

Global Climate Disruption:

How Do We Know?
What Can We Do?



Andy Jorgensen, Ph.D.

Associate Professor Emeritus of Chemistry, University of Toledo
School of Green Chemistry and Engineering
Senior Fellow, National Council for Science and the Environment

Franciscan Earth Literacy Center

April 10, 2019



National Council for
Science and the Environment

Which statement best represents your opinion?

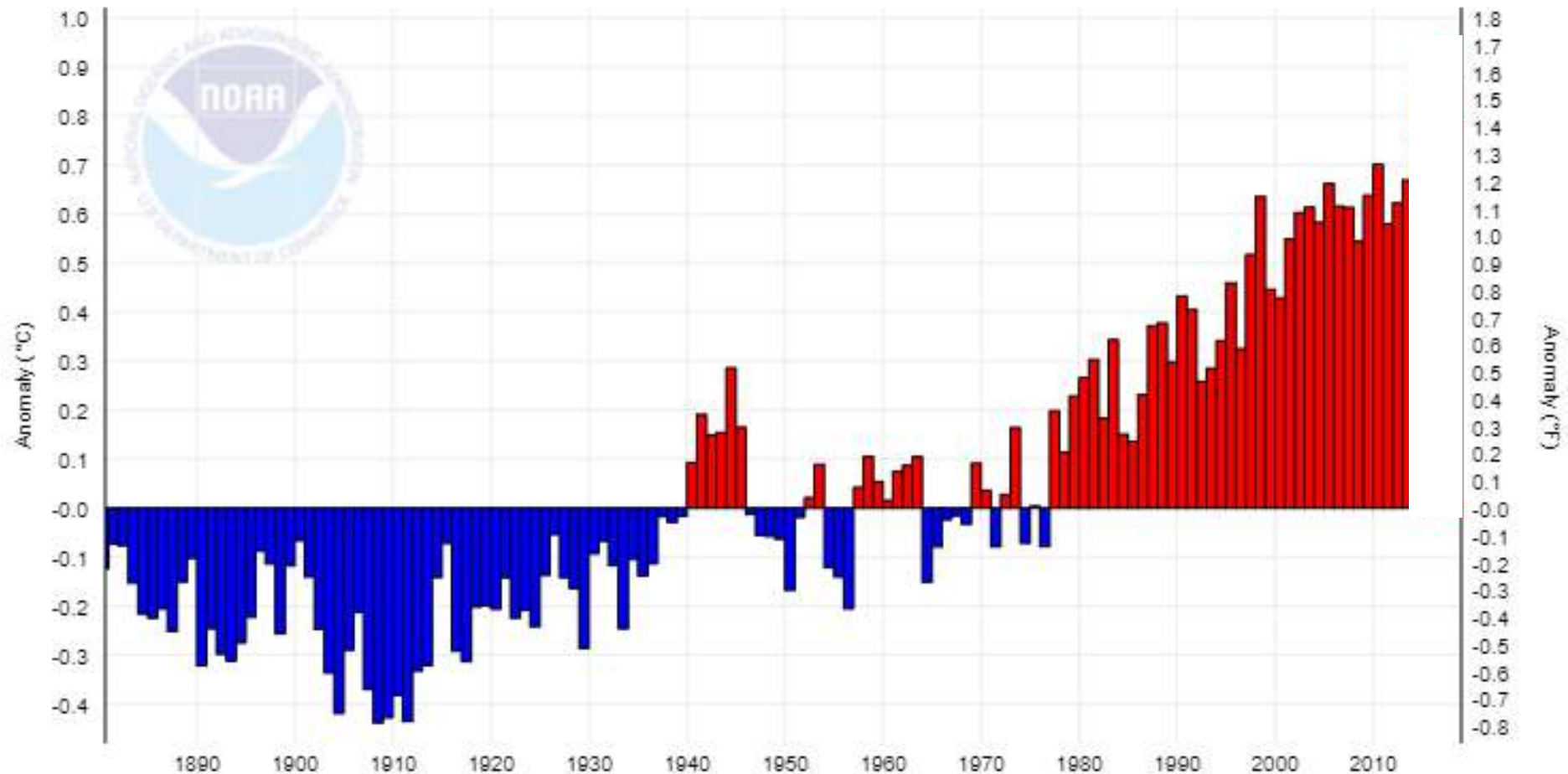
- A. Climate change is not a significant issue**
- B. Climate change is a modest-level issue**
- C. Climate change is a major issue**
- D. Climate change is major, but not practical to address**

This Pre-Talk Survey which will be followed by a Post-Talk Survey



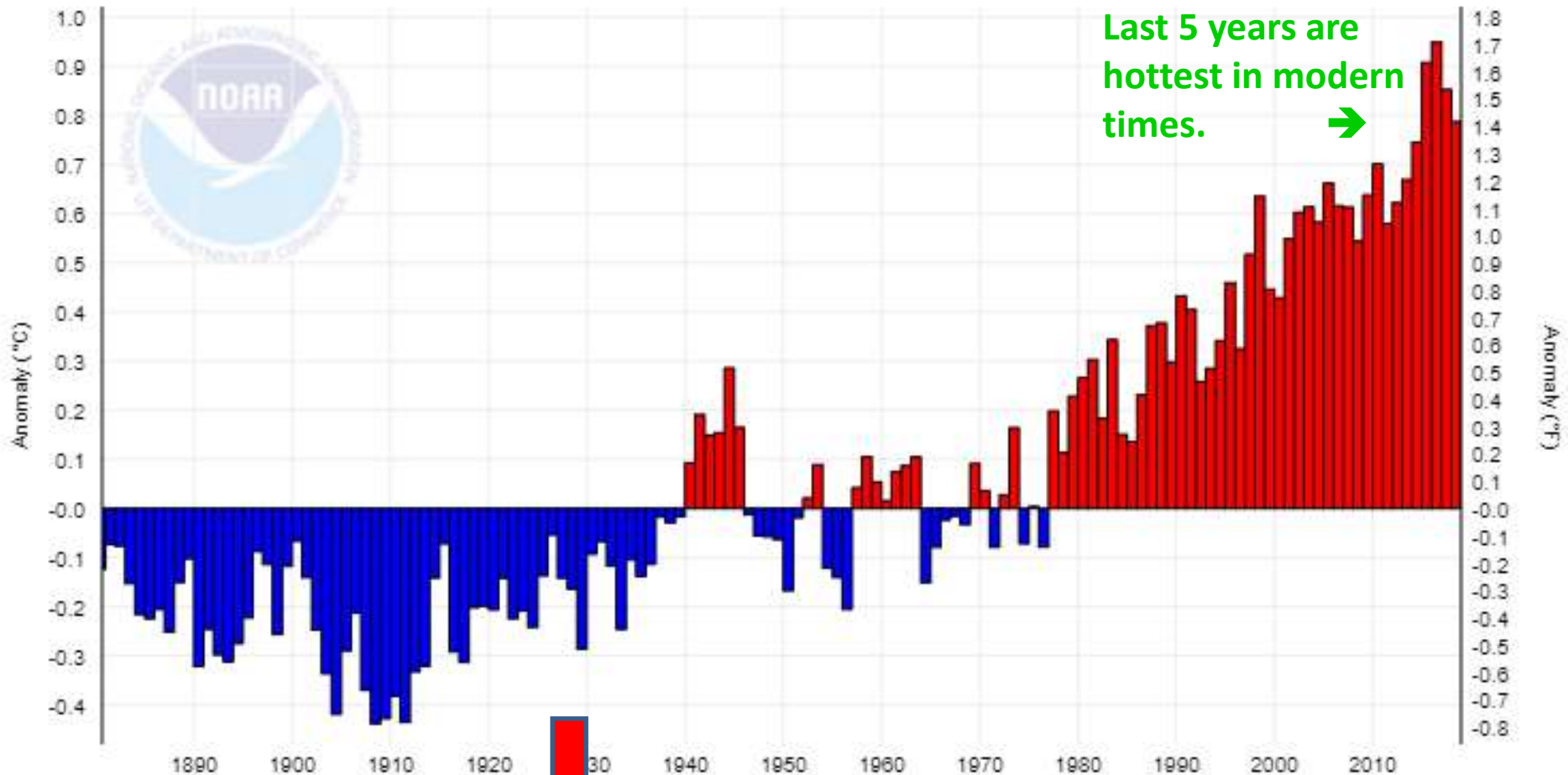
Summary of Global Direct Temperature Measurements

Global Land and Ocean Temperature Anomalies, January-December



Summary of Global Direct Temperature Measurements

Global Land and Ocean Temperature Anomalies, January-December



Link to source on most pages

https://www.ncdc.noaa.gov/cag/global/time-series/globe/land_ocean/12/12/1880-2018

2018 Fourth Warmest Year in Continued Warming Trend, According to NASA, NOAA

- “Earth's global surface temperatures in 2018 were the fourth warmest since 1880, according to independent analyses by NASA and the National Oceanic and Atmospheric Administration (NOAA).
- Global temperatures in 2018 were 1.5 degrees Fahrenheit (0.83 degrees Celsius) warmer than the 1951 to 1980 mean, according to scientists at NASA's Goddard Institute for Space Studies (GISS) in New York. Globally, 2018's temperatures rank behind those of 2016, 2017 and 2015. **The past five years are, collectively, the warmest years in the modern record....**
- **“This warming has been driven in large part by increased emissions into the atmosphere of carbon dioxide and other greenhouse gases caused by human activities, according to Schmidt.”**

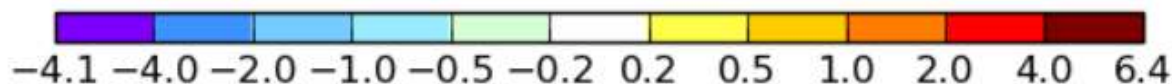
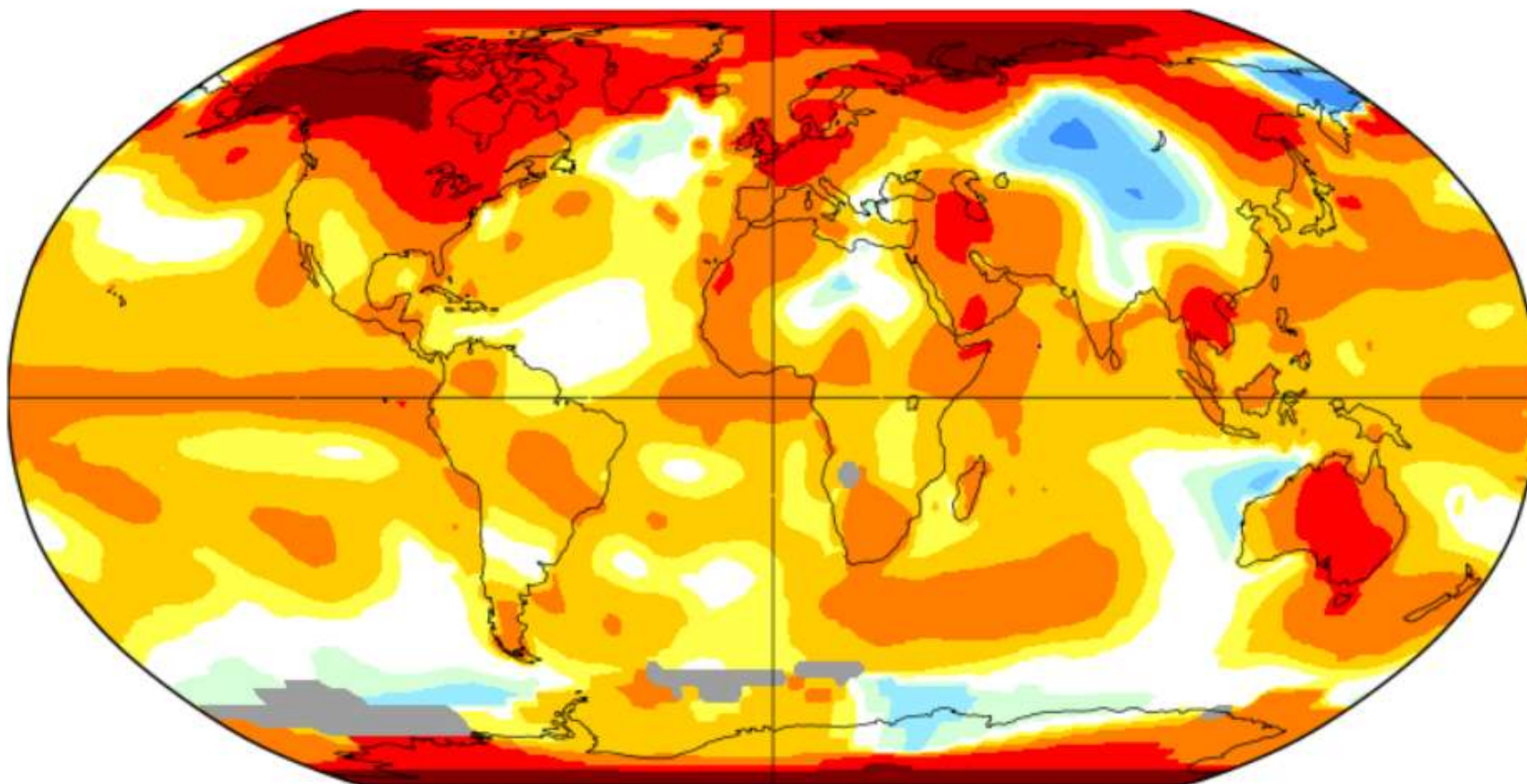
The Earth has a fever!

December 2018

L-OTI(°C) Anomaly vs 1951-1980



0.92 °C

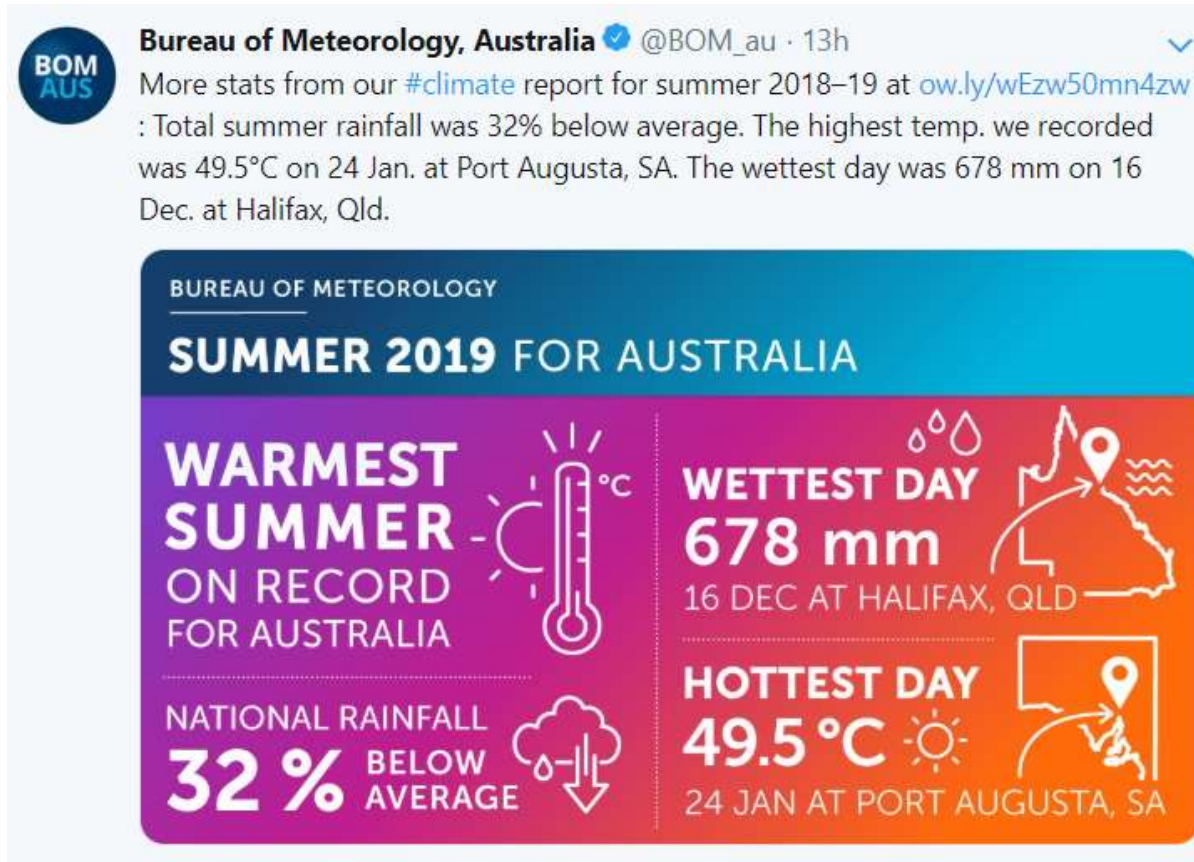


Note: Gray areas signify missing data.

Note: Ocean data are not used over land nor within 100km of a reporting land station.

**What does this mean for humans,
that is, what are the consequences?**

And in Australia...



← This is 121 °F.

- Their drought has lasted for several years
- This season crops are expected to be 20% lower than average.

Do you like ticks and mosquitoes? Then you will love the future!

HEALTH

Tick and Mosquito Infections Spreading Rapidly, C.D.C. Finds

Global Health

By DONALD G. McNEIL Jr. MAY 1, 2018



More Americans are living in wooded suburbs near deer, which carry the ticks that spread Lyme disease, anaplasmosis, Rocky Mountain spotted fever, babesiosis, rabbit fever and Powassan virus.

Scott Camazine/Science Source

Warmer weather is an important cause of the surge in cases reported to the Centers for Disease Control and Prevention, according to the lead author of [a study](#) in the agency's Morbidity and Mortality Weekly Report.

The New York Times

https://www.nytimes.com/2018/05/01/health/ticks-mosquitoes-diseases.html?emc=edit_na_20180501&nl=breaking-news&nlid=68834884ing-news&ref=cta

Why the California wildfires are spreading so quickly

By Ralph Ellis, CNN

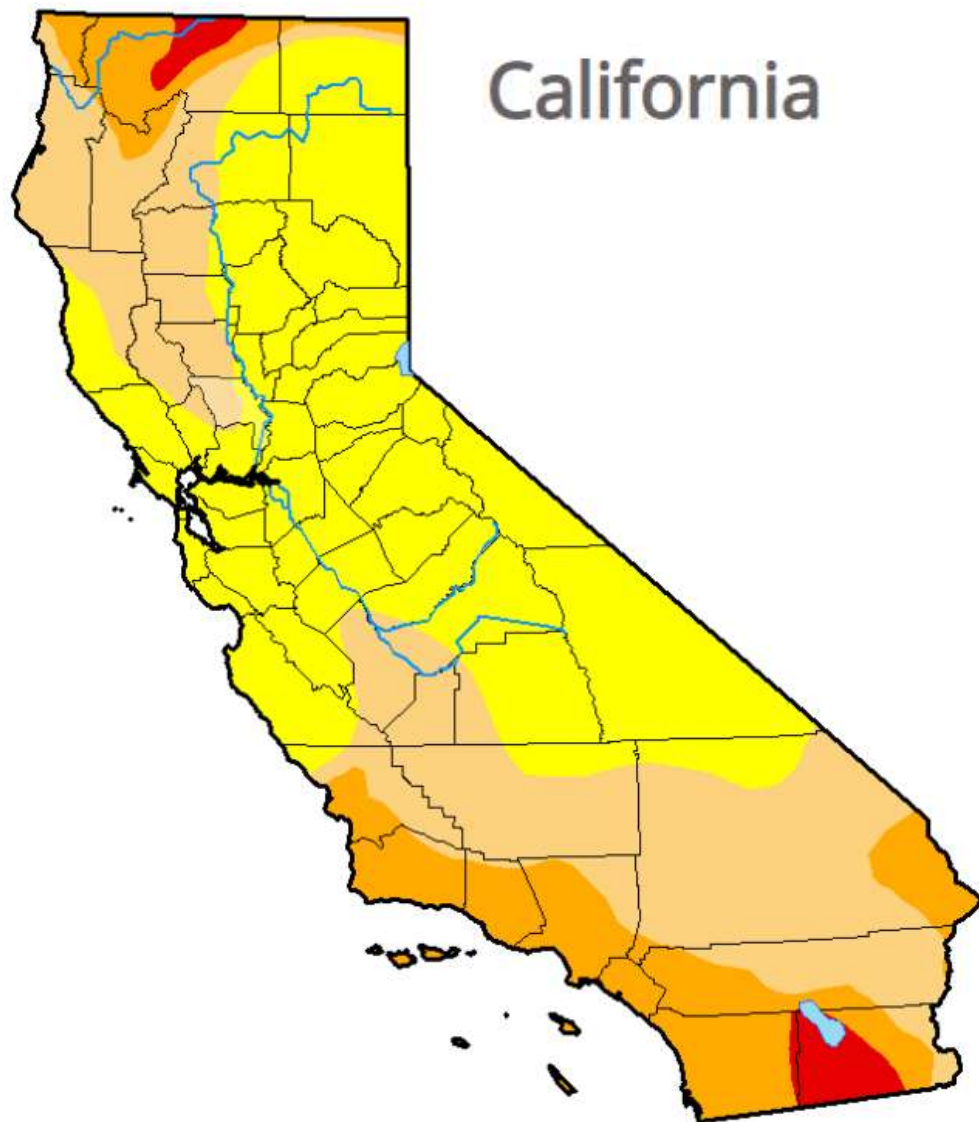
🕒 Updated 11:40 AM ET, Mon November 12, 2018

(CNN) — The three wildfires [burning in California](#) are devouring acres of land at a terrifying speed due to strong winds and [extremely dry ground conditions created by climate change](#), authorities say.

At its fastest, the Camp Fire in Northern California [spread at more than a football field a second](#), or around 80 football fields per minute. It burned through 20,000 acres in less than 14 hours on Thursday. By Monday, it had reached 113,000 acres.

The Woolsey Fire in Ventura and Los Angeles counties doubled in size in a 90-minute period Friday morning, to 8,000 acres. By Monday morning, it was up to more than 91,500 acres. The Hill Fire in Ventura County has torched 4,531 acres.

United States Drought Monitor



California

Map released: Thurs. November 8, 2018

Data valid: November 6, 2018 at 7 a.m. EST

Intensity:

- None
- D0 (Abnormally Dry)
- D1 (Moderate Drought)
- D2 (Severe Drought)
- D3 (Extreme Drought)
- D4 (Exceptional Drought)

Author(s):

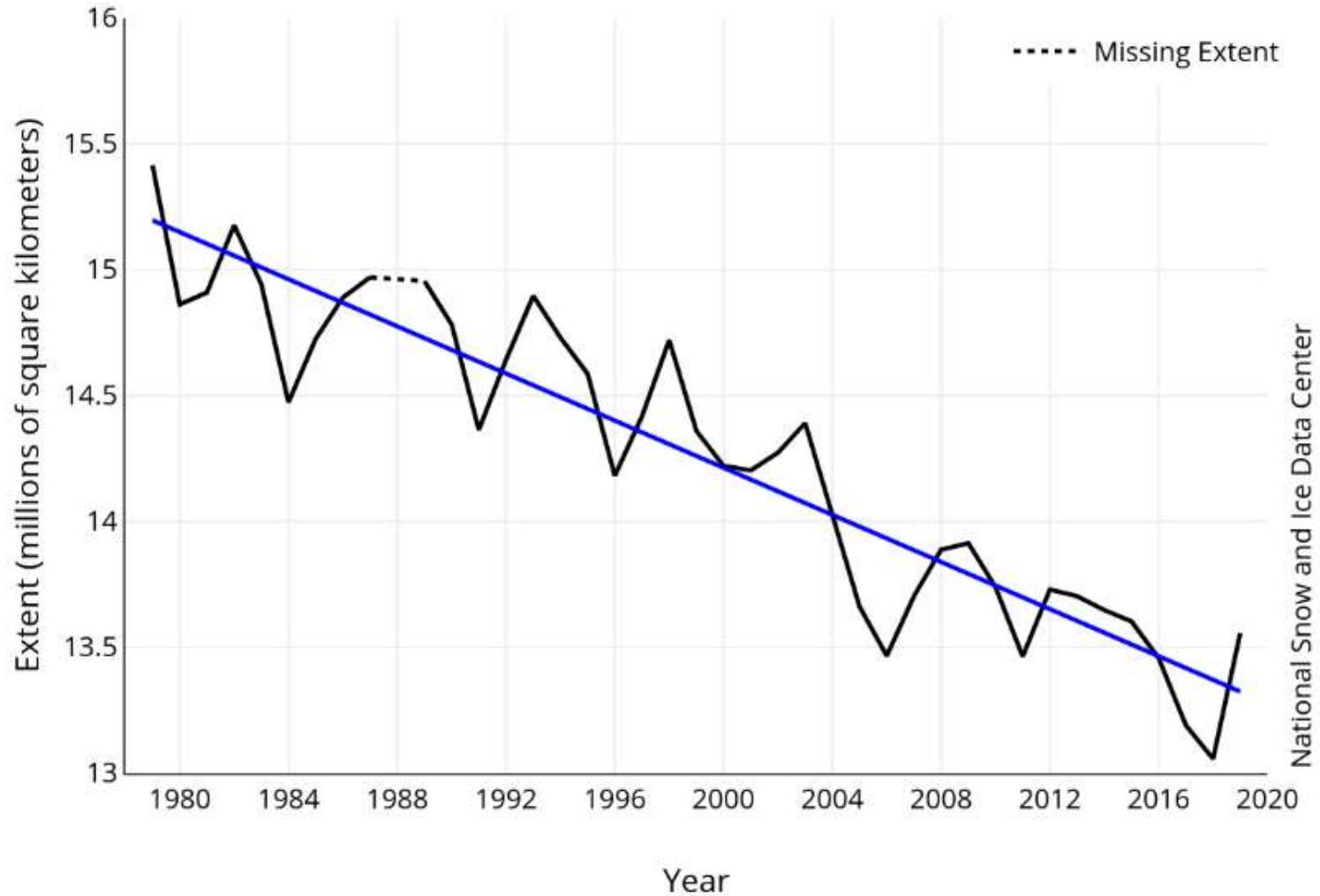
David Simeral, Western Regional Climate Center

In Addition to Life and Property Losses In California, There are Broader Consequences

- *California is the largest dairy state**
- *It grows 1/3rd of all US vegetables**
- *It grows 2/3rds of all US fruits & nuts**

Climate is a major factor for food production.

Average Monthly Arctic Sea Ice Extent January 1979 - 2019



<https://nsidc.org/arcticseaicenews/>



“Between 60 and 90 percent of the world’s fresh water is frozen in the ice sheets of Antarctica, a continent roughly the size of the United States and Mexico combined. If all that ice melted, it would be enough to raise the world’s sea levels by roughly 200 feet. While that won’t happen overnight, Antarctica is indeed melting, and a [study published Wednesday in the journal Nature](#) shows that the melting is speeding up.”

The rate at which Antarctica is losing ice has tripled since 2007, according to the latest available data. The continent is now melting so fast, scientists say, that it will contribute six inches (15 centimeters) to sea-level rise by 2100. That is at the upper end of what the Intergovernmental Panel on Climate Change has estimated Antarctica alone could contribute to sea level rise this century.



U.S. Global Change
Research Program

Fourth National Climate Assessment

November, 2018

- “Earth’s climate is now changing faster than at any point in the history of modern civilization, primarily as a result of human activities.
- “The impacts of global climate change are already being felt in the United States and are projected to intensify in the future—**but the severity of future impacts will depend largely on actions taken to reduce greenhouse gas emissions and to adapt to the changes that will occur.**

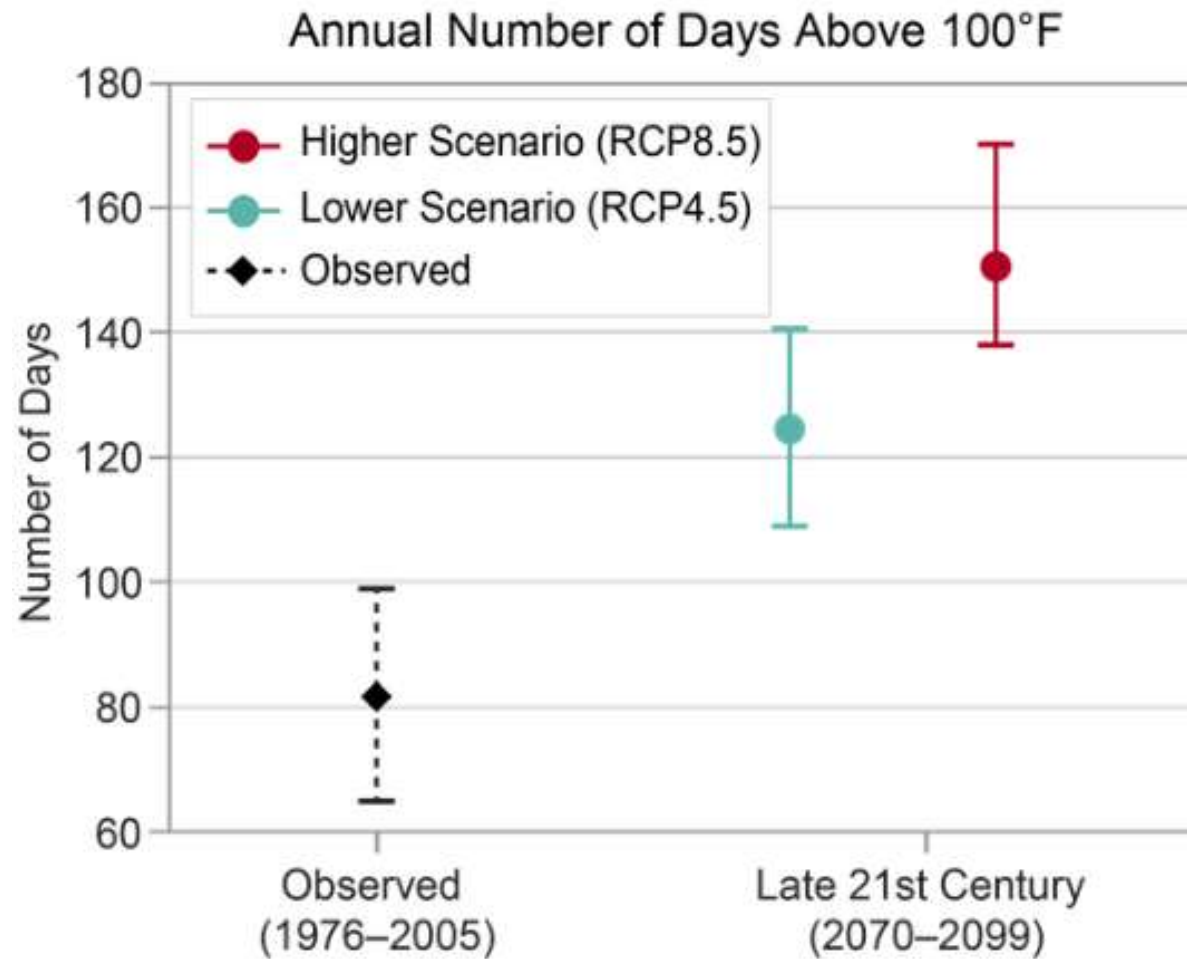
50 Inches of Rain Fell on Houston During Hurricane Harvey



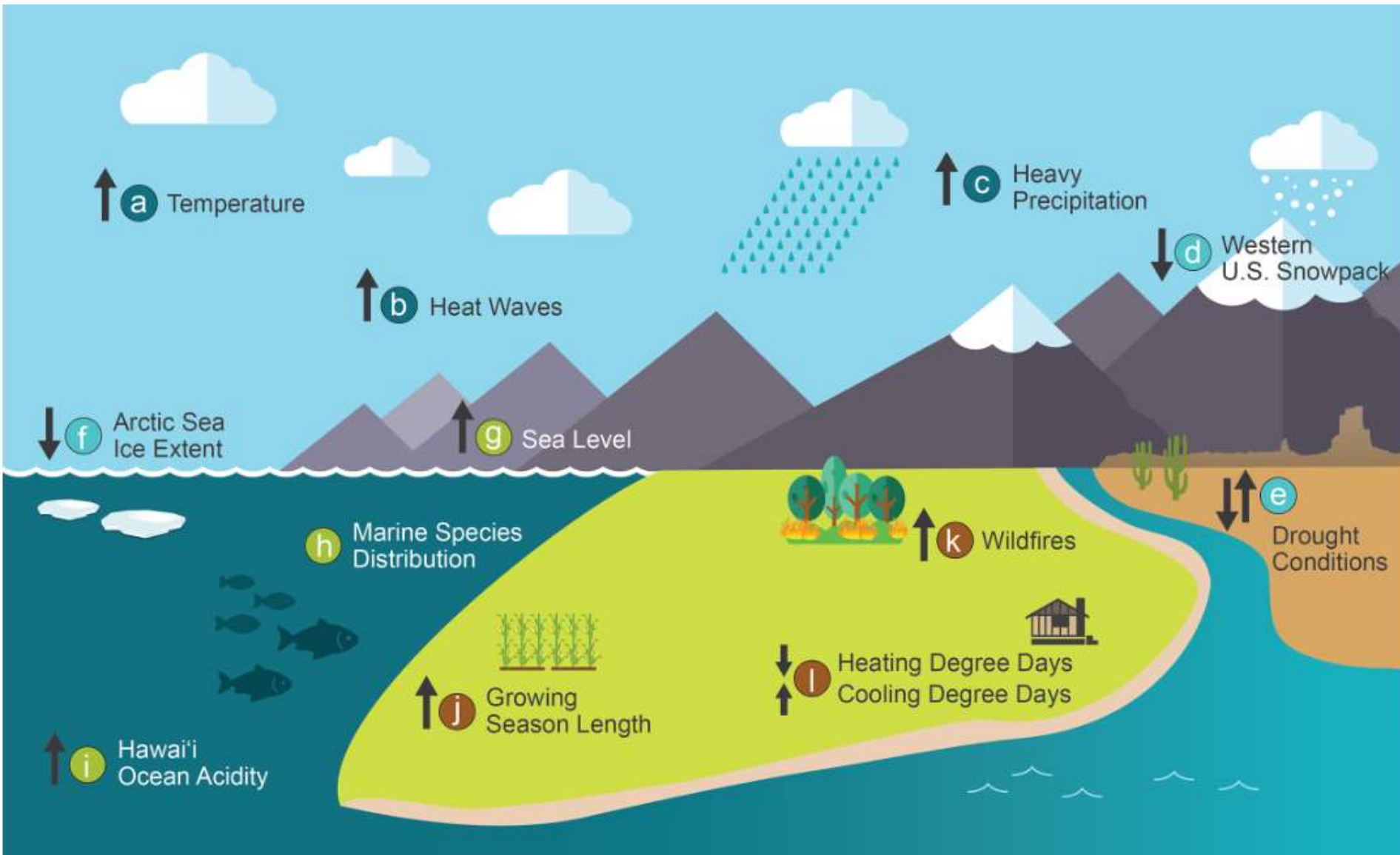
Widespread Impacts from Hurricane Harvey

Figure 1.6: Hurricane Harvey led to widespread flooding and knocked out power to 300,000 customers in Texas in 2017, with cascading effects on critical infrastructure facilities such as hospitals, water and wastewater treatment plants, and refineries. The photo shows Port Arthur, Texas, on August 31, 2017—six days after Hurricane Harvey made landfall along the Gulf Coast. From Figure 17.2, Ch. 17: Complex Systems (Photo credit: Staff Sgt. Daniel J. Martinez, U.S. Air National Guard).

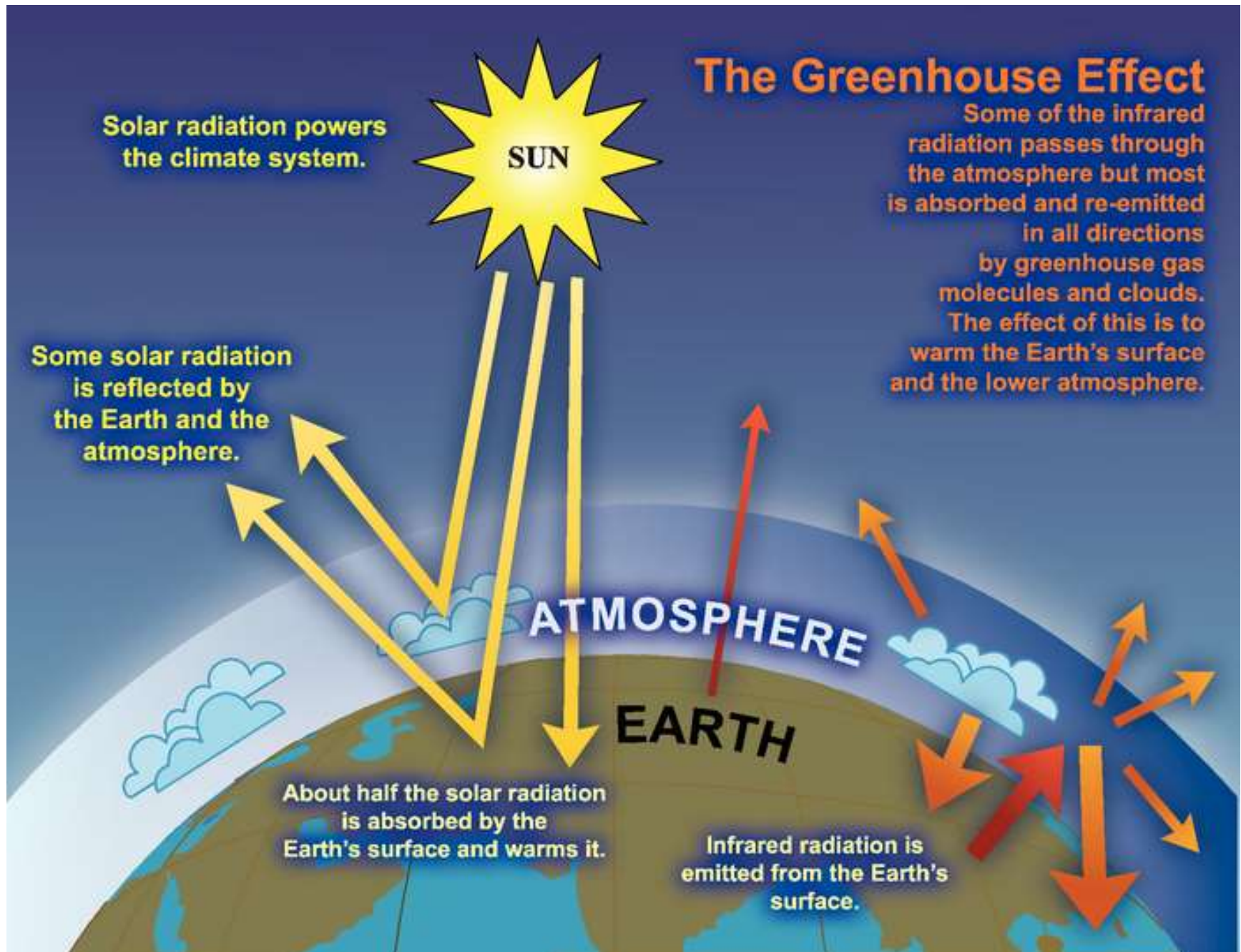
Figure 1.16: Projected Change in Very Hot Days by 2100 in Phoenix, Arizona



Evidence of Recent Climate Change

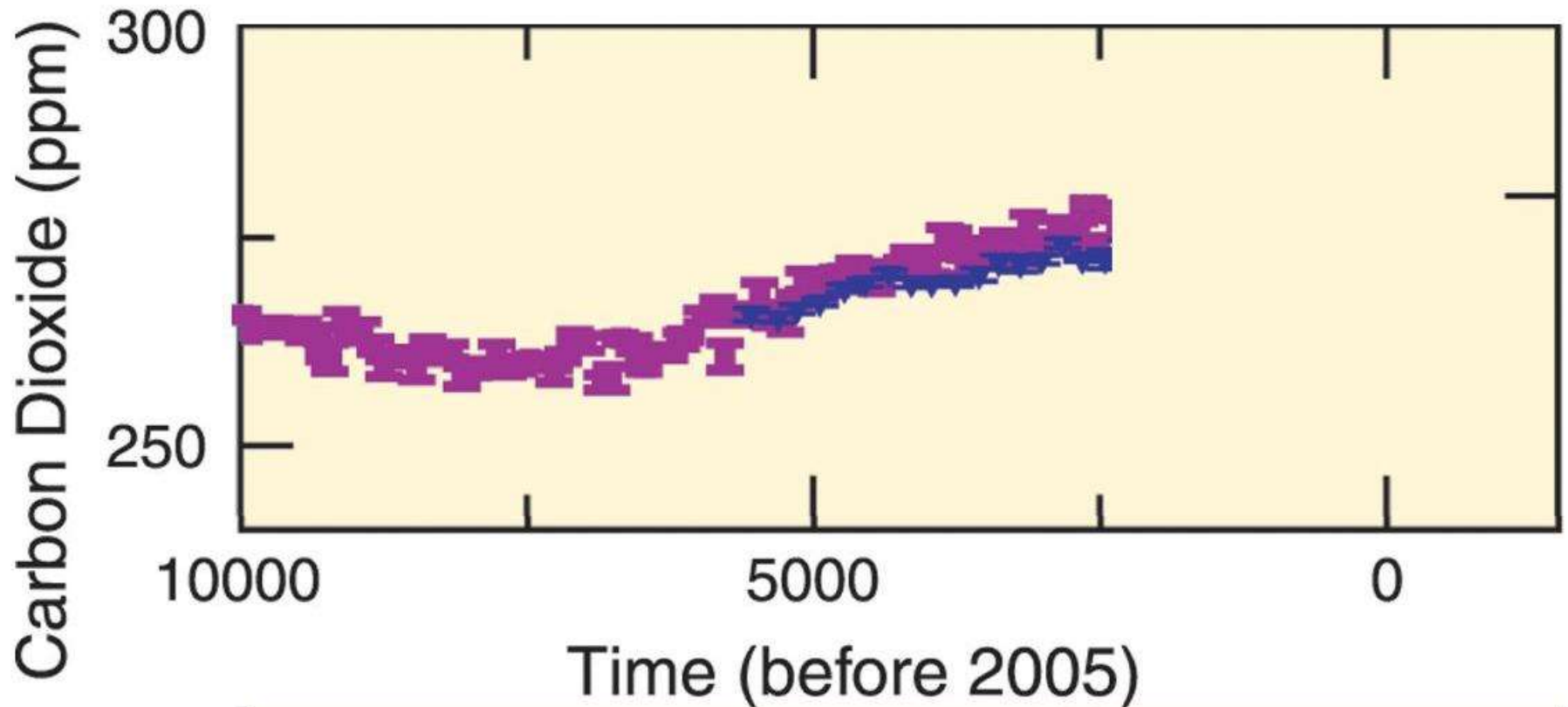


Why is Earth's temperature changing?



**Let's look at the primary chemical
behind the Greenhouse Effect, CO₂**

This data is from a time when humans were not a factor.



IPCC Climate Change 2007: Synthesis Report

How high are recent values?

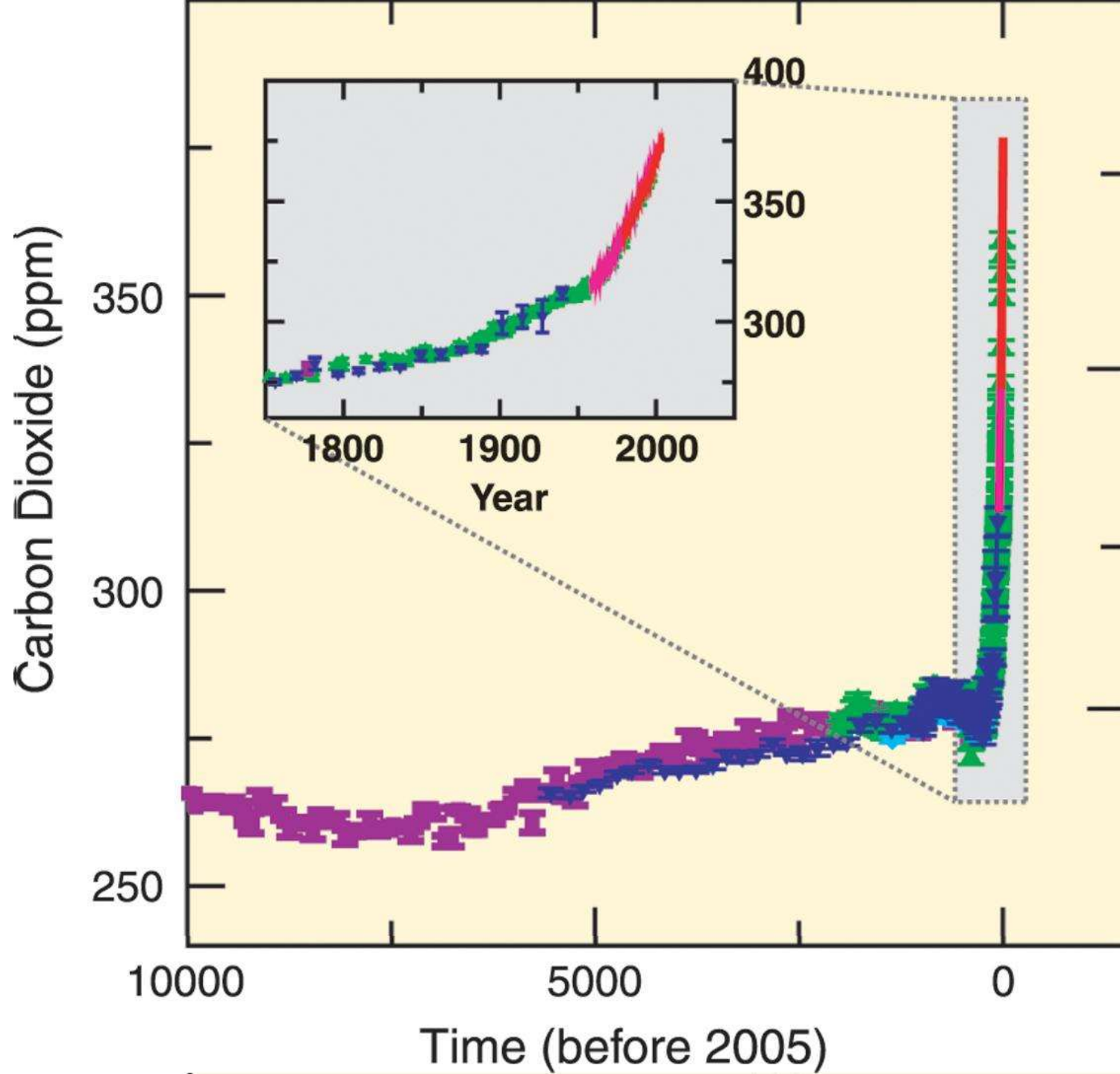
2% A. 292

7% B. 345

18% C. 390

32% ✓ D. 411

42% E. 435



Recent Monthly Average Mauna Loa CO₂

May 2018: 411.25 ppm

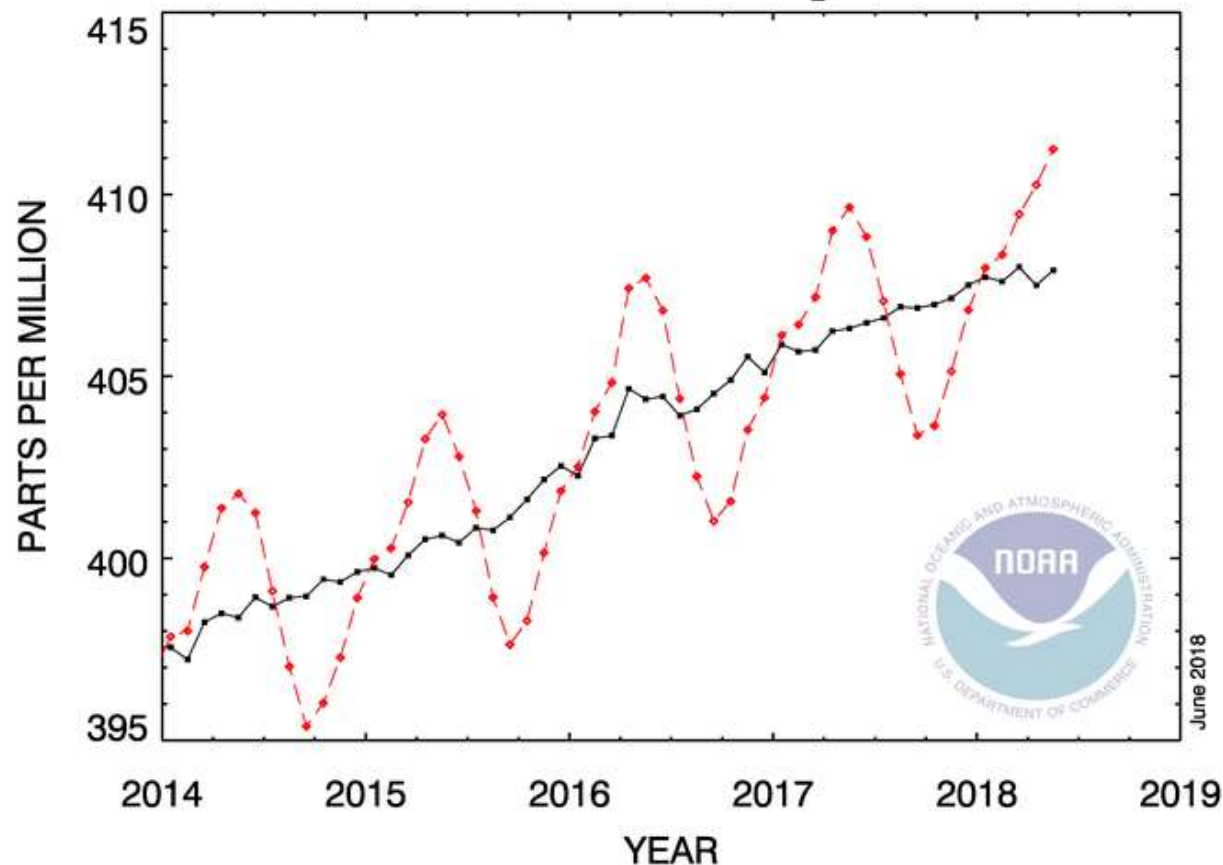
May 2017: 409.65 ppm

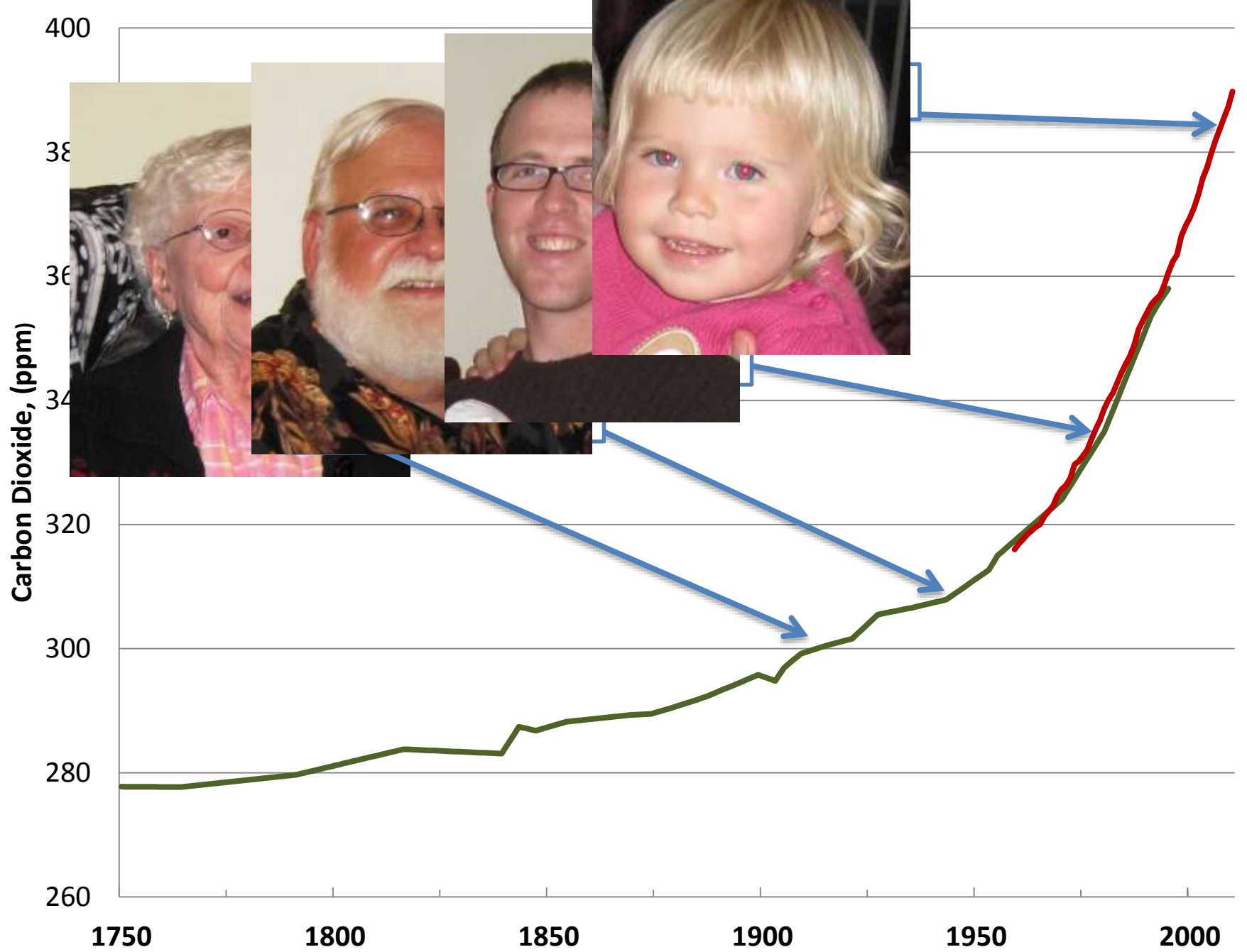
Last updated: June 5, 2018

**New Record
But Broken Recently:**

February 3, 2019: 411.63 ppm

RECENT MONTHLY MEAN CO₂ AT MAUNA LOA





What do you think is the largest source of GHG's in the world?



Greenhouse Gas Emissions by Economic Sectors

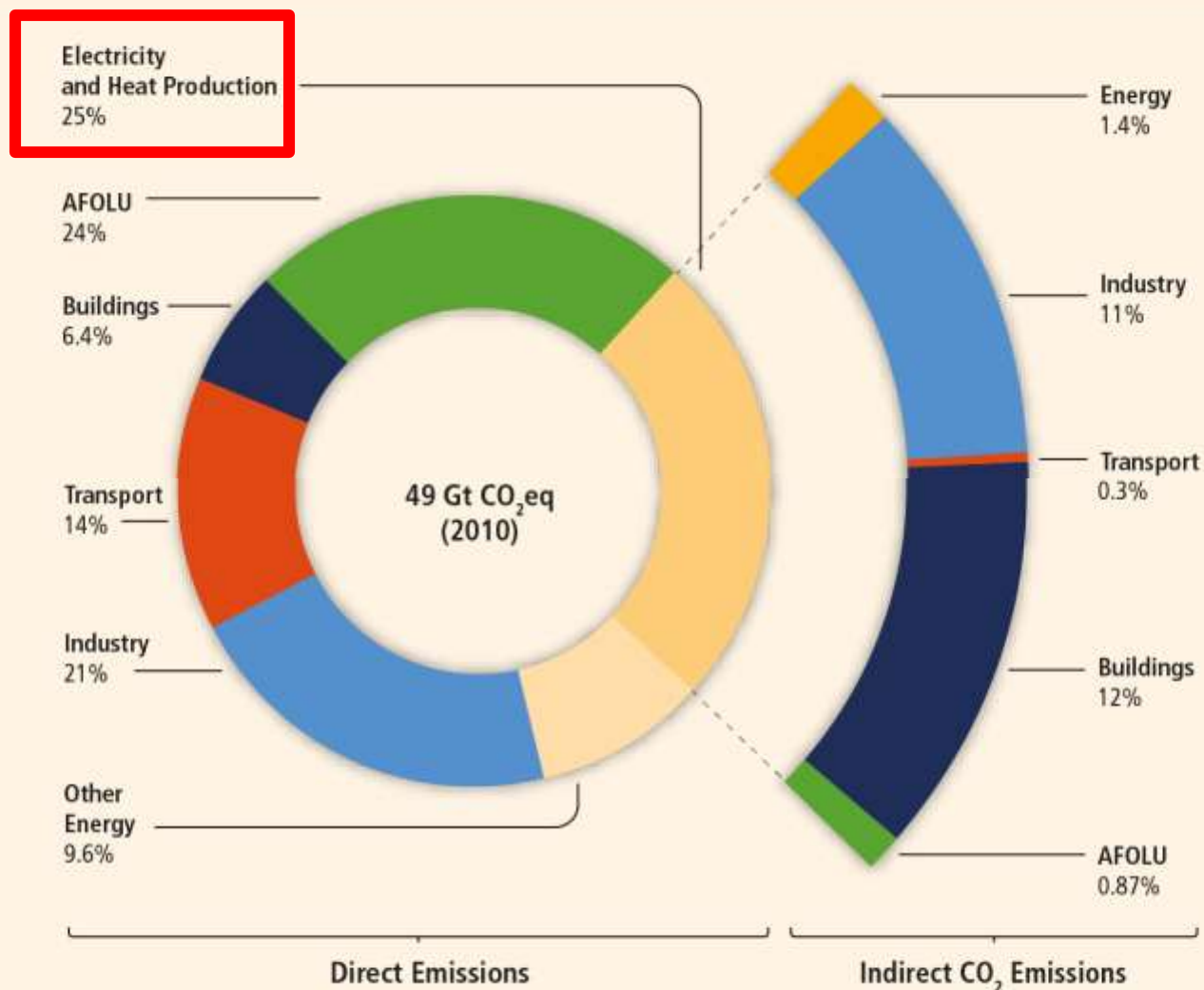
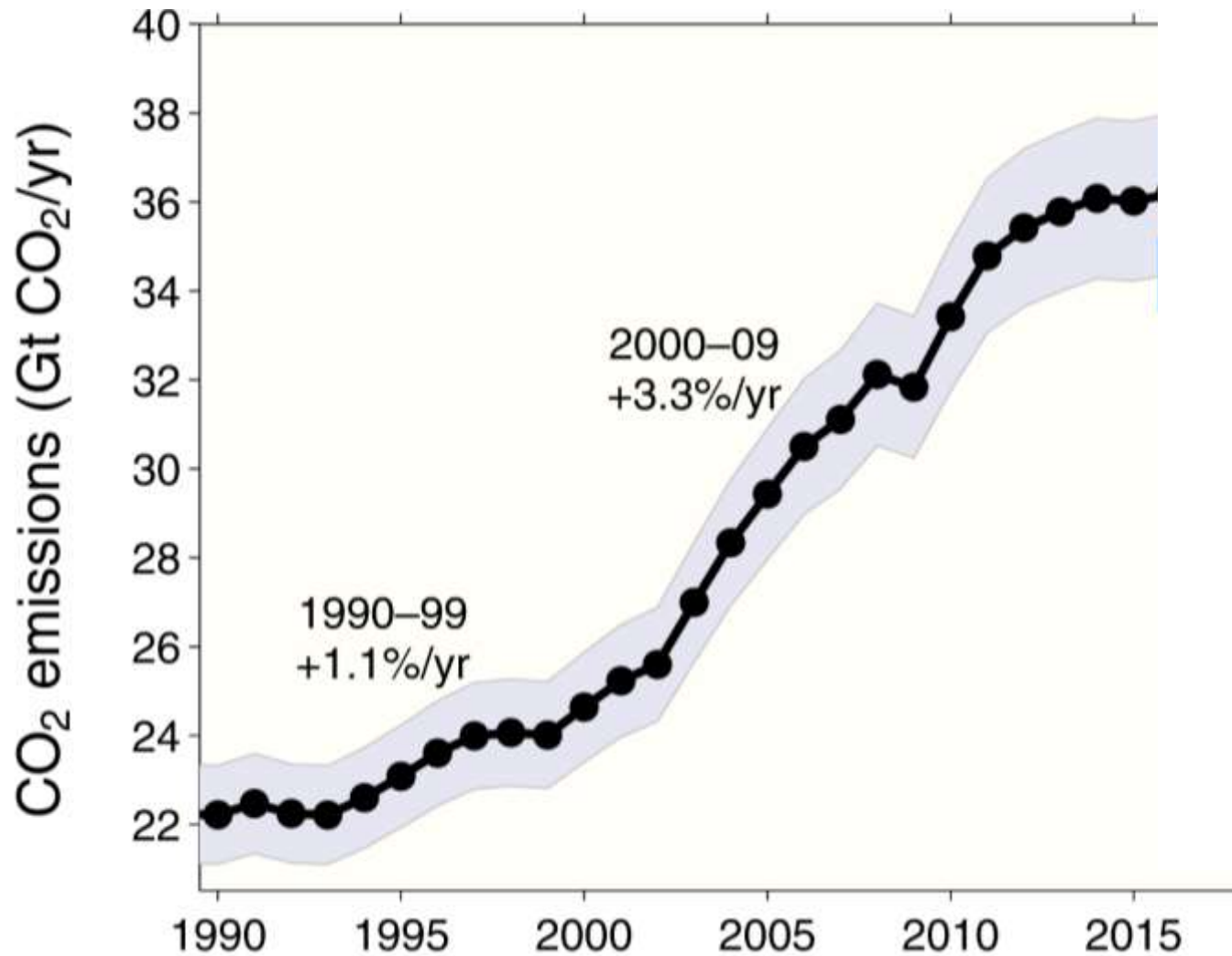
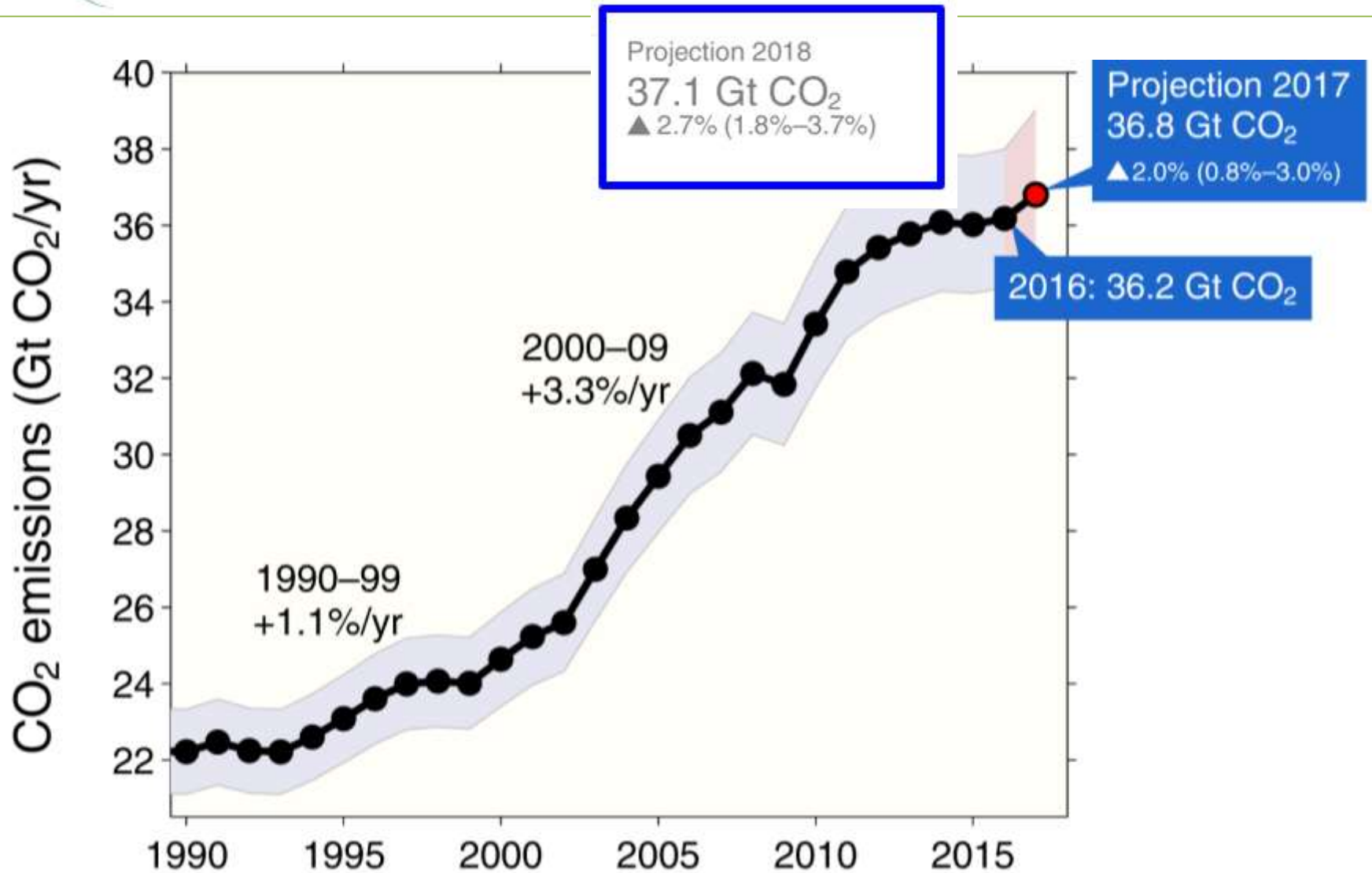


Figure SPM.2. Total anthropogenic GHG emissions (GtCO₂eq/yr) by economic sectors. Inner circle shows direct GHG emission shares (in % of total anthropogenic GHG emissions) of five economic sectors in 2010. Pull-out shows how indirect CO₂ emission shares (in % of total anthropogenic GHG emissions) from electricity and heat production are attributed to sectors of final energy use. “Other Energy” refers to all GHG emission sources in the energy sector as defined in Annex II other than electricity and heat production [A.II.9.1]. The emissions data from Agriculture, Forestry and Other Land Use (AFOLU) includes land-based CO₂ emissions from forest fires, peat fires and peat decay that approximate to net CO₂ flux from the Forestry and Other Land Use (FOLU) sub-sector as described in Chapter 11 of this report. Emissions are converted into CO₂-equivalents based on GWP100 6 from the IPCC Second Assessment Report. Sector definitions are provided in Annex II.9. [Figure 1.3a, Figure TS.3 a/b] [Subject to final quality check and copy edit.]

Emissions from fossil fuel use and industry



Emissions from fossil fuel use and industry



What Country has the Highest Total Emissions?

53% 😊 **A. China**

38% **B. United States**

3%

C. India

0%

D. Germany

5%

E. Saudia Arabia



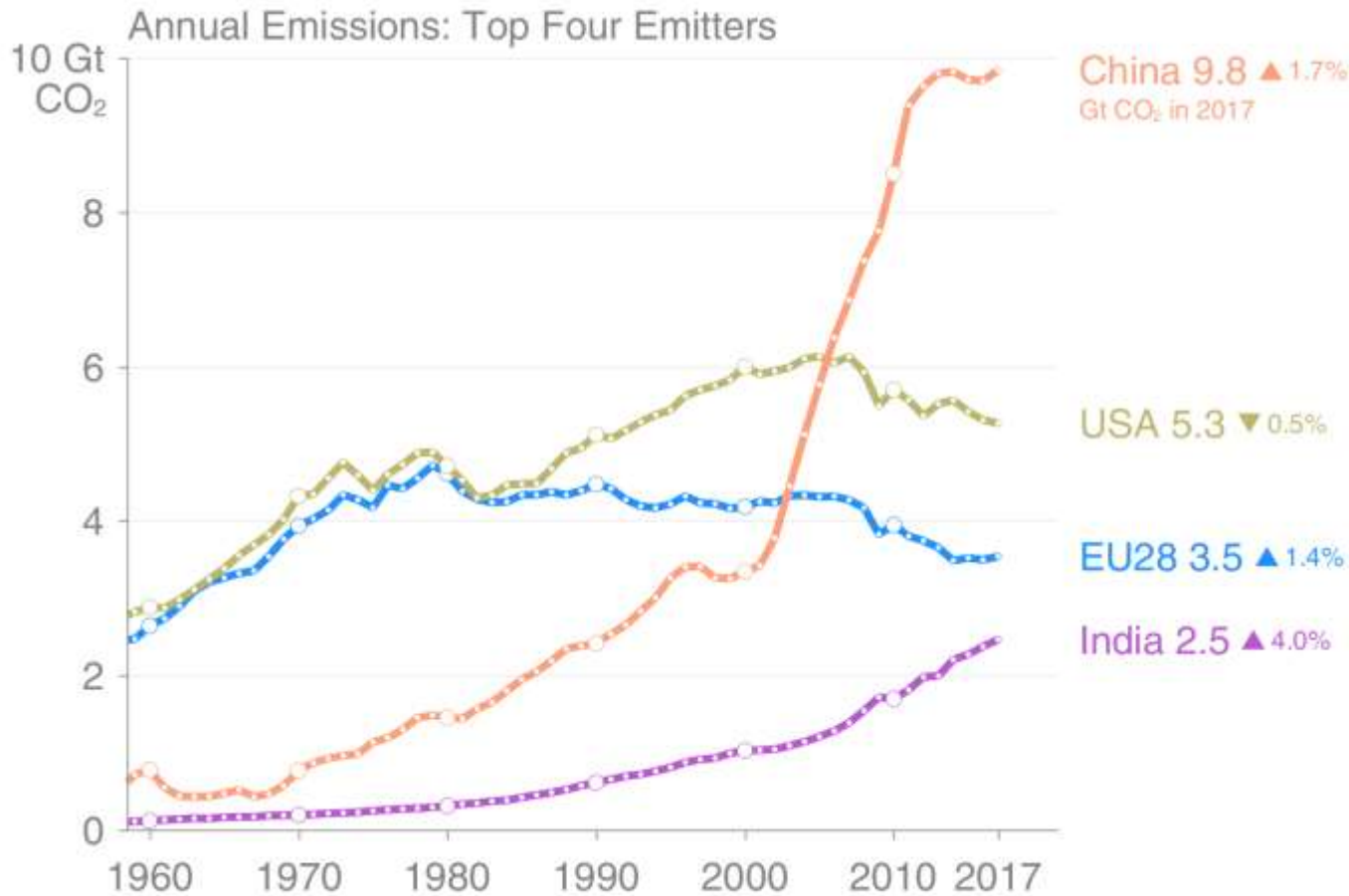
What Country has the Second Highest Total Emissions?

- 0% A. China
- 77% 😊 B. United States
- 16% C. India
- 0% D. Germany
- 6% E. Saudia Arabia



Top emitters: Fossil CO₂ emissions

The top four emitters in 2017 covered 58% of global emissions
China (27%), United States (15%), EU28 (10%), India (7%)



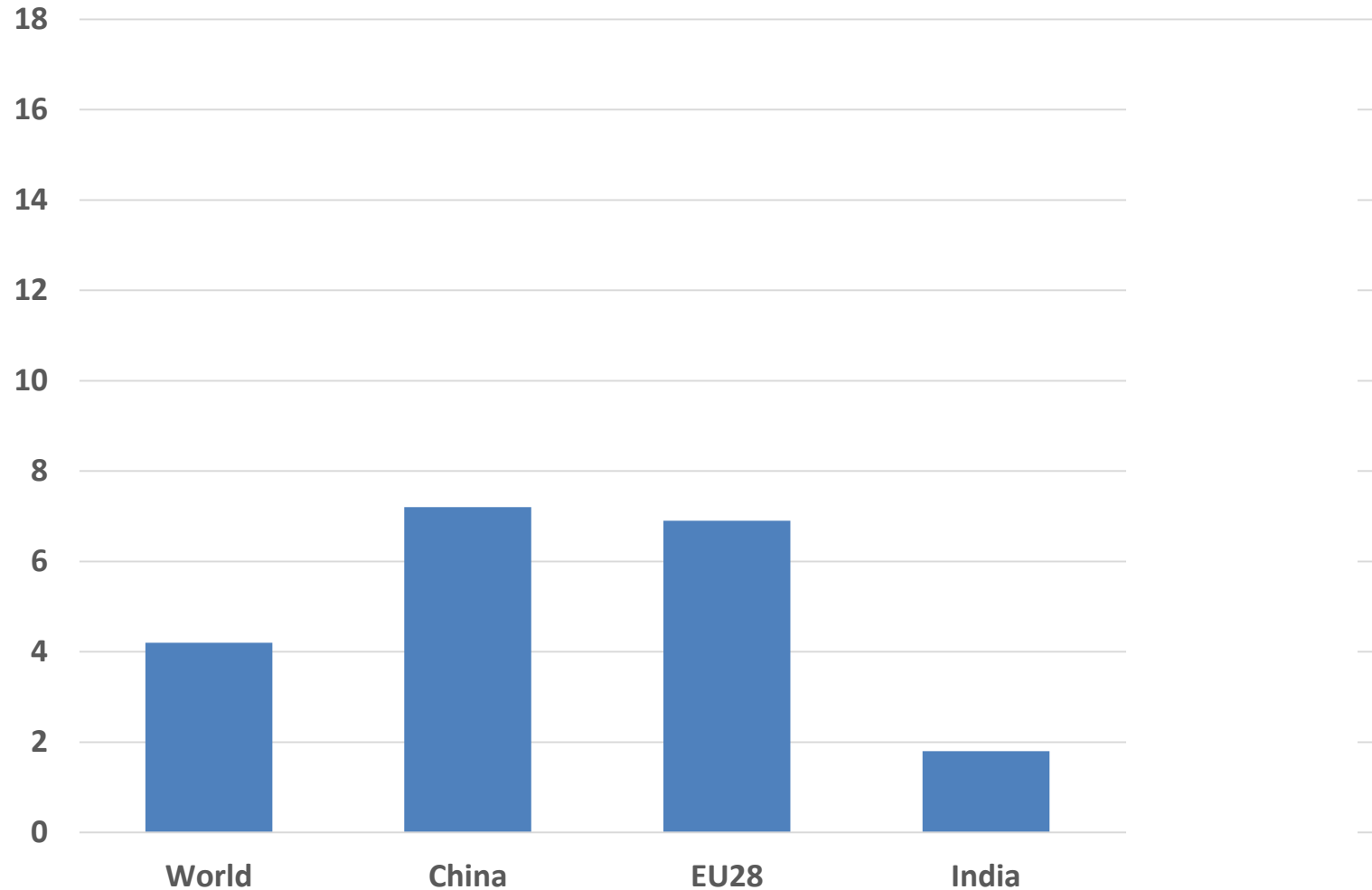
Bunker fuels, used for international transport, are 3.2% of global emissions.

Statistical differences between the global estimates and sum of national totals are 0.7% of global emissions.

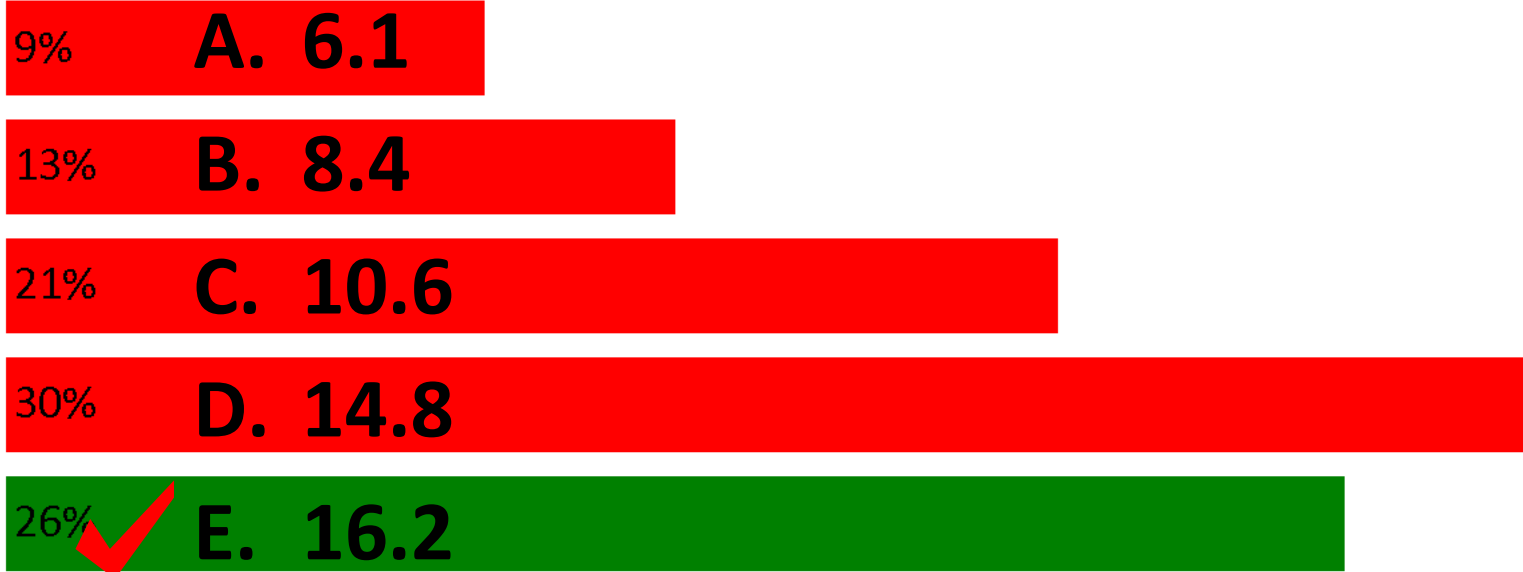
Source: [CDIAC](#); [Le Quéré et al 2018](#); [Global Carbon Budget 2018](#)

Tons CO₂/Person

2016

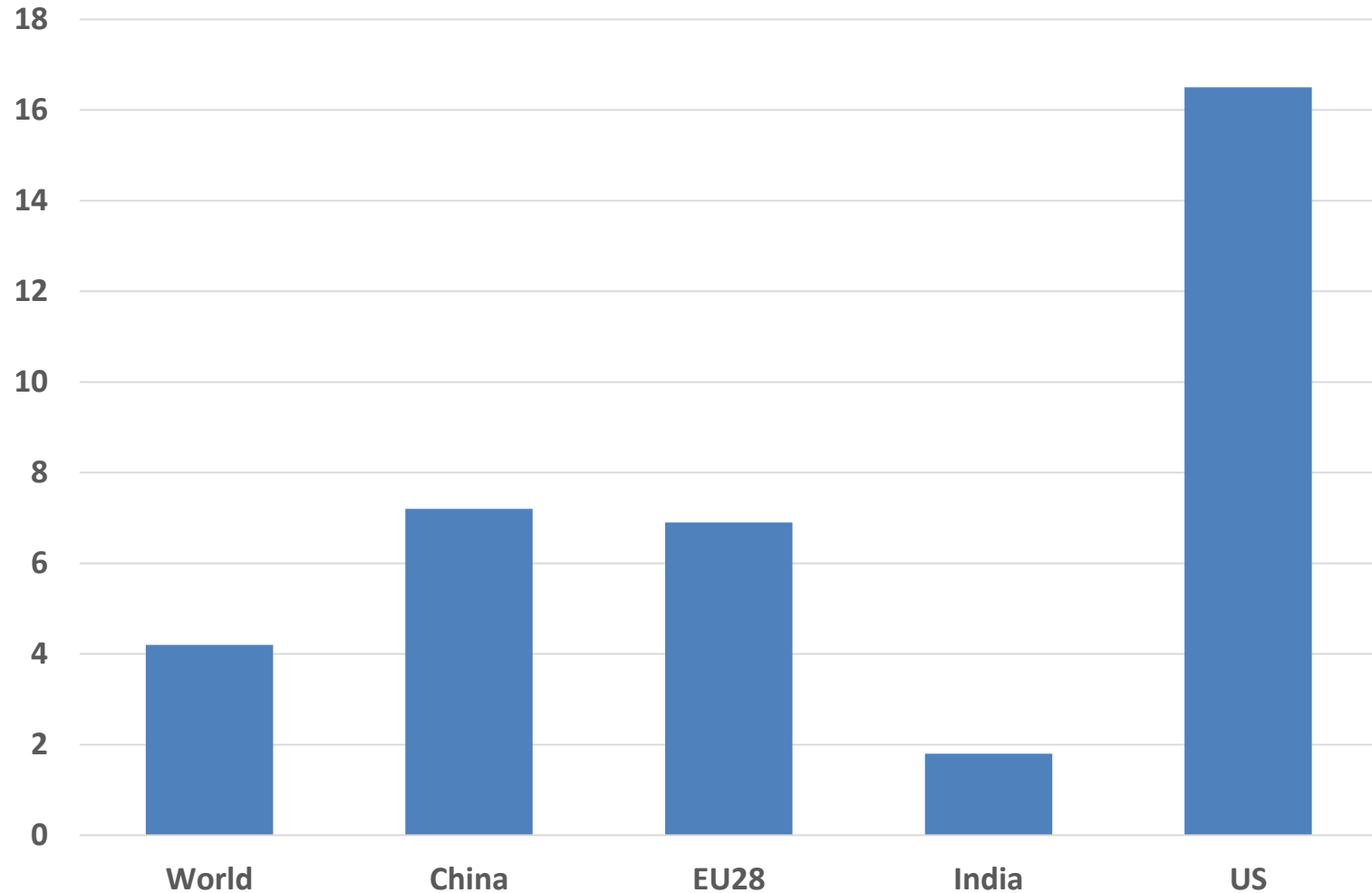


What do you think was the average emission level for the US?



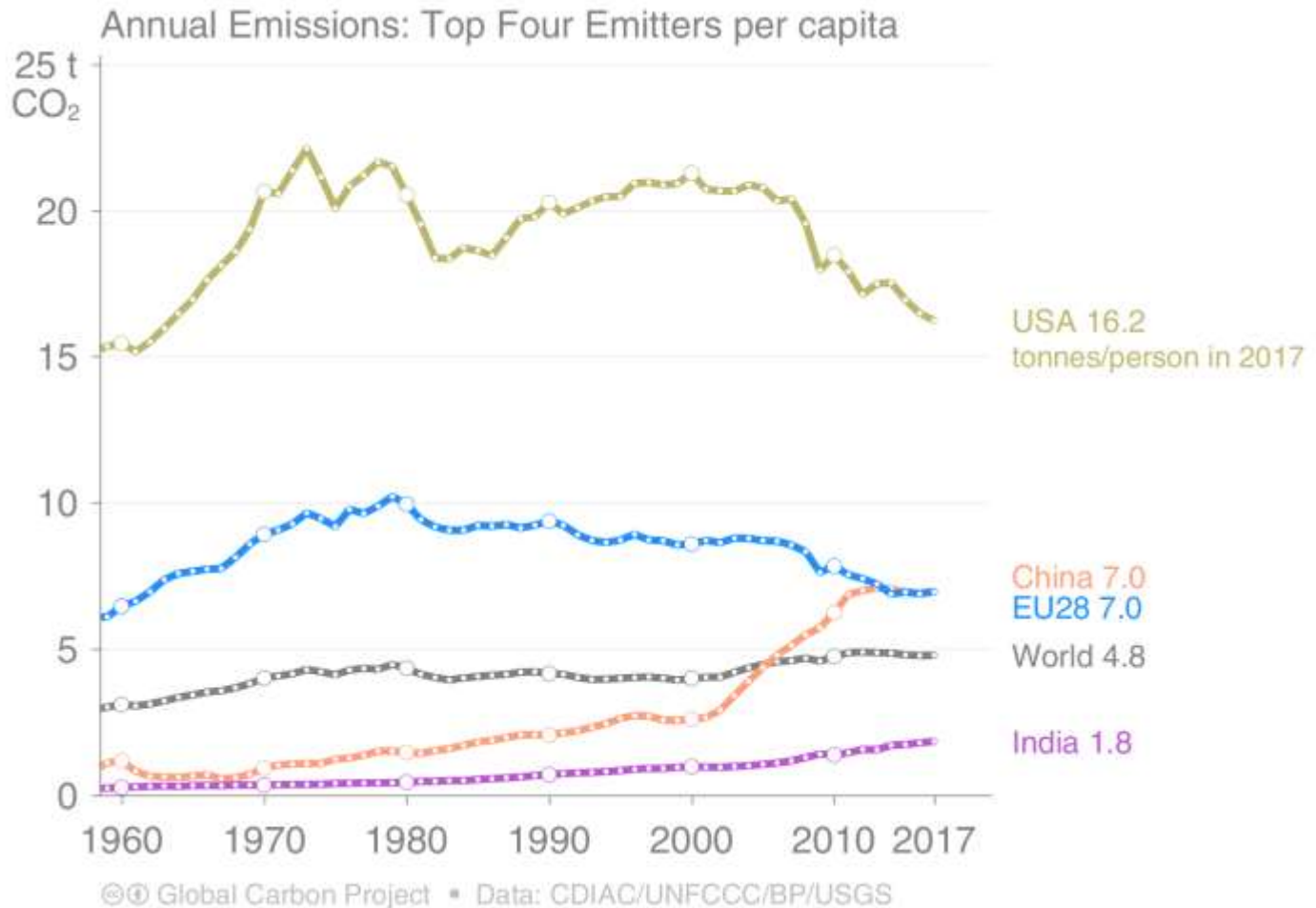
Tons CO₂/Person

2016



Top emitters: Fossil CO₂ Emissions per capita

Countries have a broad range of per capita emissions reflecting their national circumstances

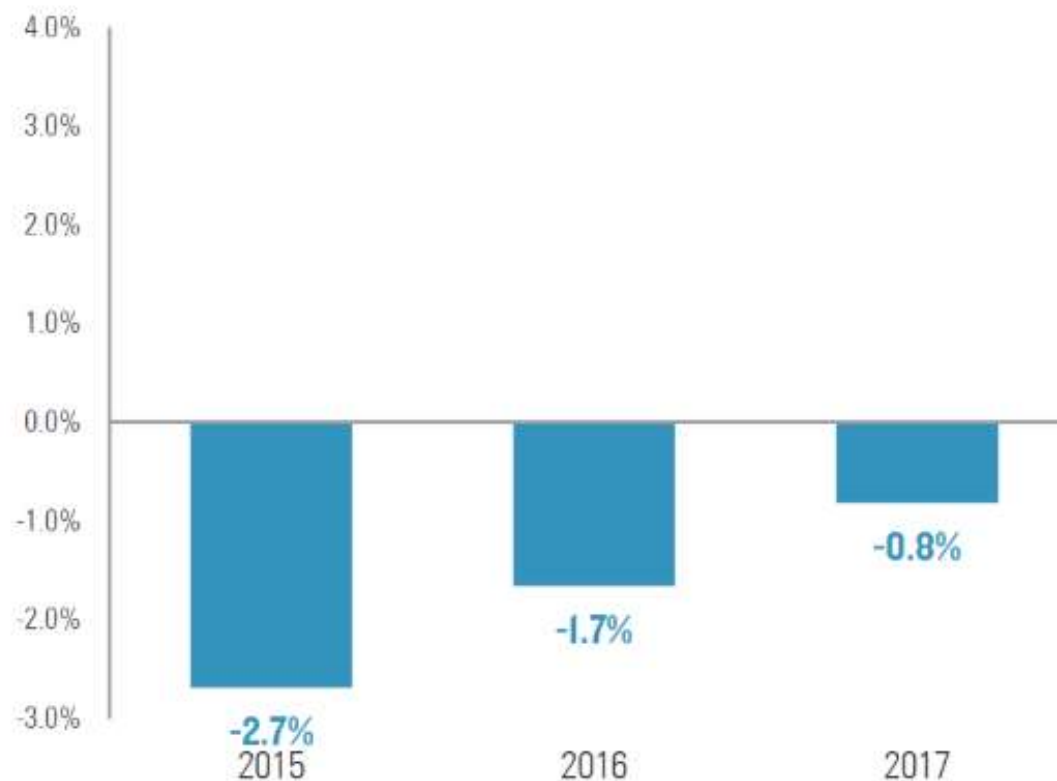


Source: [CDIAC](#); [Le Quéré et al 2018](#); [Global Carbon Budget 2018](#)

US Summary in Recent Years

Figure 1: Annual change in US CO₂ emissions

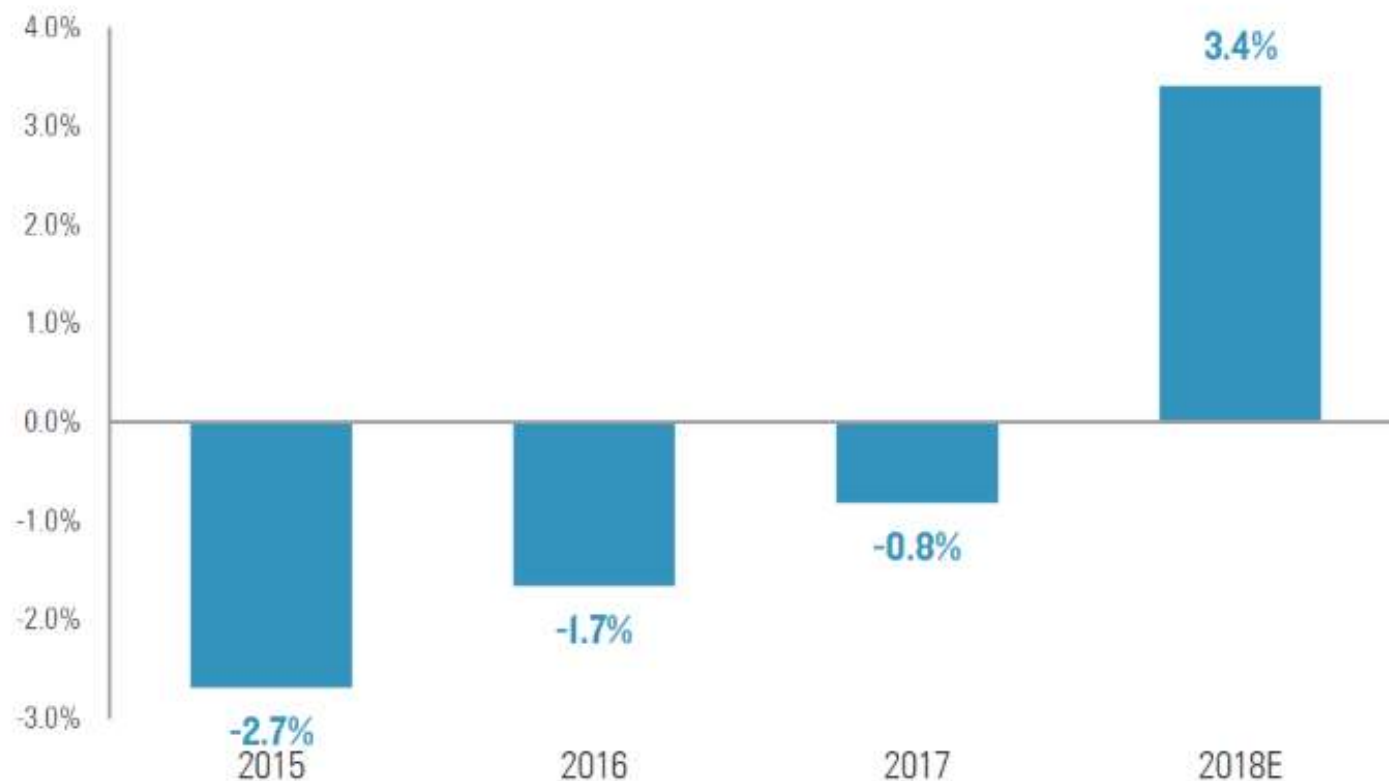
Energy combustion only



Source: Rhodium US Climate Service, based on data from the EIA, Bloomberg and Genscape

US Summary in Recent Years

Figure 1: Annual change in US CO₂ emissions
Energy combustion only



Source: Rhodium US Climate Service, based on data from the EIA, Bloomberg and Genscape

U.S. Carbon Emissions Surged in 2018 Even as Coal Plants Closed



Passenger planes at the Phoenix airport in July. Greenhouse gas emissions from airplanes and trucking increased sharply in 2018. Angus Mordant/Bloomberg



By Brad Plumer

Jan. 8, 2019



Want climate news in your inbox? [Sign up here for **Climate Fwd**](#), our email newsletter.

WASHINGTON — America's carbon dioxide emissions rose by 3.4 percent in 2018, the biggest increase in eight years, according to [a preliminary estimate published Tuesday](#).

The US population is 4.4% of the world. What percent of major emissions since 1870 came from the US?

4%

A. 2.2%

6%

B. 4.4%

6%

C. 6.6%

33%

D. 13%

52%

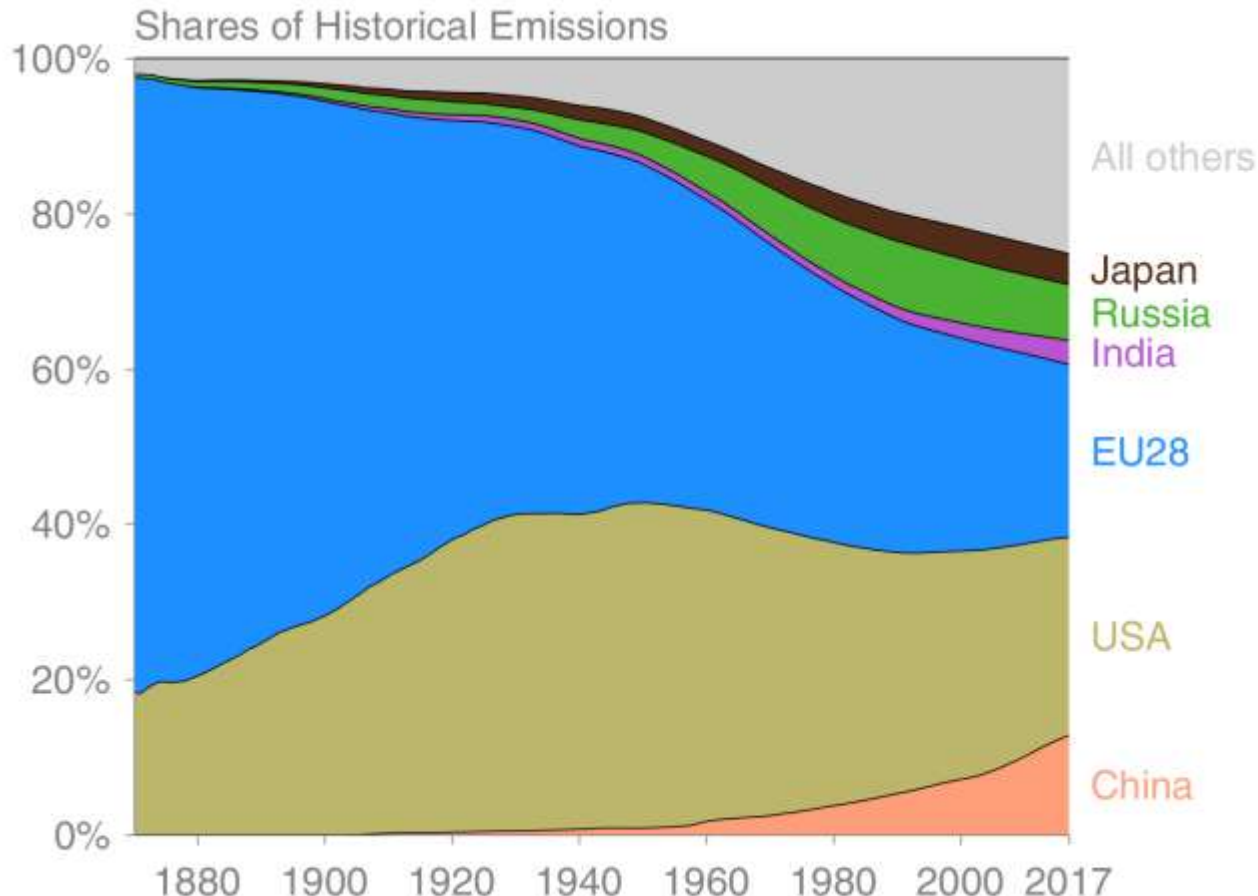


E. 25%



Historical cumulative fossil CO₂ emissions by country

Cumulative fossil CO₂ emissions were distributed (1870–2017):
 USA 25% EU28 22% China 13%, Russia 7%, Japan 4% and India 3%



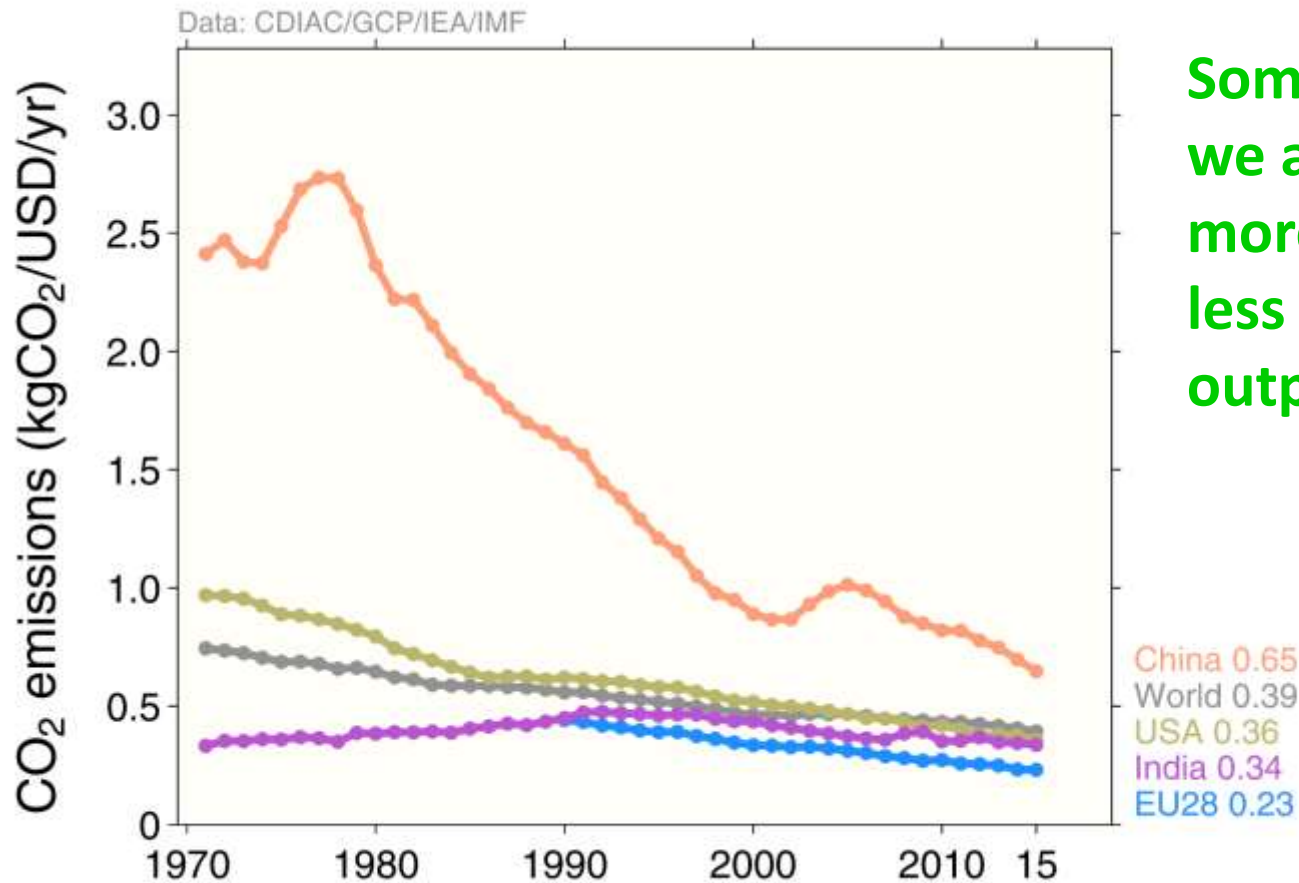
Cumulative emissions (1990–2017) were distributed China 20%, USA 20%, EU28 14%, Russia 6%, India 5%, Japan 4%

'All others' includes all other countries along with bunker fuels and statistical differences

Source: [CDIAC](#); [Le Quéré et al 2018](#); [Global Carbon Budget 2018](#)

Top emitters: fossil fuels and industry (per dollar)

Emissions per unit economic output (emissions intensities) generally decline over time
China's intensity is declining rapidly, but is still much higher than the world average



**Some Good News:
we are getting
more efficient –
less emissions per
output.**

Fate of anthropogenic CO₂ emissions (2006-2015)



34.1 GtCO₂/yr
91%



9%
3.5 GtCO₂/yr

Sources = Sinks

16.4 GtCO₂/yr
44%



31%
11.6 GtCO₂/yr



26%
9.7 GtCO₂/yr



Non-symmetric Impact of Climate Change



Bangladesh: 166 million people

Google Map

>10 million people in danger of being displaced by rising seas.

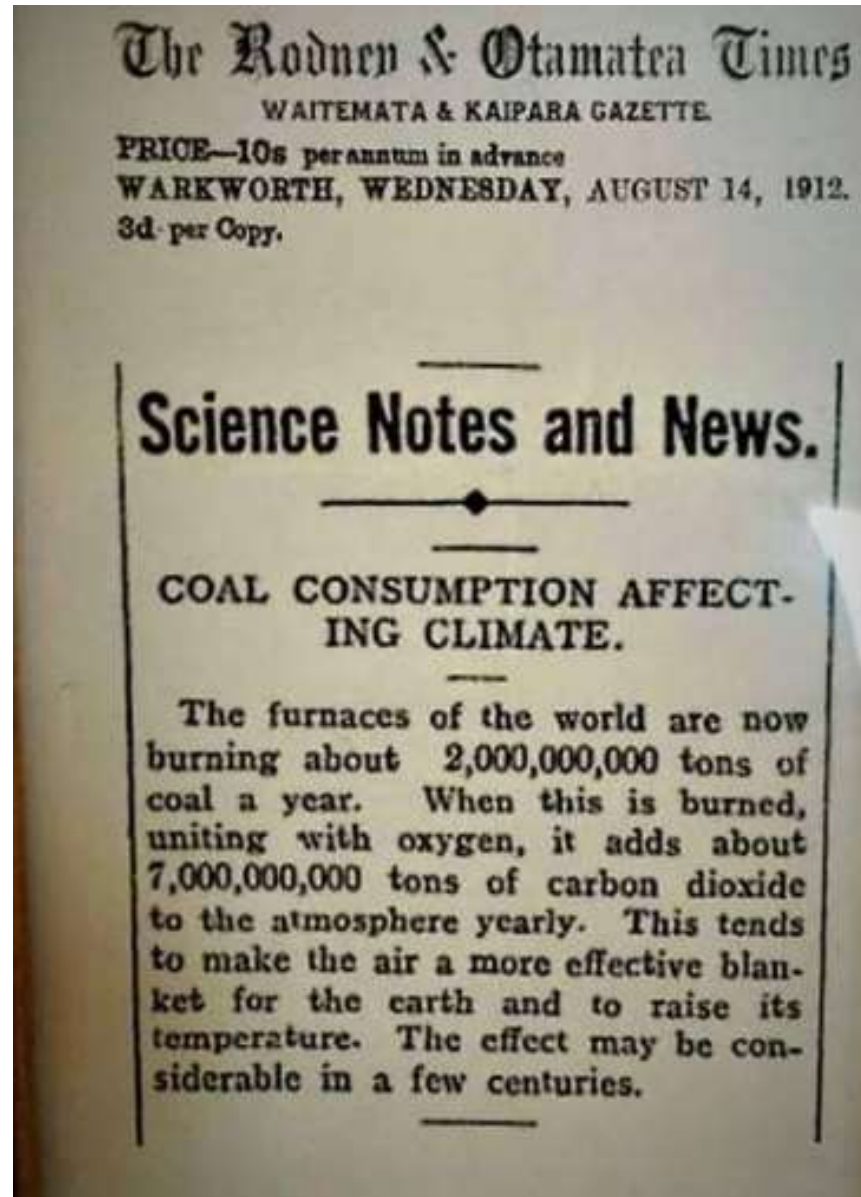
In summer of 2017, half the country was flooded.

Their emissions are less than 0.5 tons per person.

So what? It has been warmer before, so why should we be concerned?

- The population of the world was not 7.3 billion
 - Millions live in low-lying areas near the ocean
- Agriculture & animal cycles have developed with this climate
 - Example – Many Pine Bark Beetles are surviving the winter
- The present change is very rapid

A Prediction from 100 Years Ago



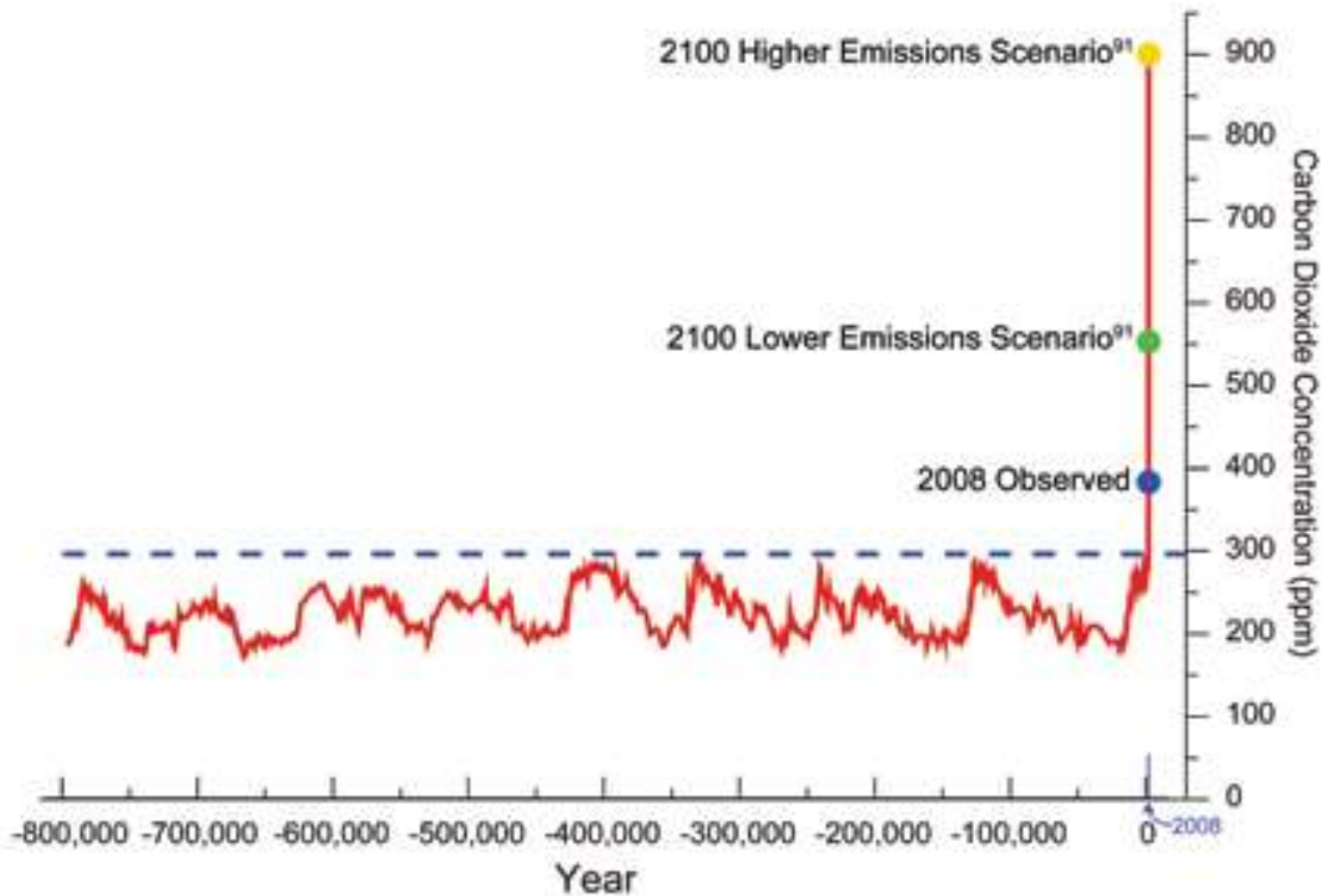
Facts About Climate Change In Past 100+ Years

- The average temperature of the earth has increased, with **2016 highest directly measured**
- CO₂ concentrations have **increased by >40%**
- Sea level has increased, though modestly (**<1 ft**)
 - **But the rate of increase is 3x historical rate**
- Glaciers, Greenland, Arctic and Antarctic ice have generally decreased in volume

Now we consider projections.

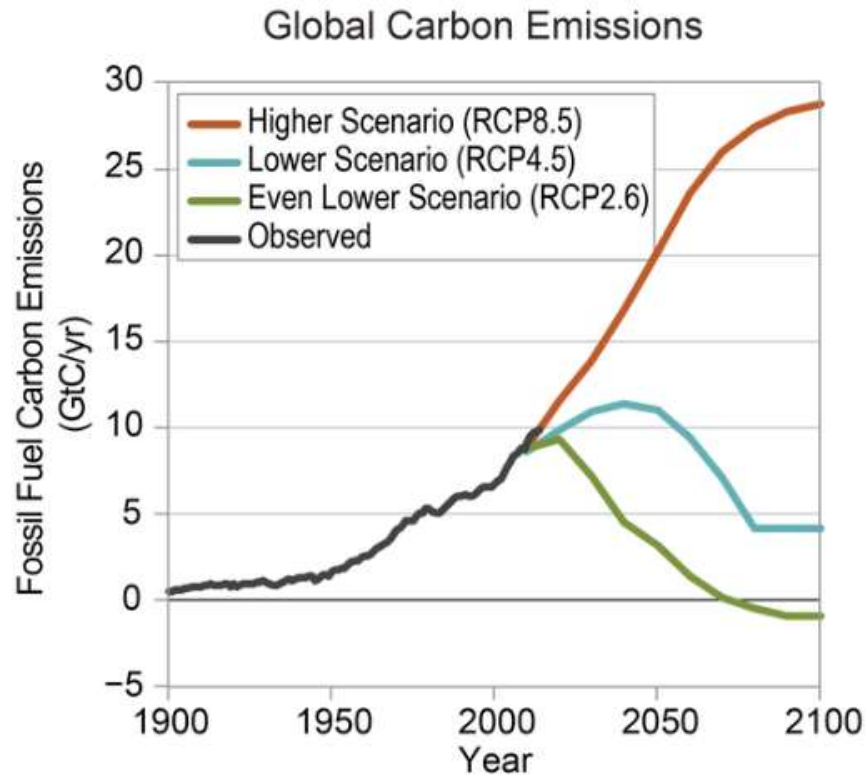
**What are the projections for CO₂
concentrations in 2100?**

800,000 Year Record of CO₂ Concentration



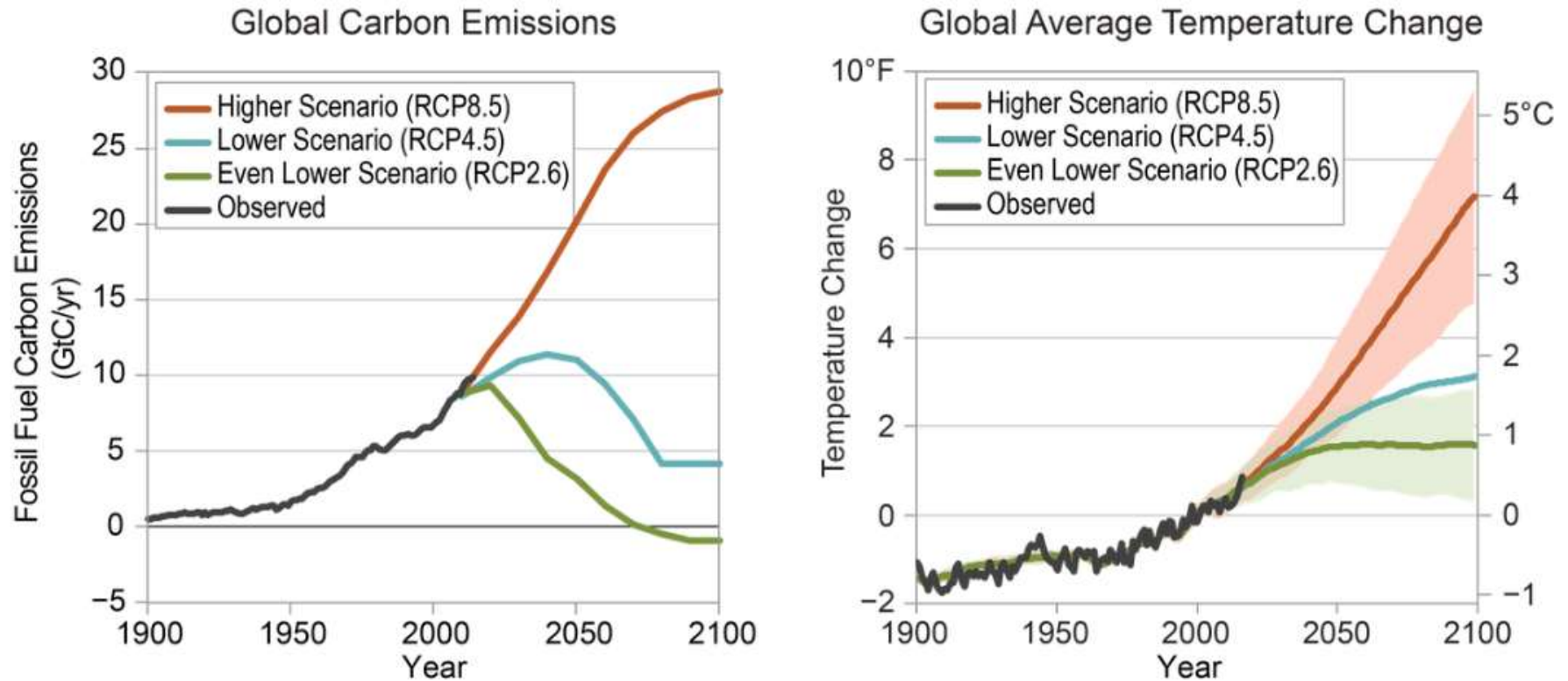
Consider the Future

Figure 2.2: Observed and Projected Changes in Carbon Emissions and Temperature



Consider the Future

Figure 2.2: Observed and Projected Changes in Carbon Emissions and Temperature



Updates from the UN's IPCC in October, 2018:

Highlights

- To prevent 1.5°C (2.7°F) need to reduce greenhouse gases by **45% from 2010 by 2030 & 100% by 2050**
- **Need to put a high price on carbon emissions**
- Damage at 2°C (3.6°F) projected at **\$69 trillion**
 - **Residents of the Tropics would leave ignoring country borders and becoming climate refugees**

What do we do about this problem?

Mitigation Strategies

Term refers to **reducing** the problem.

Reducing CO₂ and other GHG Emissions by

- Improved efficiency: homes, cars, manufacturing
- Changing to alternate fuels or nuclear fuel
- Reducing destruction of plants and trees
- Replacing coal with natural gas gives 50% more energy per unit of carbon dioxide
- **Personal actions....**

Amount of CO₂ Produced in 1 Hour



How many aluminum cans can be recycled for the same amount of energy as one new can?



Recycling Aluminum Cans

Producing each new aluminum can generates 25 gallons of CO₂



Which of these foods produces the most greenhouse gases per pound to get to your table?

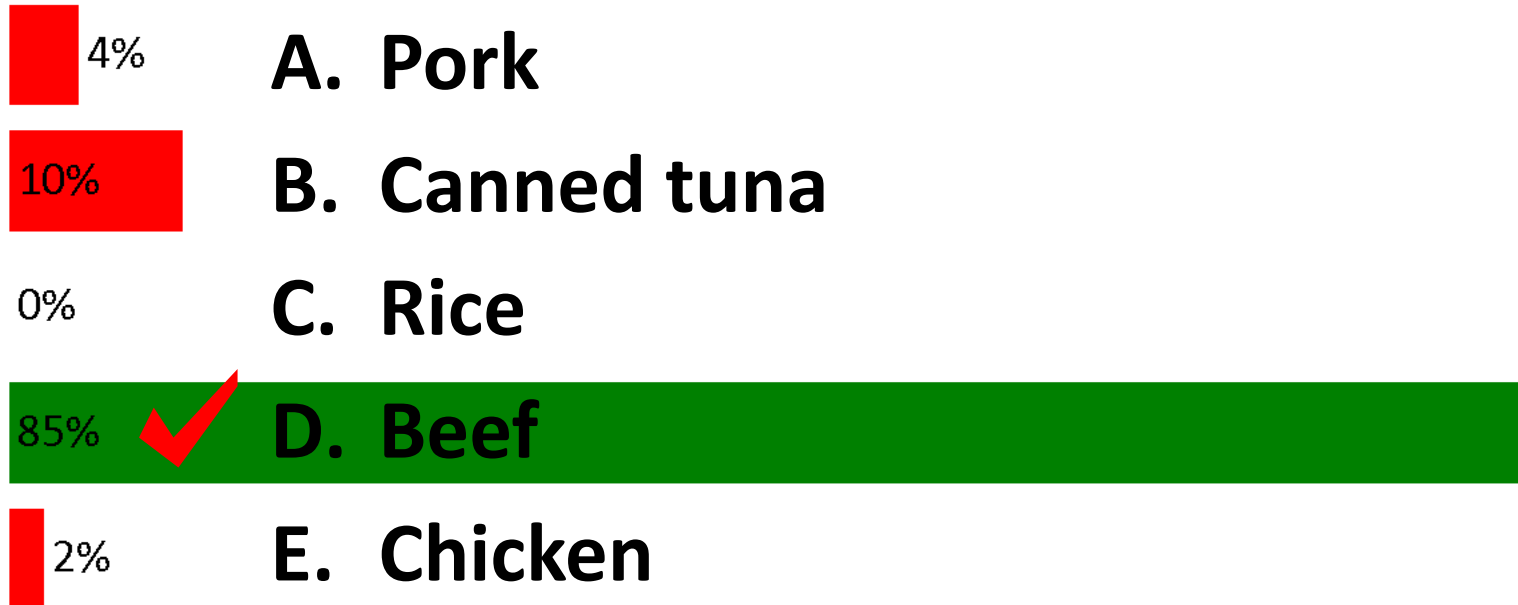
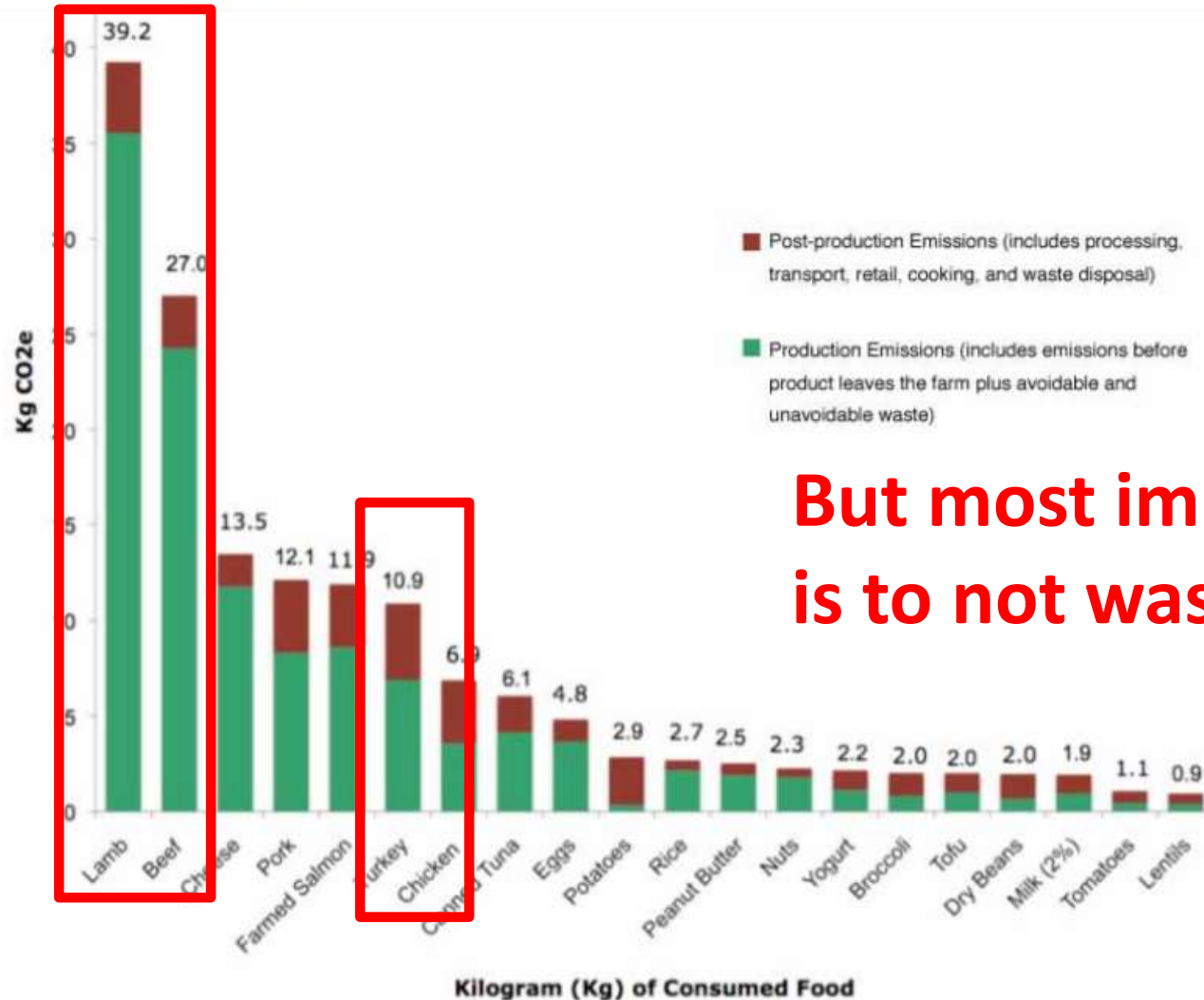


Figure 1. Full Lifecycle Assessment of Greenhouse Gas Emissions: Most Emissions from Common Proteins and Vegetables Occur During Production



**But most important
is to not waste food!**

*These include production emissions from avoidable (plate waste, spoilage) and unavoidable waste (fat and moisture loss during cooking)

Reduce



Gasoline Prices Do Not Encourage Conservation.



- **Gasoline Tax:**
 - Federal: 18.4 cents/gallon
 - Unchanged for 25 years
 - Ohio: 28.01 cents/gallon
 - Will go up by 10.5 cents, diesel by 19 cents in July

Recent Trip East Coast



Recent Trip East Coast



Change your



Use Renewable Energy - Wind



By © Hans Hillewaert, CC BY-SA 4.0,
<https://commons.wikimedia.org/w/index.php?curid=6361901>

Local News onSolar

ENERGY

First Solar breaks ground on \$400 million plant in Wood County



By [Mark Rosenberg](#) | BLADE STAFF WRITER

Published on June 8, 2018 | Updated 12:52 a. m.

An empty expanse of dirt off State Rt. 795 in Wood County will soon be home to part of the largest solar factory, by capacity, in the Western Hemisphere.

Tempe, Ariz.-based First Solar broke ground Friday morning on a \$400-million, 1-million-square-foot plant in Lake Township, which will produce its new Series 6 thin-film solar panels. The plant, [which is set to reach full capacity in late 2019](#), will bring **500 jobs** to the region, compensating for the 350 jobs First Solar cut to upgrade its Perrysburg Township plant, located less than two miles away, from Series 4 to Series 6 panel production last year.



<http://www.firstsolar.com/en/PV-Plants/Utility-Scale>

<http://www.toledoblade.com/Energy/2018/06/08/First-Solar-breaks-ground-on-400-million-plant-in-Wood-County.html>

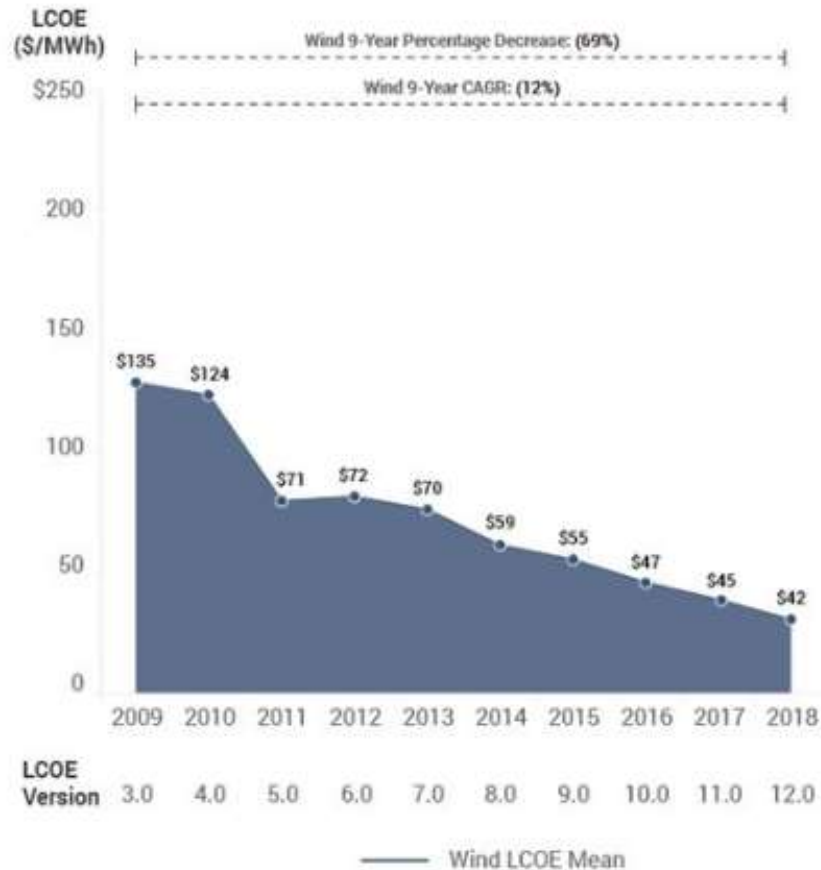
Levelized Cost of Energy and Levelized Cost of Storage 2018

NOV 8 2018

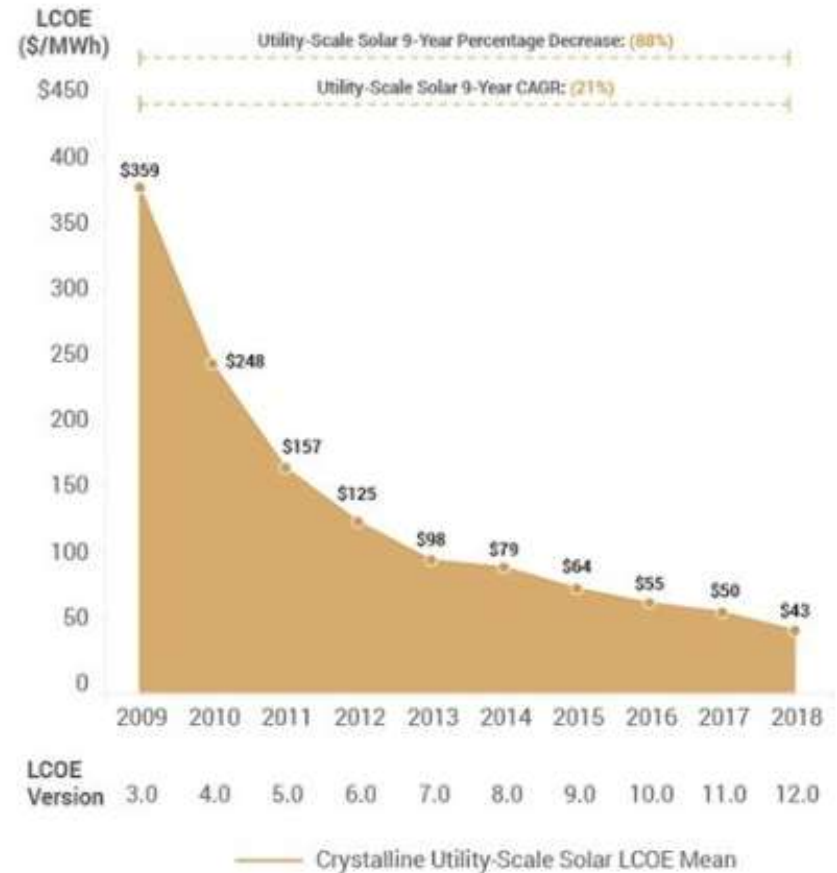
“Lazard’s latest annual Levelized Cost of Energy Analysis (LCOE 12.0) shows a continued decline in the cost of generating electricity from alternative energy technologies, especially utility-scale solar and wind. In some scenarios, alternative energy costs have decreased to the point that they are now at or below the marginal cost of conventional generation.”

From the Lazard Study in November, 2018

Unsubsidized Wind LCOE

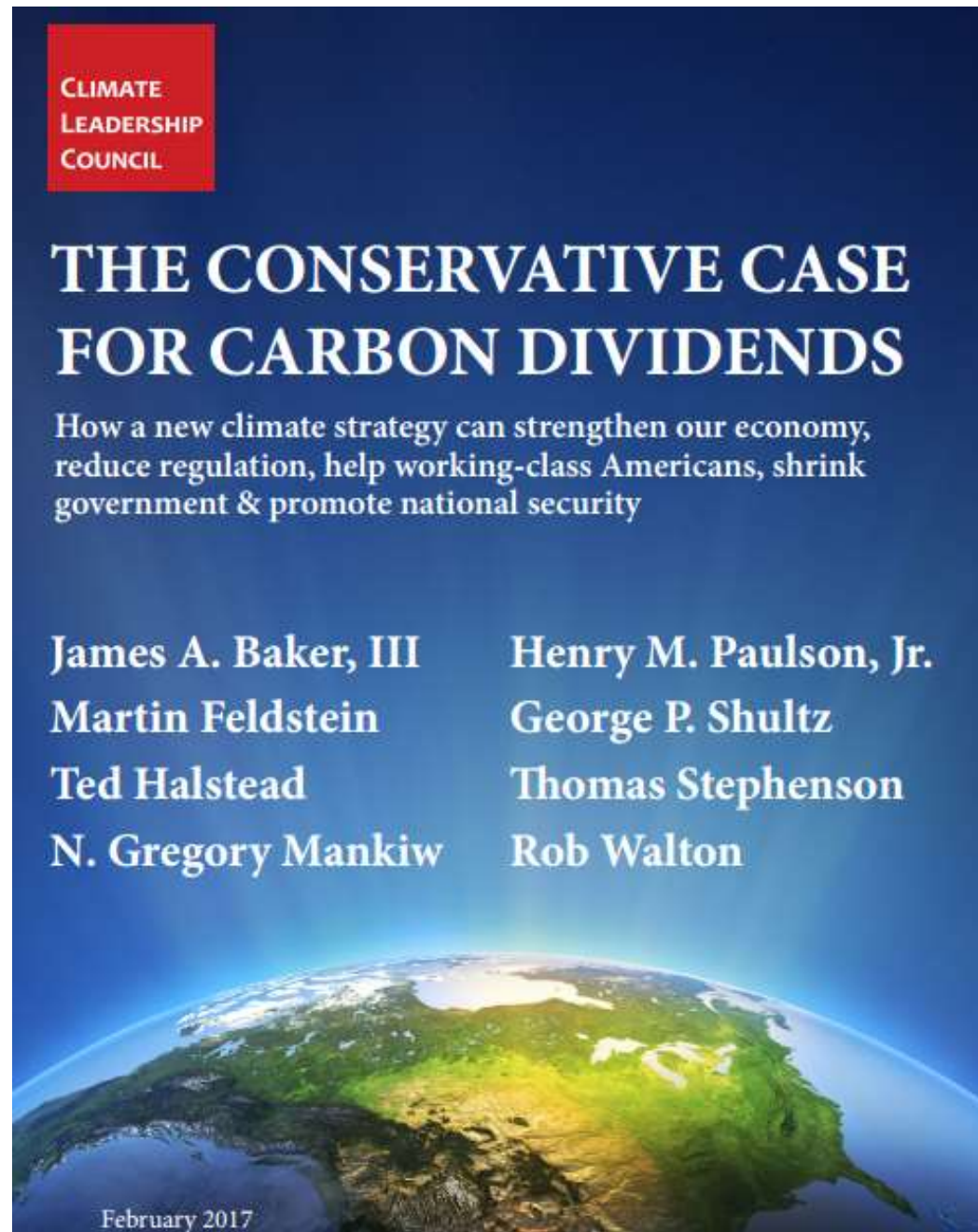


Unsubsidized Solar PV LCOE



THE AVERAGE COST OF ELECTRICITY FROM WIND AND SOLAR PLANTS ALL OVER THEIR LIFETIME -- THE LCOE -- HAS CONTINUED TO DROP SHARPLY IN RECENT YEARS. CREDIT: LAZARD.

Proposal for a Carbon Tax from GOP Leaders



<https://www.clcouncil.org/wp-content/uploads/2017/02/TheConservativeCaseforCarbonDividends.pdf>

THE FOUR PILLARS OF A CARBON DIVIDENDS PLAN

1. A GRADUALLY INCREASING CARBON TAX

The first pillar of a carbon dividends plan is a gradually increasing tax on carbon dioxide emissions, to be implemented at the refinery or the first point where fossil fuels enter the economy, meaning the mine, well or port. Economists are nearly unanimous in their belief that a carbon tax is the most efficient and effective way to reduce carbon emissions. A sensible carbon tax might begin at \$40 a ton and increase steadily over time, sending a powerful signal to businesses and consumers, while generating revenue to reward Americans for decreasing their collective carbon footprint.

2. CARBON DIVIDENDS FOR ALL AMERICANS

All the proceeds from this carbon tax would be returned to the American people on an equal and quarterly basis via dividend checks, direct deposits or contributions to their individual retirement accounts. In the example above, a family of four would receive approximately \$2,000 in carbon dividend payments in the first year. This amount would grow over time as the carbon tax rate increases, creating a positive feedback loop: the more the climate is protected, the greater the individual dividend payments to all Americans. The Social Security Administration should administer this program, with eligibility for dividends based on a valid social security number.

3. BORDER CARBON ADJUSTMENTS

Border adjustments for the carbon content of both imports and exports would protect American competitiveness and punish free-riding by other nations, encouraging them to adopt carbon pricing of their own. Exports to countries without comparable carbon pricing systems would receive rebates for carbon taxes paid, while imports from such countries would face fees on the carbon content of their products. Proceeds from such fees would benefit the American people in the form of larger carbon dividends. Other trade remedies could also be used to encourage our trading partners to adopt comparable carbon pricing.

4. SIGNIFICANT REGULATORY ROLLEBACK

The final pillar is the elimination of regulations that are no longer necessary upon the enactment of a rising carbon tax whose longevity is secured by the popularity of dividends. Much of the EPA's regulatory authority over carbon dioxide emissions would be phased out, including an outright repeal of the Clean Power Plan. Robust carbon taxes would also make possible an end to federal and state tort liability for emitters. To build and sustain a bipartisan consensus for a regulatory rollback of this magnitude, the initial carbon tax rate should be set to exceed the emissions reductions of current regulations.

2018 Nobel in Economics Is Awarded to William Nordhaus and Paul Romer



William D. Nordhaus and Paul M. Romer were announced as the winners of the 2018 Nobel Prize in economics at a news conference in Stockholm. Pool photo by Henrik Montgomery.

By Binyamin Appelbaum

Oct. 8, 2018



WASHINGTON — The Yale economist William D. Nordhaus has spent the better part of four decades trying to persuade governments to address climate change, preferably by imposing a tax on carbon emissions.

Best Possible First Step....

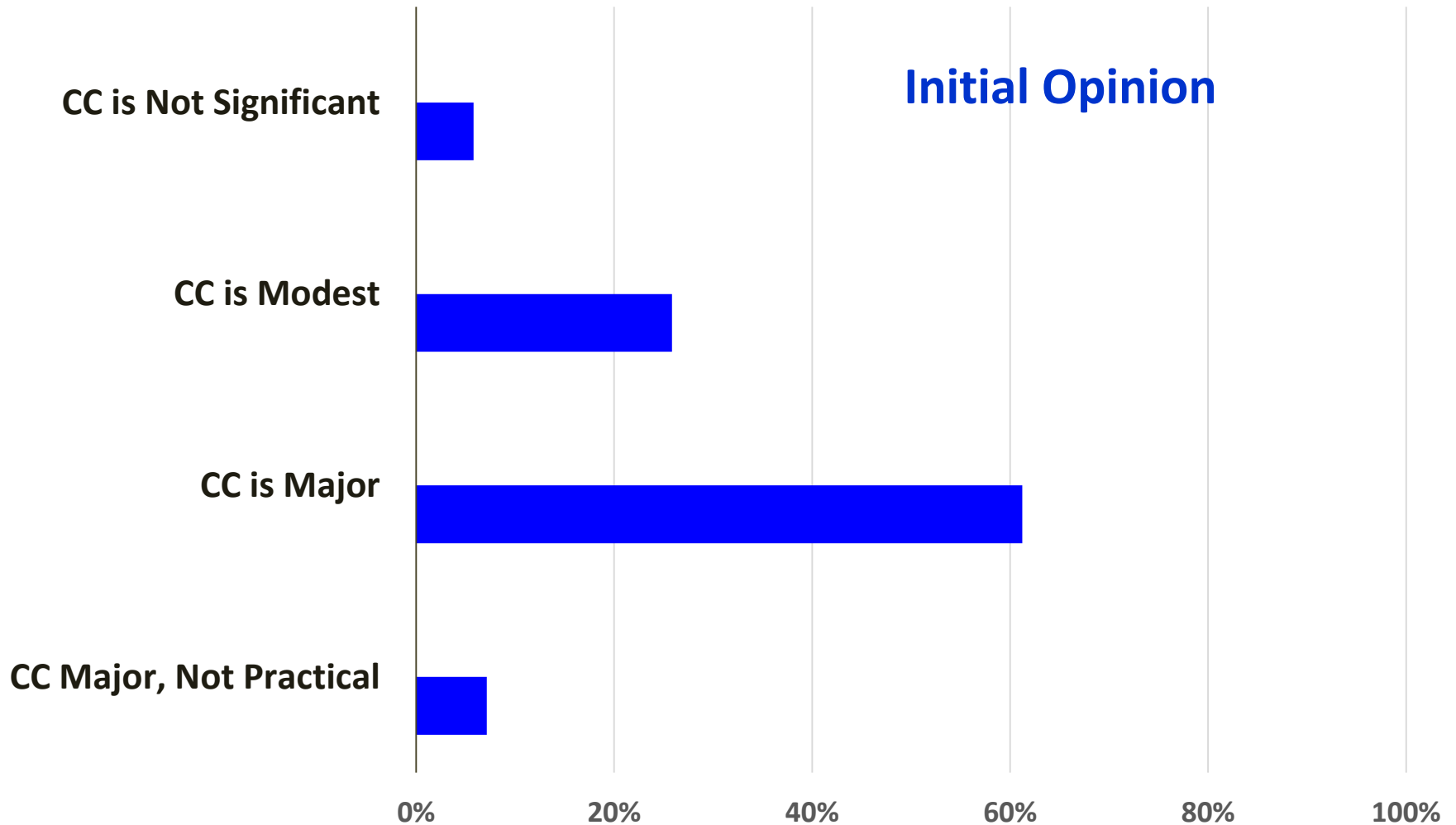
Don't Waste!!!!

Which statement best represents your opinion?

- 0% A. Climate change is not a significant issue
- 2% B. Climate change is a modest-level issue
- 94% C. Climate change is a major issue
- 4% D. Climate change is major, but it is not practical to address

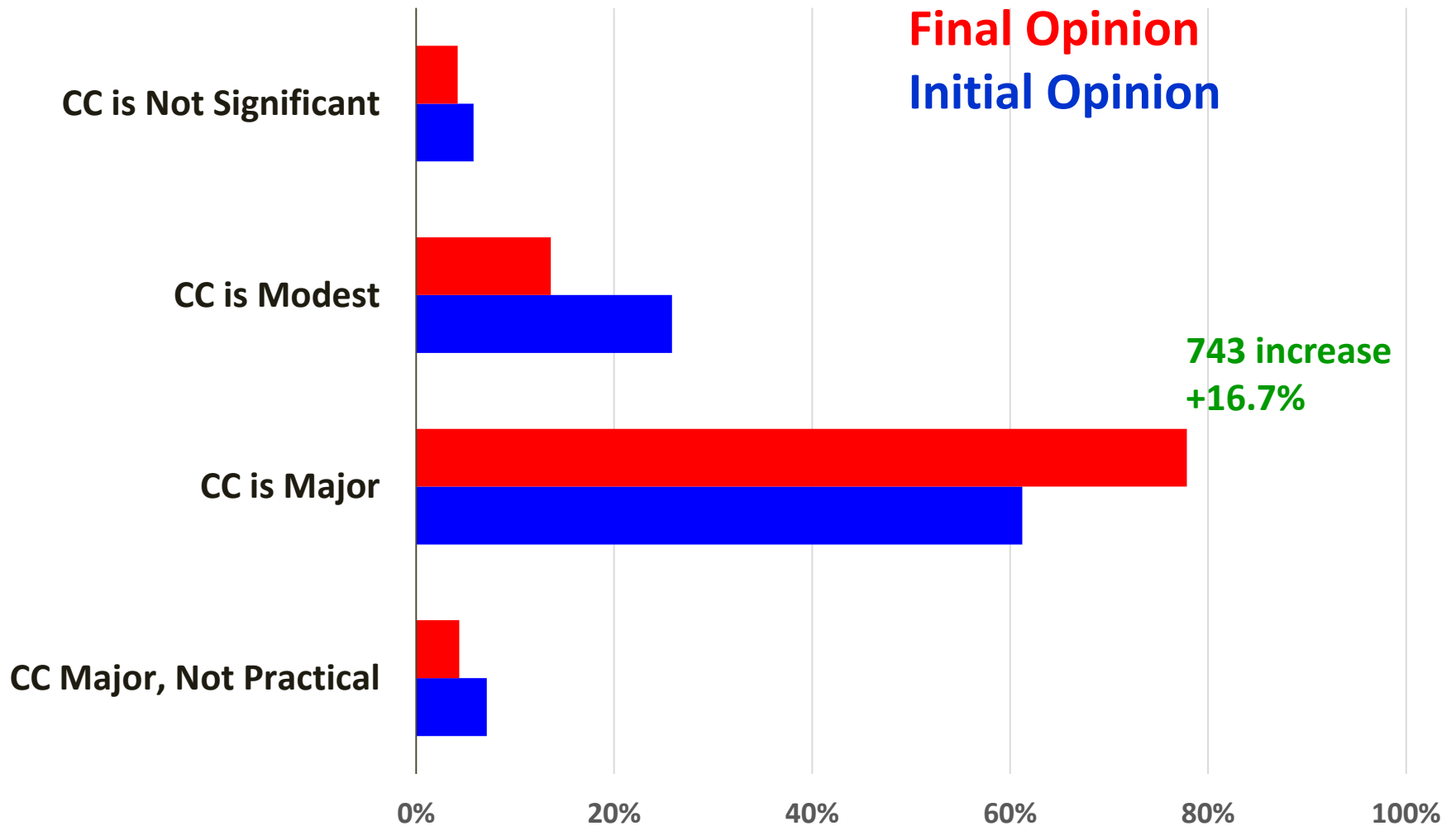


Opinions on Climate Change



108 Presentations: N=5,248

Opinions on Climate Change



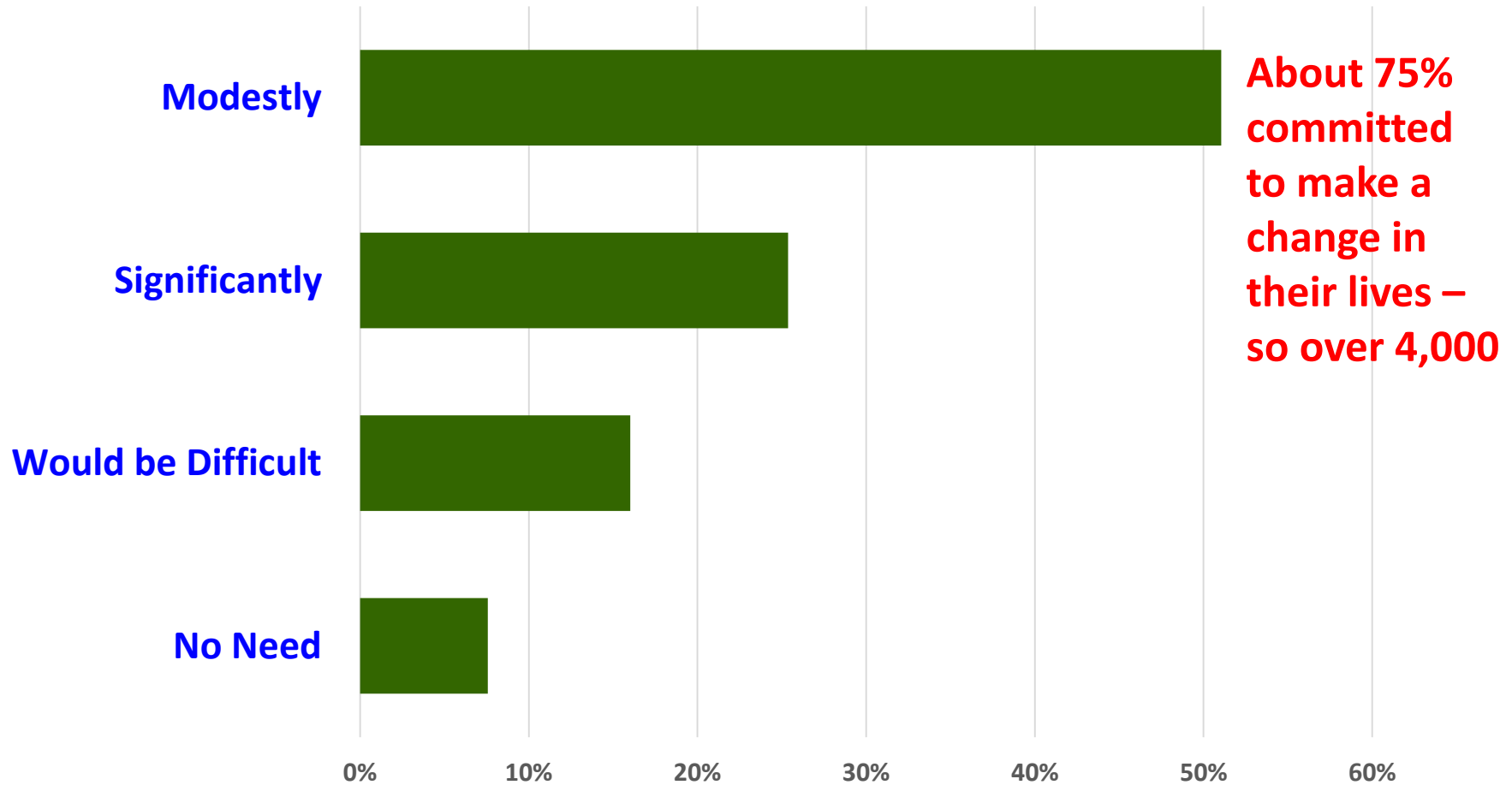
108 Presentations: N=5,248 N=5,082

Are you willing to reduce your emissions by conserving, recycling, changing eating habits, etc?

- 24% **A. I will modestly reduce my emissions**
- 67% **B. I will significantly reduce my emissions**
- 6% **C. It would be difficult to reduce emissions**
- 4% **D. I see no need to reduce my emissions**



Are You Willing to Reduce Your Emissions?



N=5,500

Some “Good News” About Climate Change

- **Conservation saves money** – and perhaps as much as 33% of goals can be reached this way
- The “fuel” for solar and wind is always free
- **Green jobs** can be a boon to the economy

What Else Can You Do?

Tell your friends and family members!

The next generations need us to respond.



Web Resource on Climate Change



Featured Resources



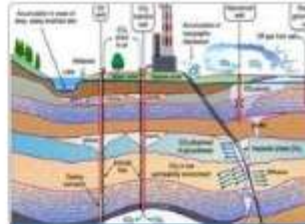
Role Playing: NYC Case Study

Students will apply a role-playing activity to explore the challenges facing climate change planning in New York City....



Unit: Geoengineering

Students will apply a role-playing activity to explore the challenges facing climate change planning in New York City....



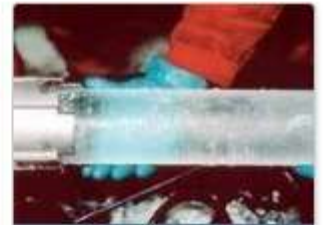
Module: Carbon Capture and Sequestration

Students will learn the basics of carbon capture and sequestration (CCS). Spiraling from the carbon cycle activity.....



Game: ClimateEnergyFusion Game

Climate and Carbon Science Mission – developed by Lawrence Livermore National Laboratory.....



Lab Exercise: Vostok Ice Core: The Cold Hard Truth

In this lab, students learn how to use data from the Vostok ice core to measure...

*<http://camelclimatechange.org/index.html>

Acknowledgments

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Award# NNX09AL64G

"Creation and Dissemination of an Interdisciplinary Undergraduate General Education Course on Climate Change"



National Science Foundation for support under Climate Change Education

Award #DUE-0950396

"Creating a Learning Community for Solutions to Climate Change"



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Save the Data!