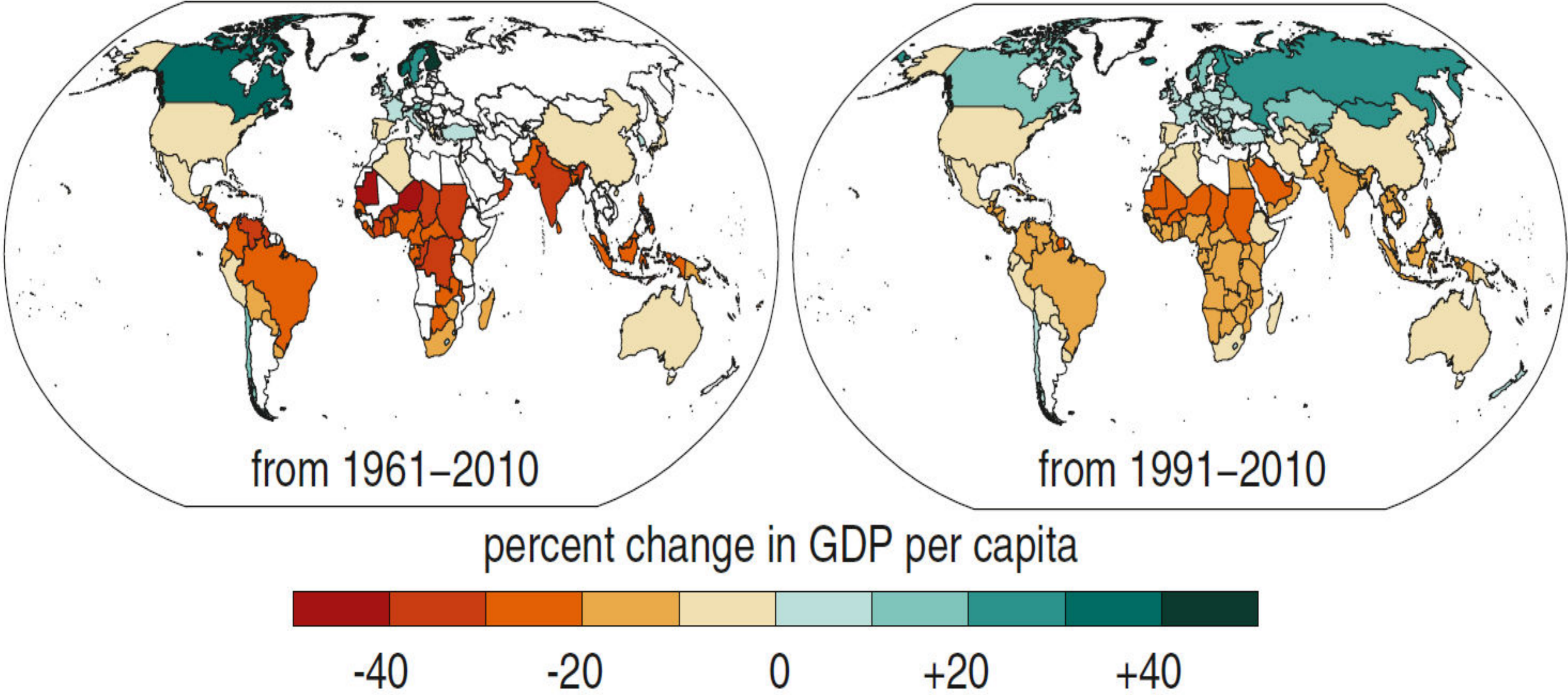
- Severe heat waves even with serious emission reductions.



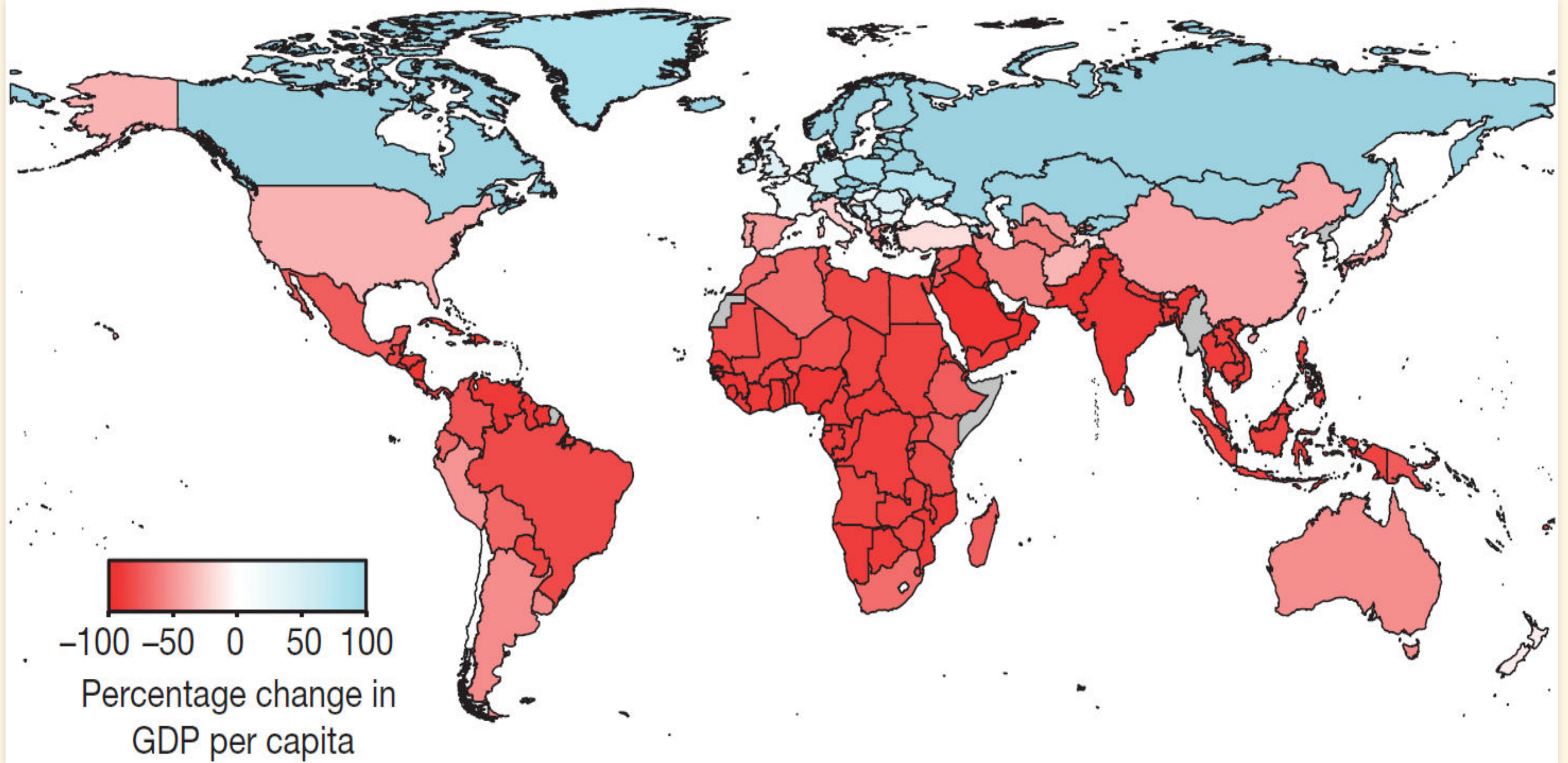
Dust Bowl in Context

- 1930s Dust Bowl:
 - Lower 48: hottest years since 1880
 - 6 years of drought
 - Plains states: 25% less rain
- Medieval Megadroughts:
 - N. America: 1–2°C hotter than today
 - 60–240 year droughts
 - Plains states: 40% less rain
 - Affected everything west of Mississippi

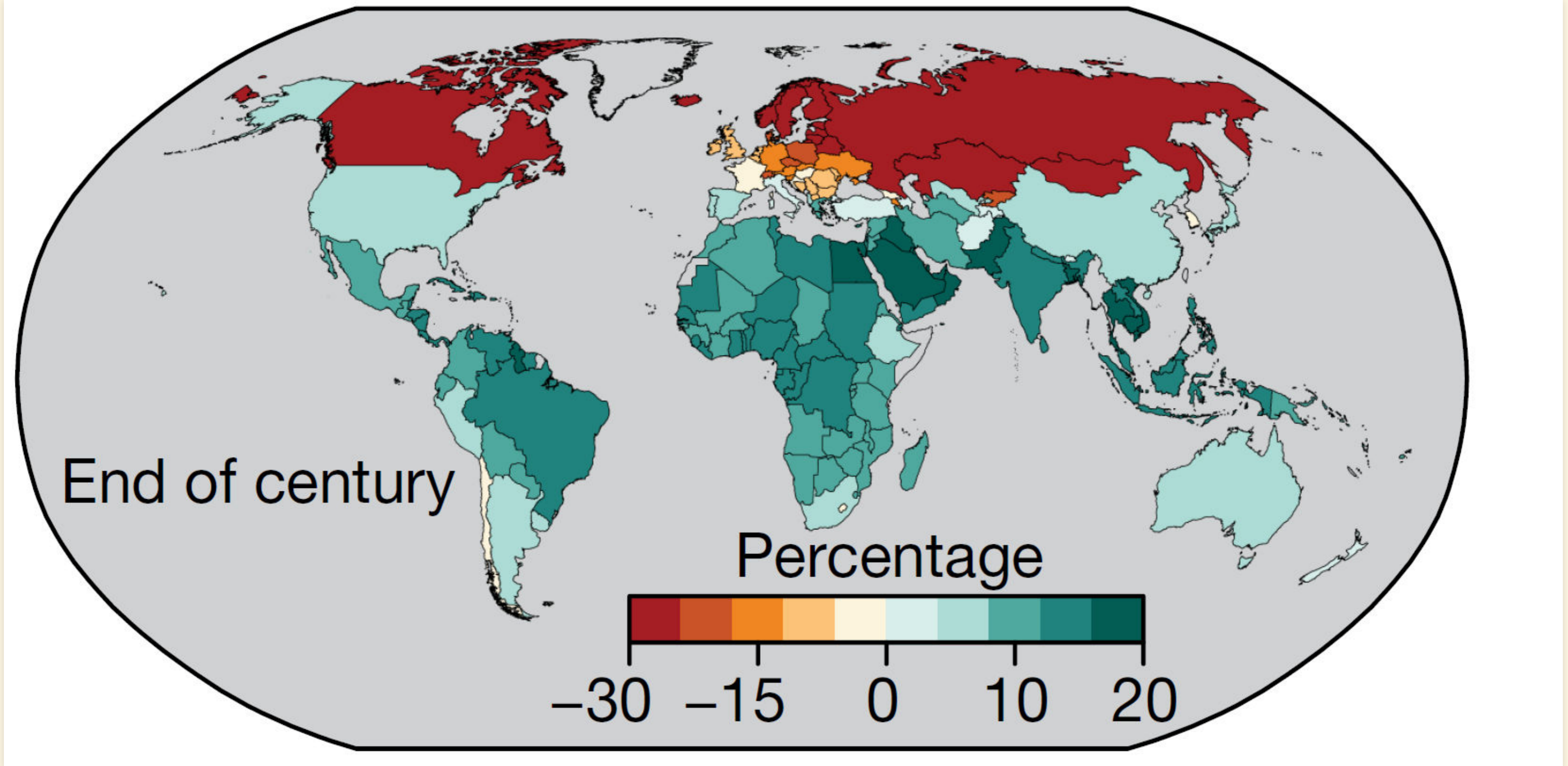
Global Warming is Already Affecting Economic Inequality



Future Economic Damages



Benefits of Reaching International Climate Goals

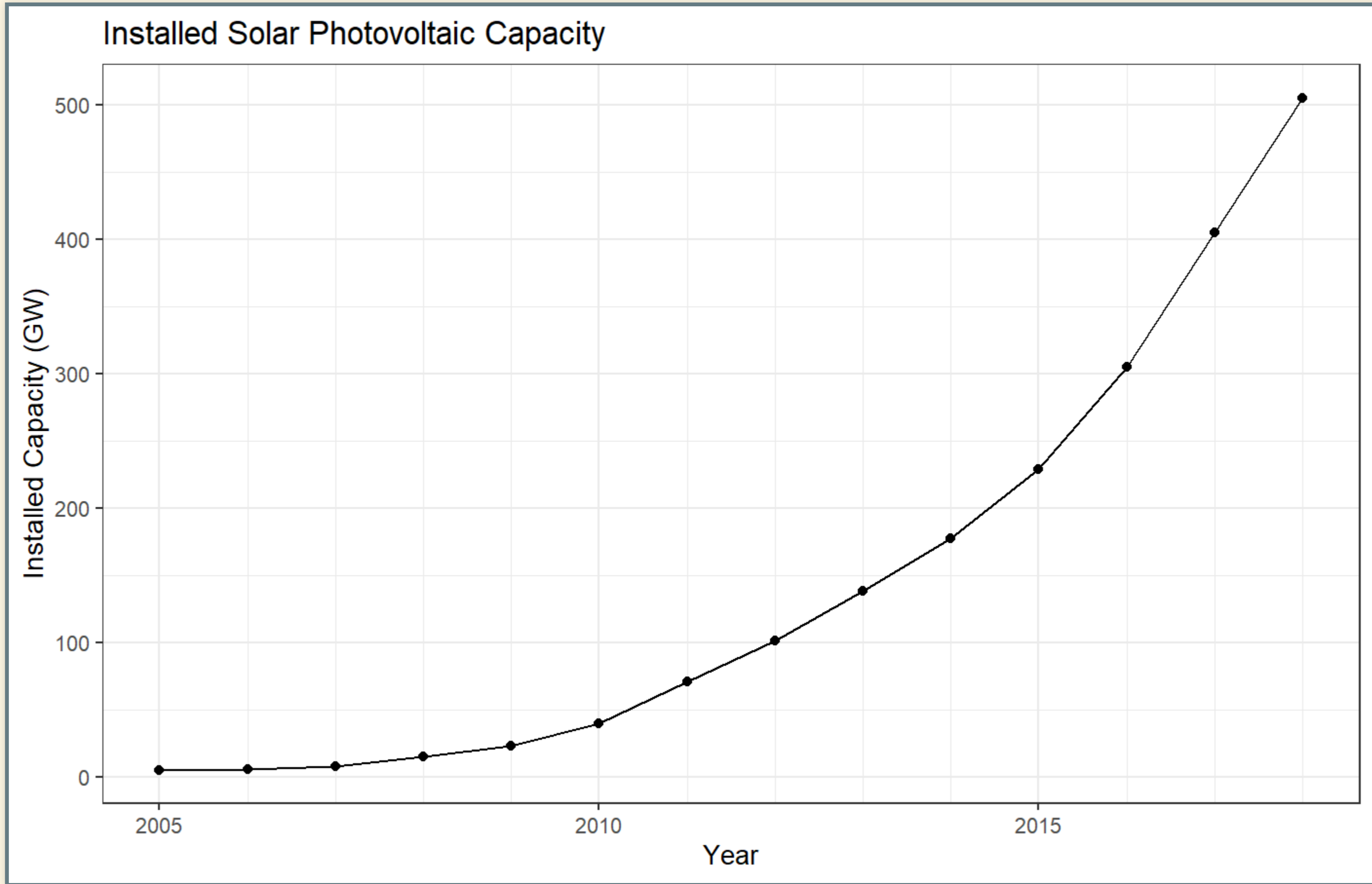


Prospects for Clean Energy

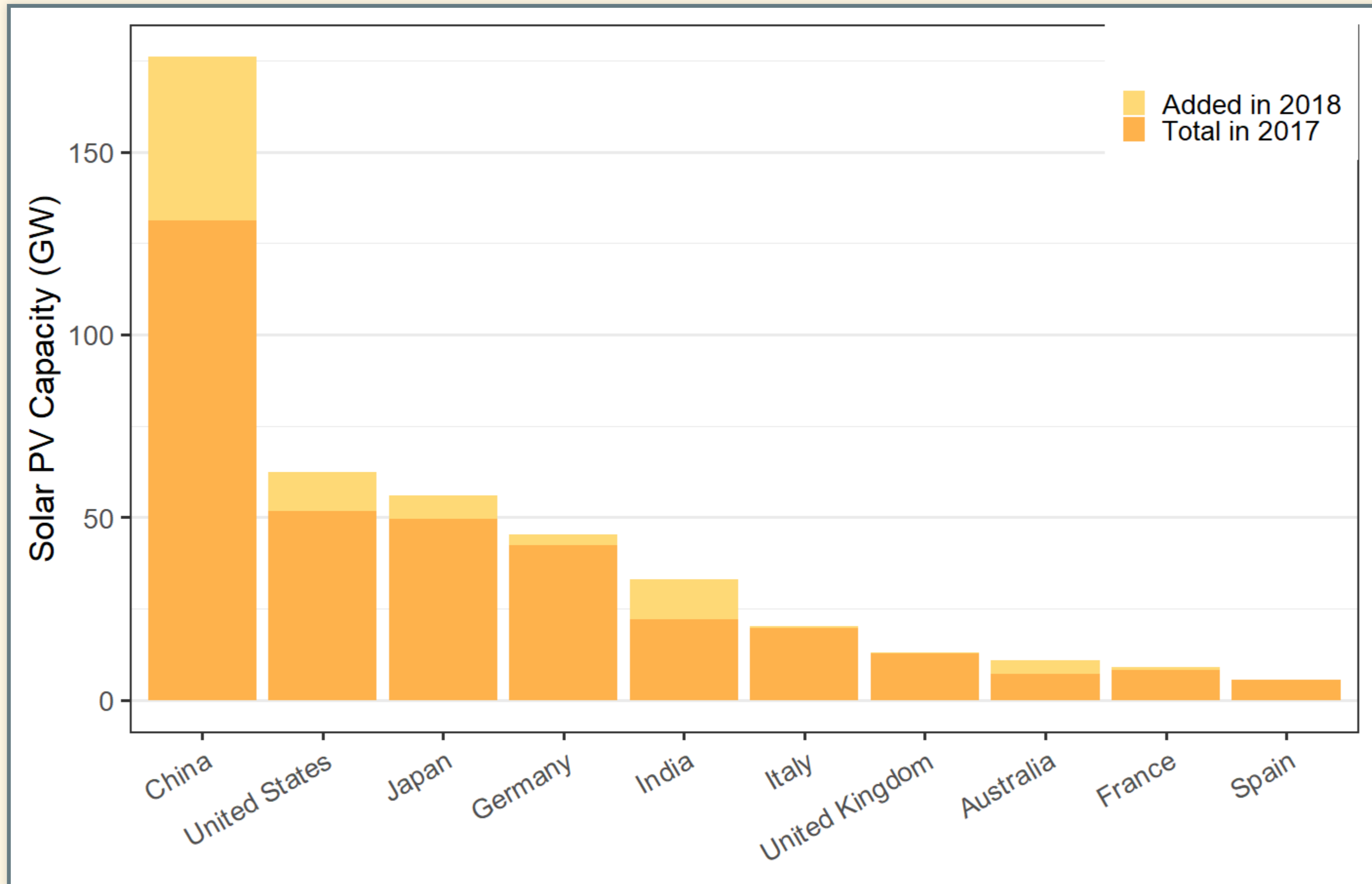
Solar Power



Solar Energy over Time



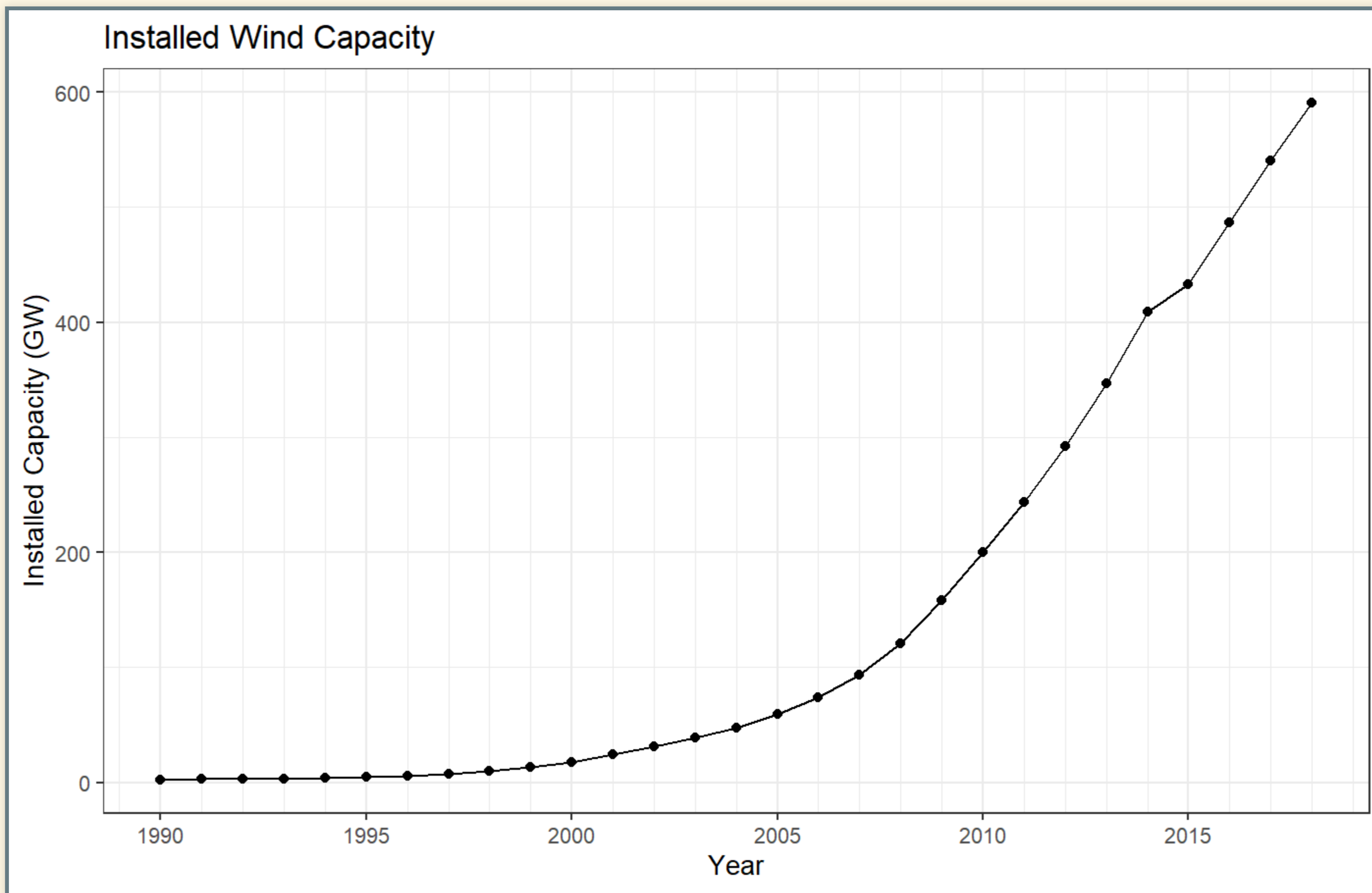
Top-10 Nations for Solar PV



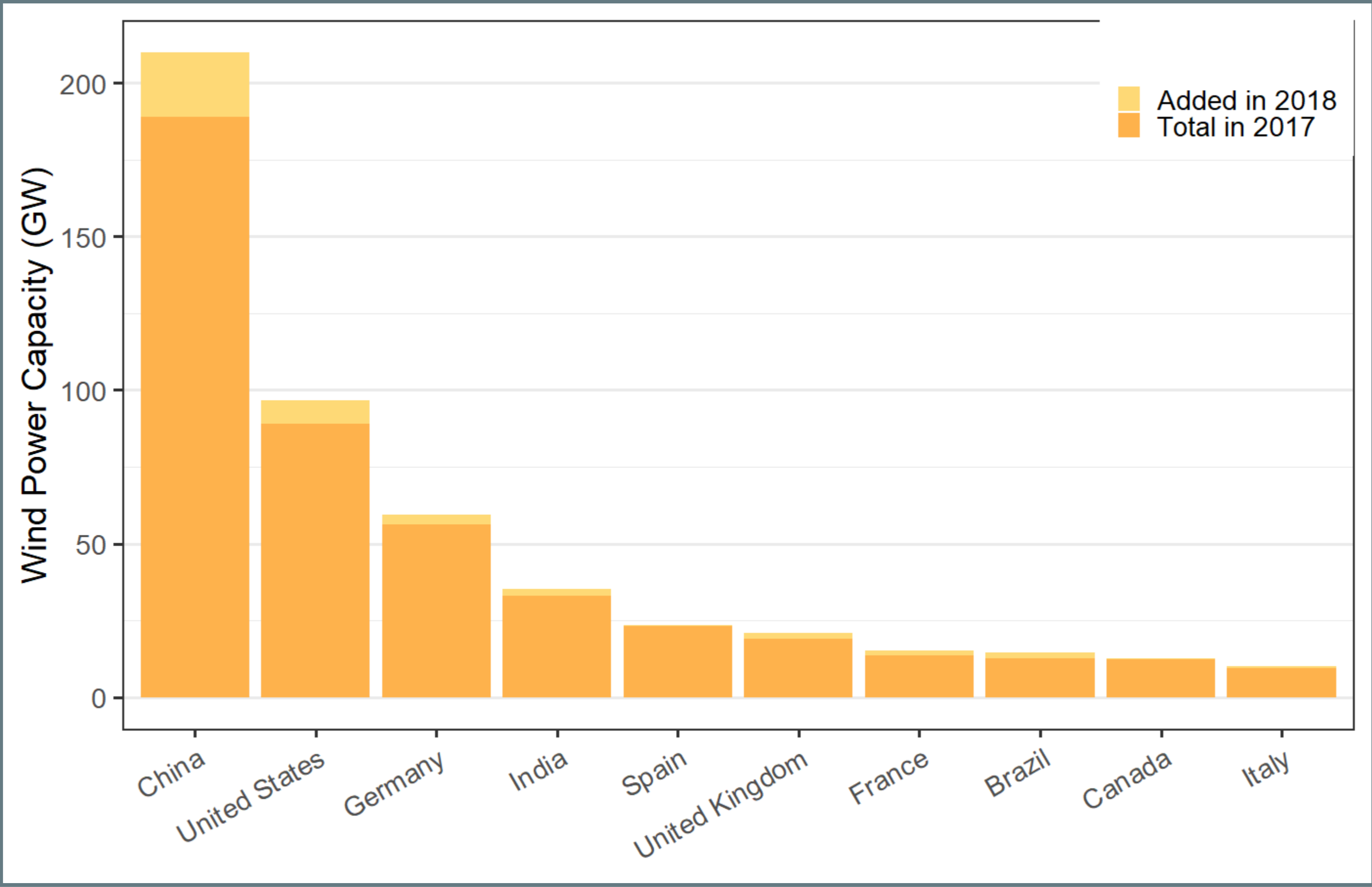
Wind Power



Wind Energy over Time



Top-10 Nations for Wind



Prospects for Future Renewable Energy

Cost of Renewable Power

- Cost of solar panels is 70% less than in 2009
 - Down 93% since 1990
- Cost of wind and solar is now less than half the cost of coal power
- Cost of battery storage is down 85% since 2010.
- Most car companies say the future of cars is electric
- Politics and government regulations are **preventing** the rapid expansion of renewable electricity
- Many tech companies like Amazon, Facebook, Google, Microsoft, and Apple want to install more renewable electricity
- Vanderbilt University just signed a deal to build a 35 million Watt solar power facility.

What Can You Do?

- Reduce energy waste at home:
 - Drive less, walk, bicycle, and take the bus more
- Don't waste food
 - Growing and preparing food takes energy.
 - Food in landfills generates greenhouse gases
- Eat less meat
 - Especially beef
 - Switching from beef to pork or chicken does a lot of good
- Demand that adults behave responsibly
 - Make your voice heard
- When you turn 18, register to vote and vote in every election