

Understanding Climate Change

Joyce Tuten

Middletown, MD 21769

Dec 8, 2018

Outline

- Welcome & Intro

Part 1 - The Basic Science

- Greenhouse Effect
- Global Warming & Climate Change

Part 2 - Impacts of Climate Change

Part 3 - Solutions

- Personal actions
- Government actions

- Questions

Joyce Tuten

Biology Teacher – Clarksburg High School, MCPS

B.S. Kinesiology - College of William & Mary

M.S. Nutritional Sciences - Rutgers University

16 years teaching high school:

- AP Environmental Science
- Chemistry
- Biology
- German
- ESOL

NOAA – Climate Steward Educator



Climate Education Event
The White House



Climate Reality Leadership



National Center
for Atmospheric
Research



NSTA
Convention



2006



2018





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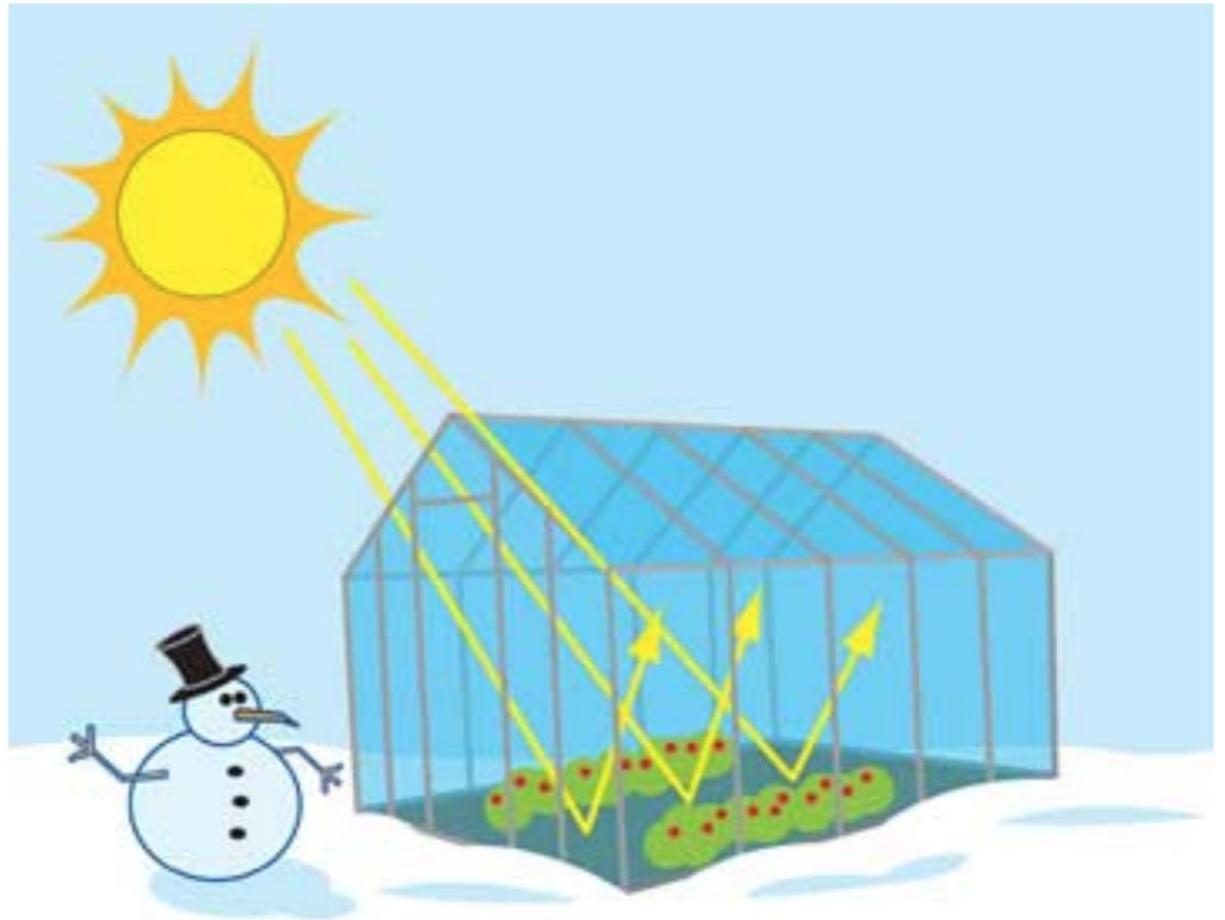
Part 3 - Solutions

- Personal actions
- Government actions

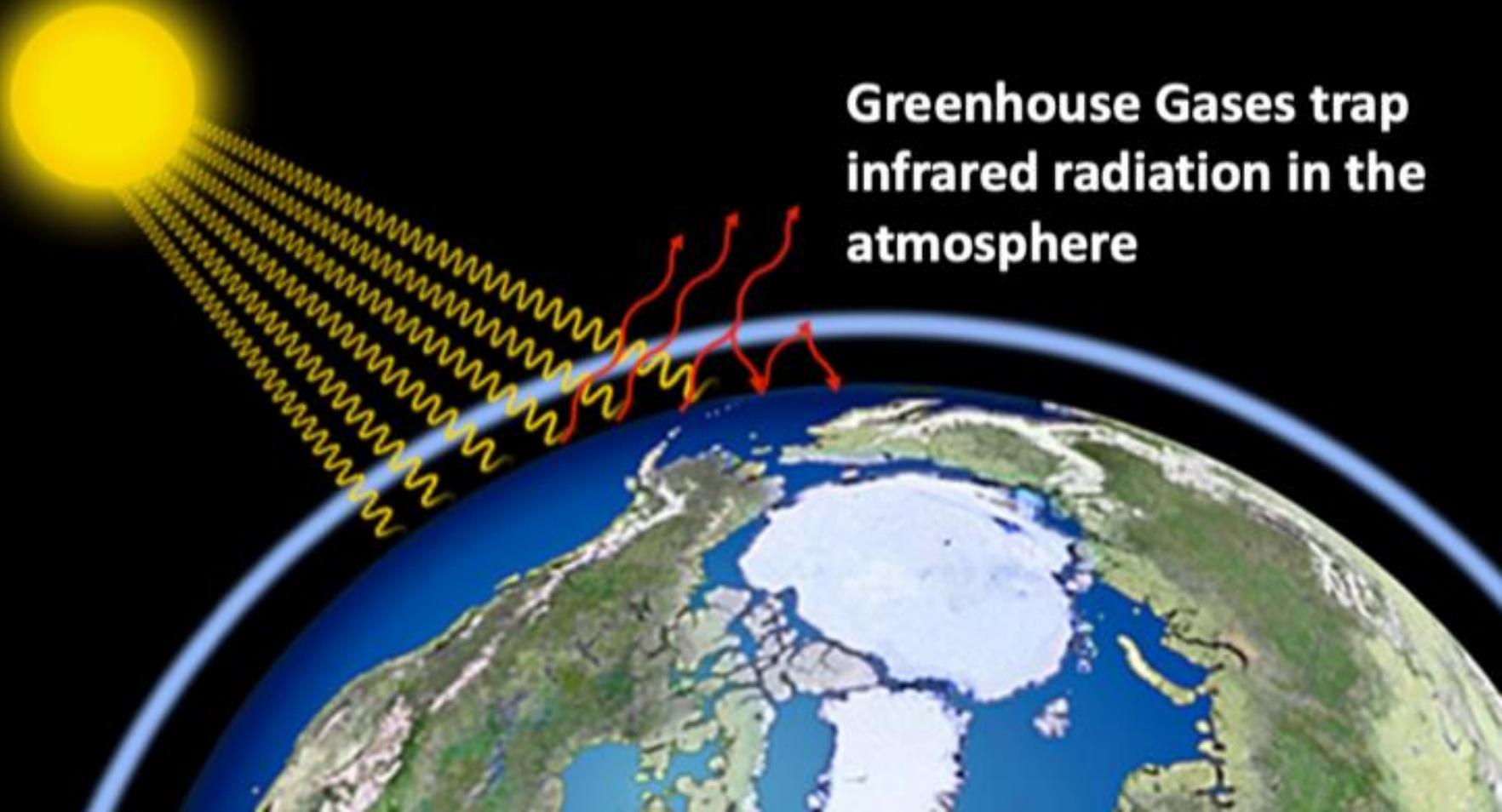
• Questions

The Greenhouse Effect

warming of the earth when some of the sun's energy is trapped in our atmosphere



The Greenhouse Effect

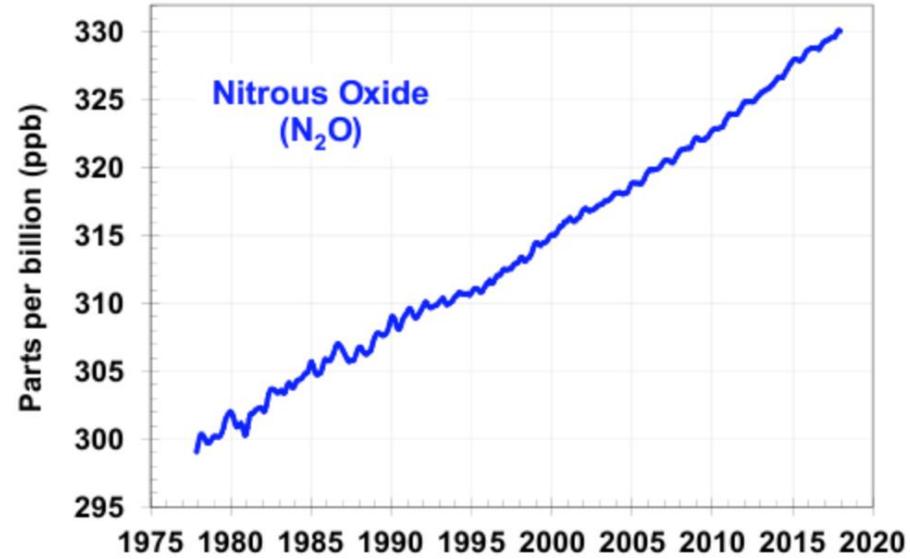
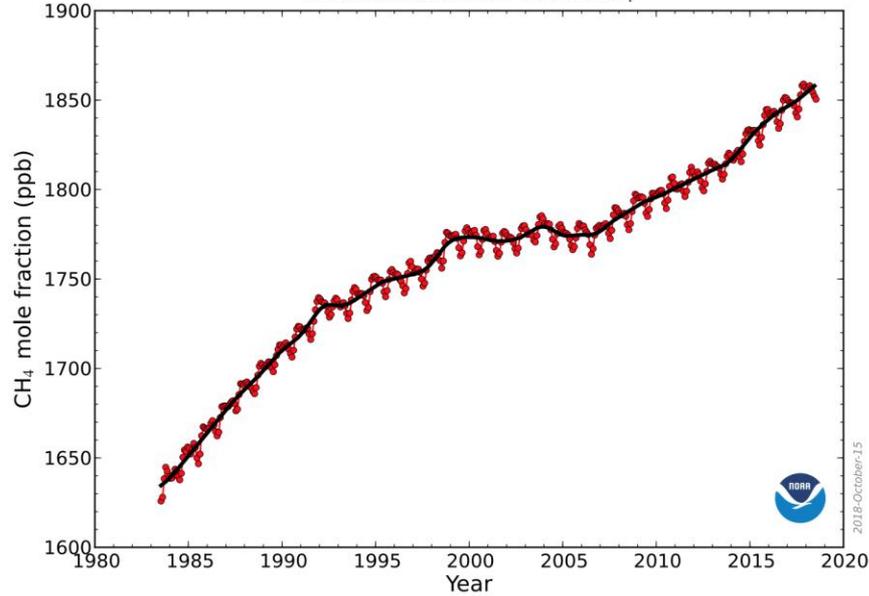


**Greenhouse Gases trap
infrared radiation in the
atmosphere**

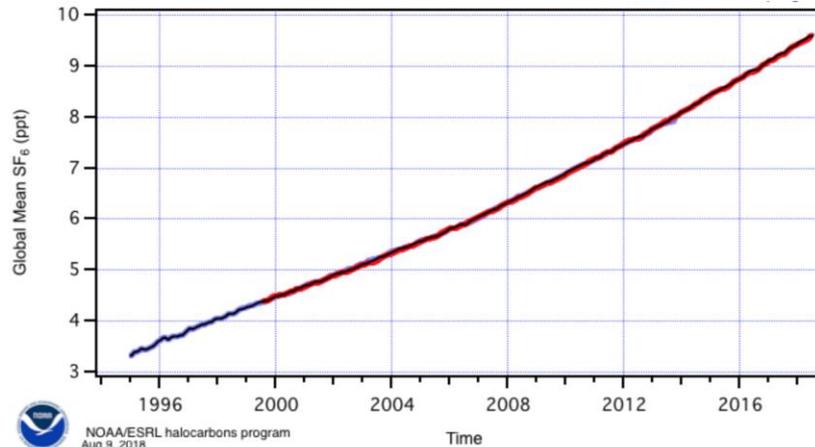
Greenhouse Gas	Chemical Formula	Global Warming Potential	Atmospheric Lifetime
carbon dioxide	CO₂	1	~ 2,000 years
methane	CH₄	32	10 years
nitrous oxide	N₂O	280	100 years
ozone	O₃	varies	hours
water	H₂O	varies	varies
CFCs, HFCs, HCFCs, CF₄, SF₆, etc	SF₆	23,000	3,200 years

Increase in Atmospheric Greenhouse Gases

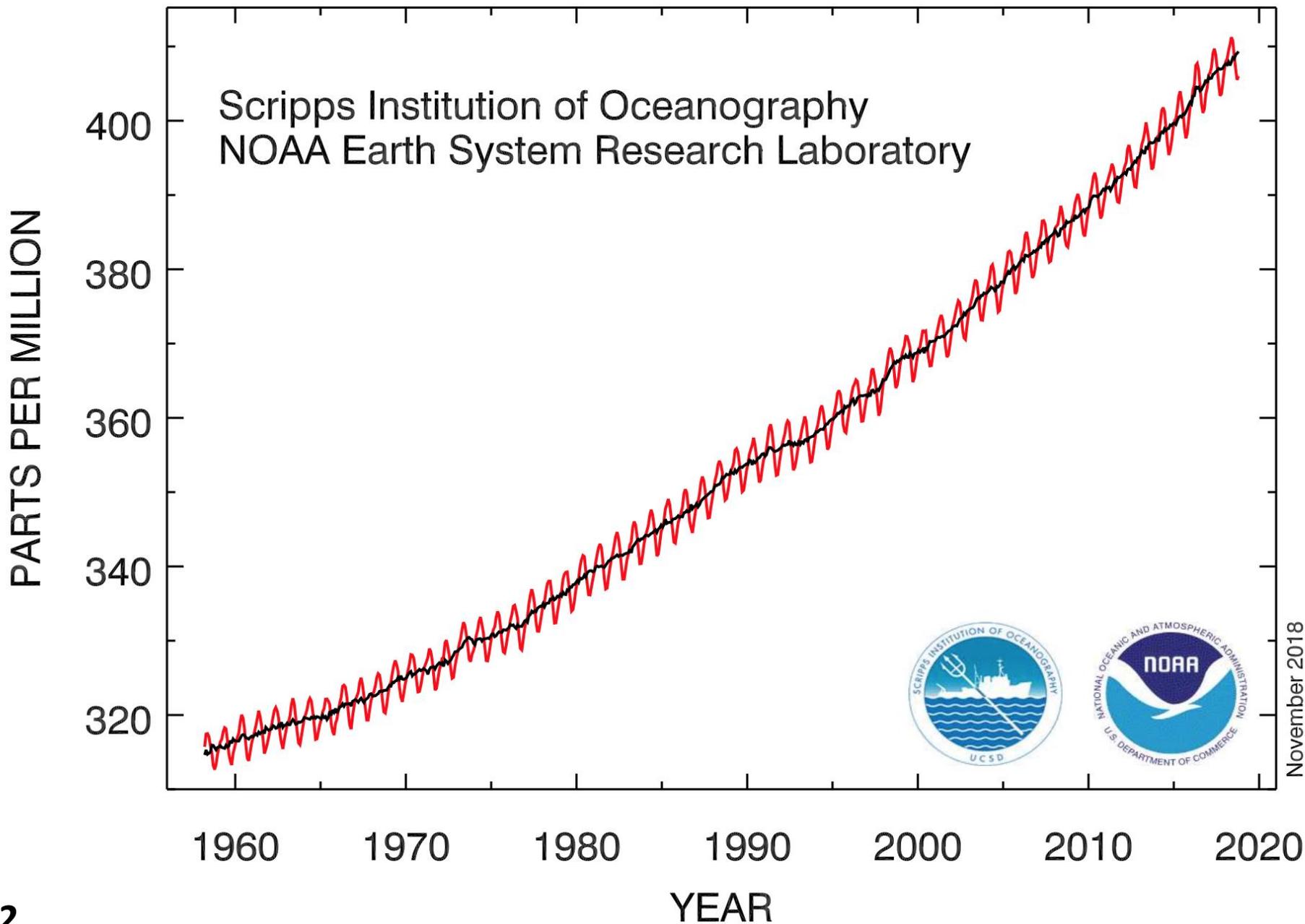
GLOBAL MONTHLY MEAN CH₄



Sulfur Hexafluoride Concentration in the Atmosphere



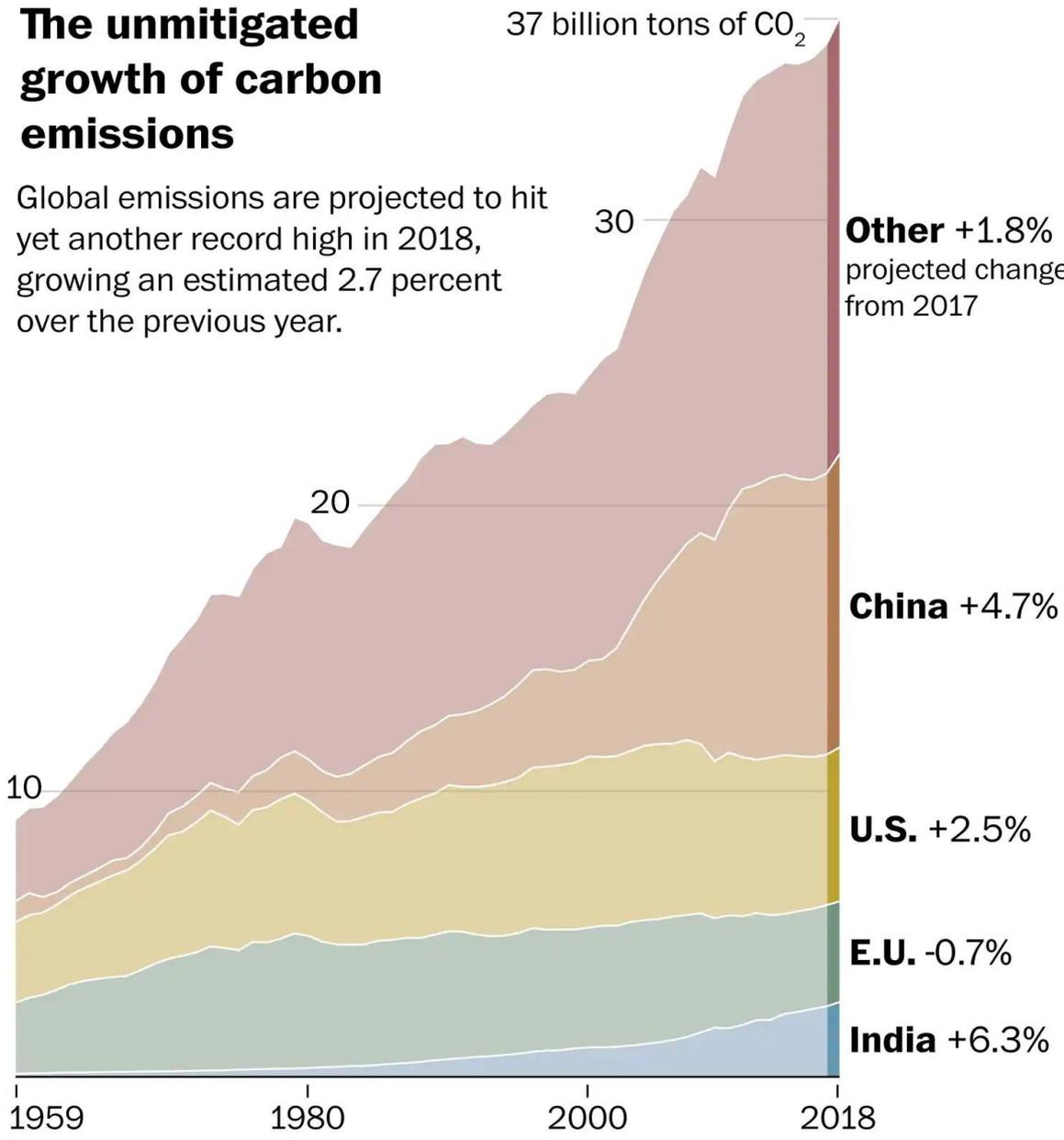
Atmospheric CO₂ at Mauna Loa Observatory



2018 Record High Global Carbon Emission

The unmitigated growth of carbon emissions

Global emissions are projected to hit yet another record high in 2018, growing an estimated 2.7 percent over the previous year.

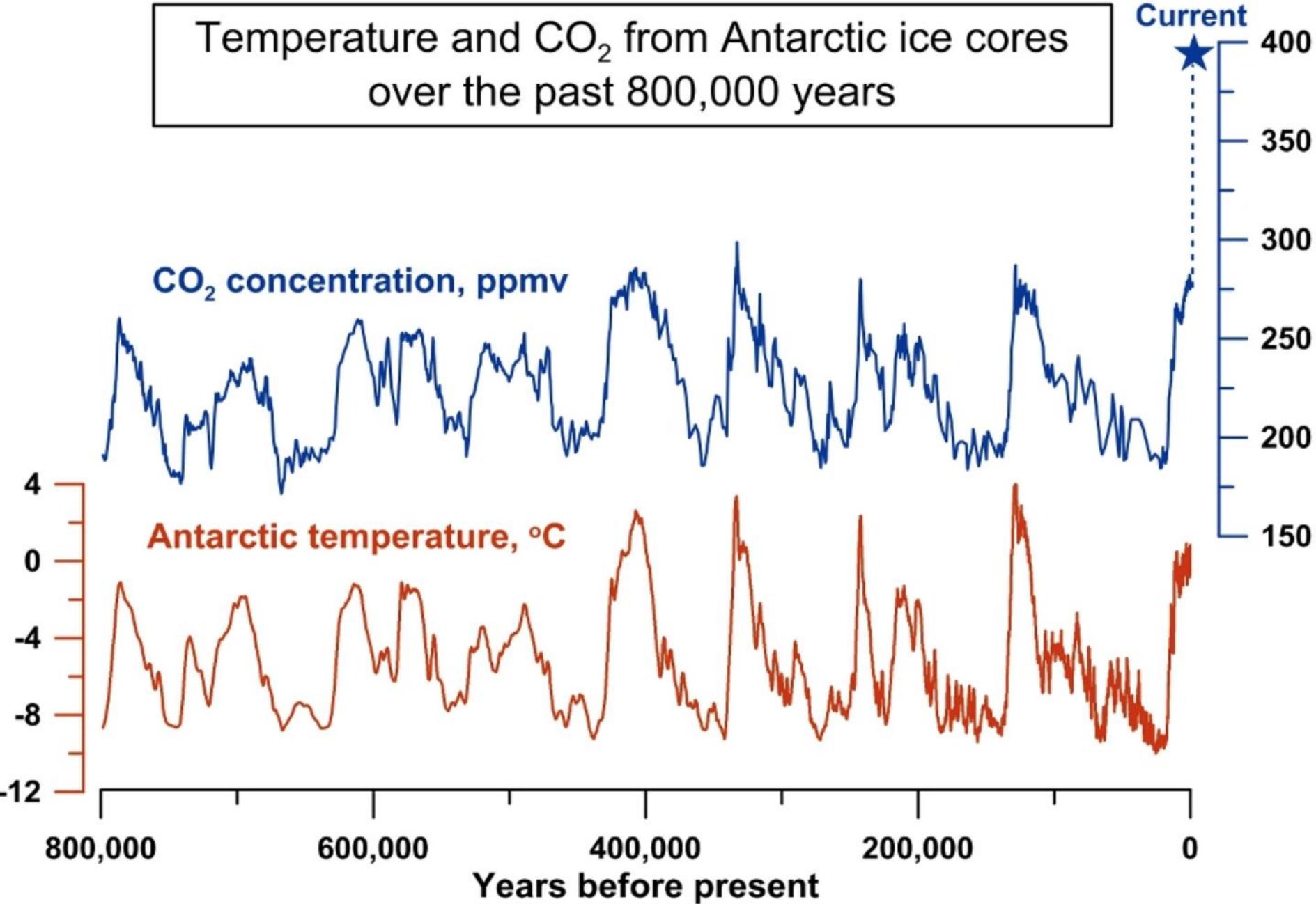


Figures show emissions from fossil fuels and industry, which includes cement manufacturing but not deforestation.

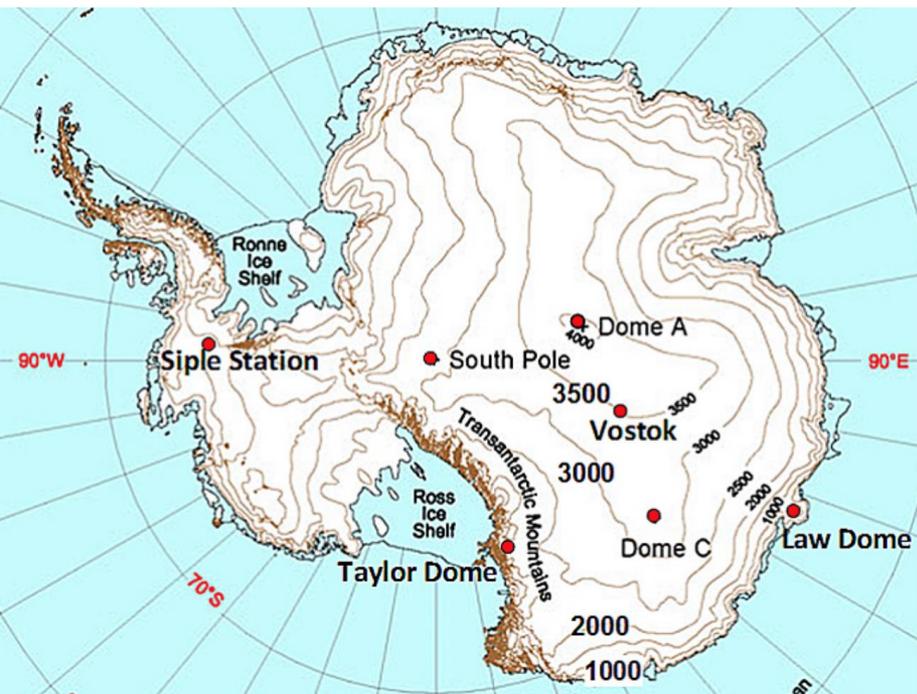
Source: Global Carbon Project

JOHN MUYSKENS/THE WASHINGTON POST

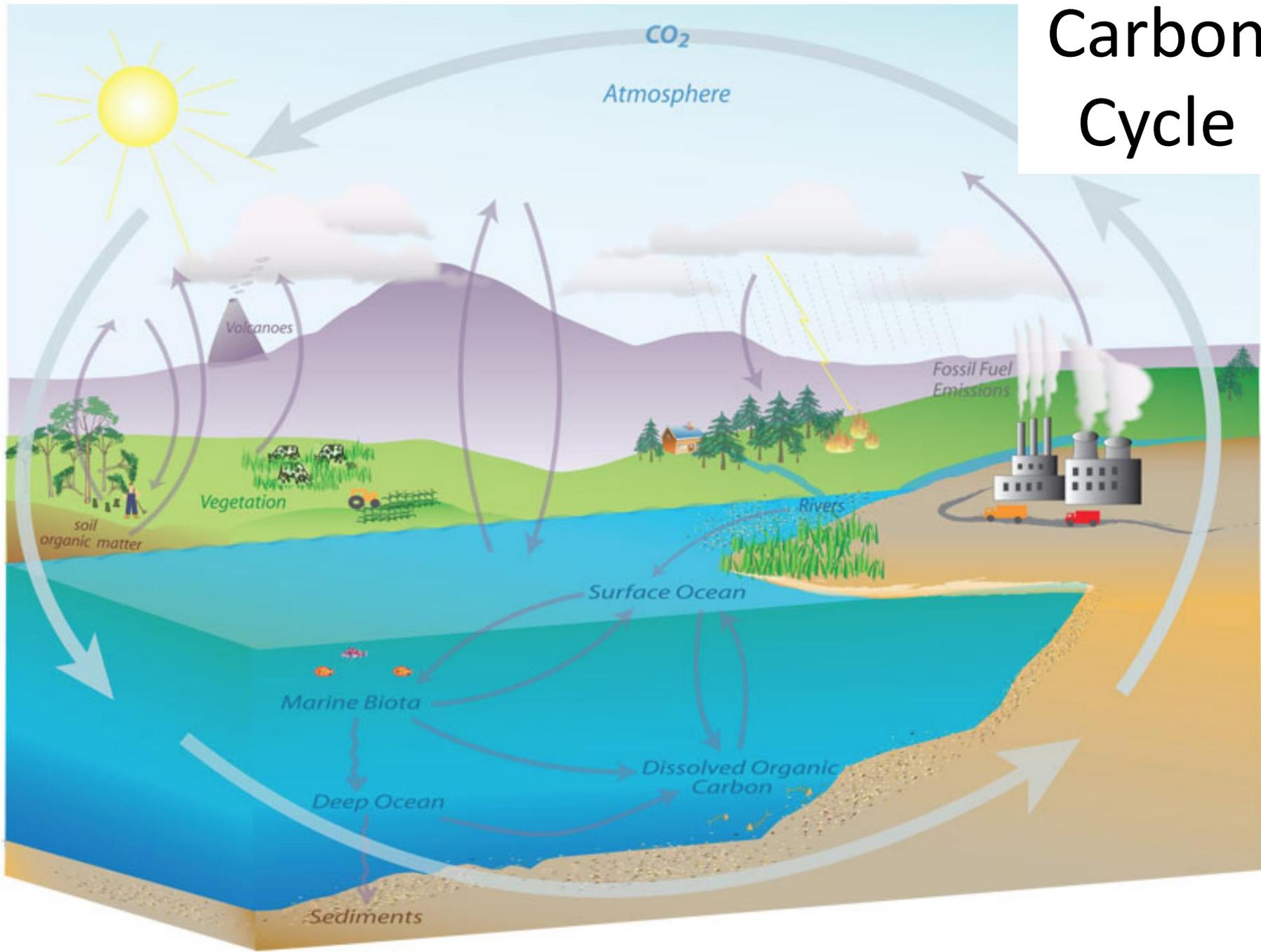
Temperature and CO₂ from Antarctic ice cores over the past 800,000 years



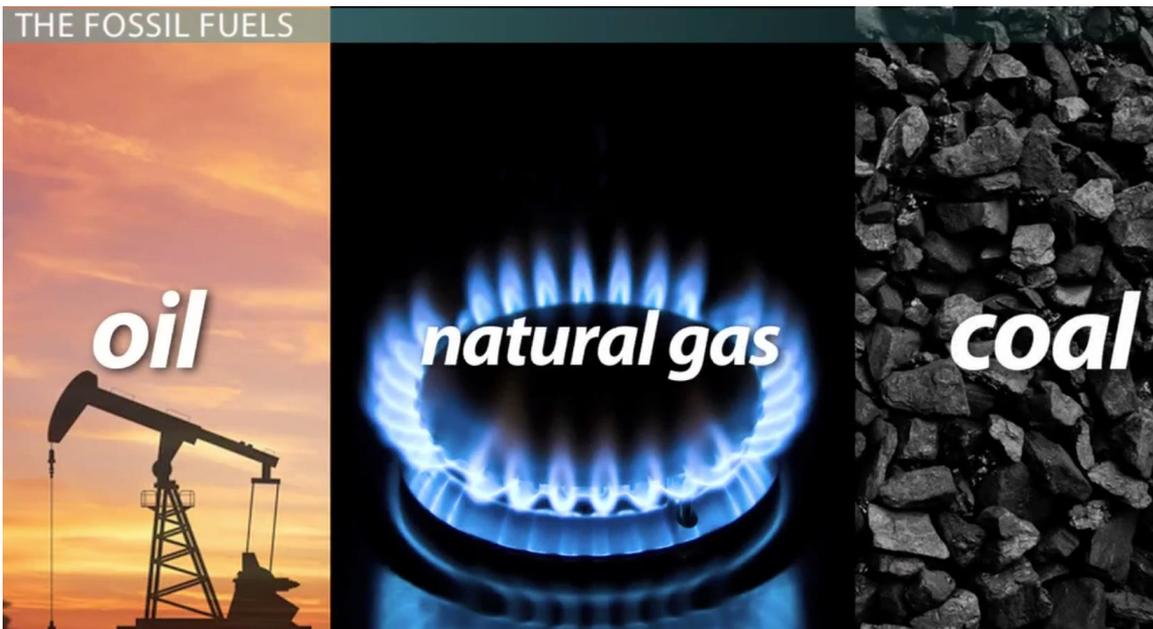
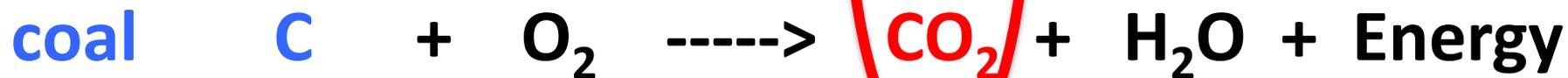
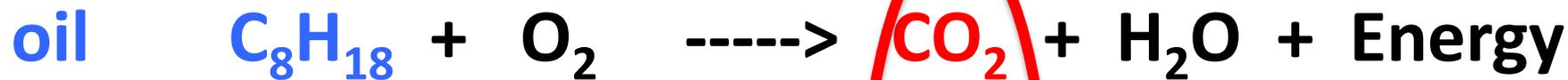
Antarctic Ice Cores



Carbon Cycle

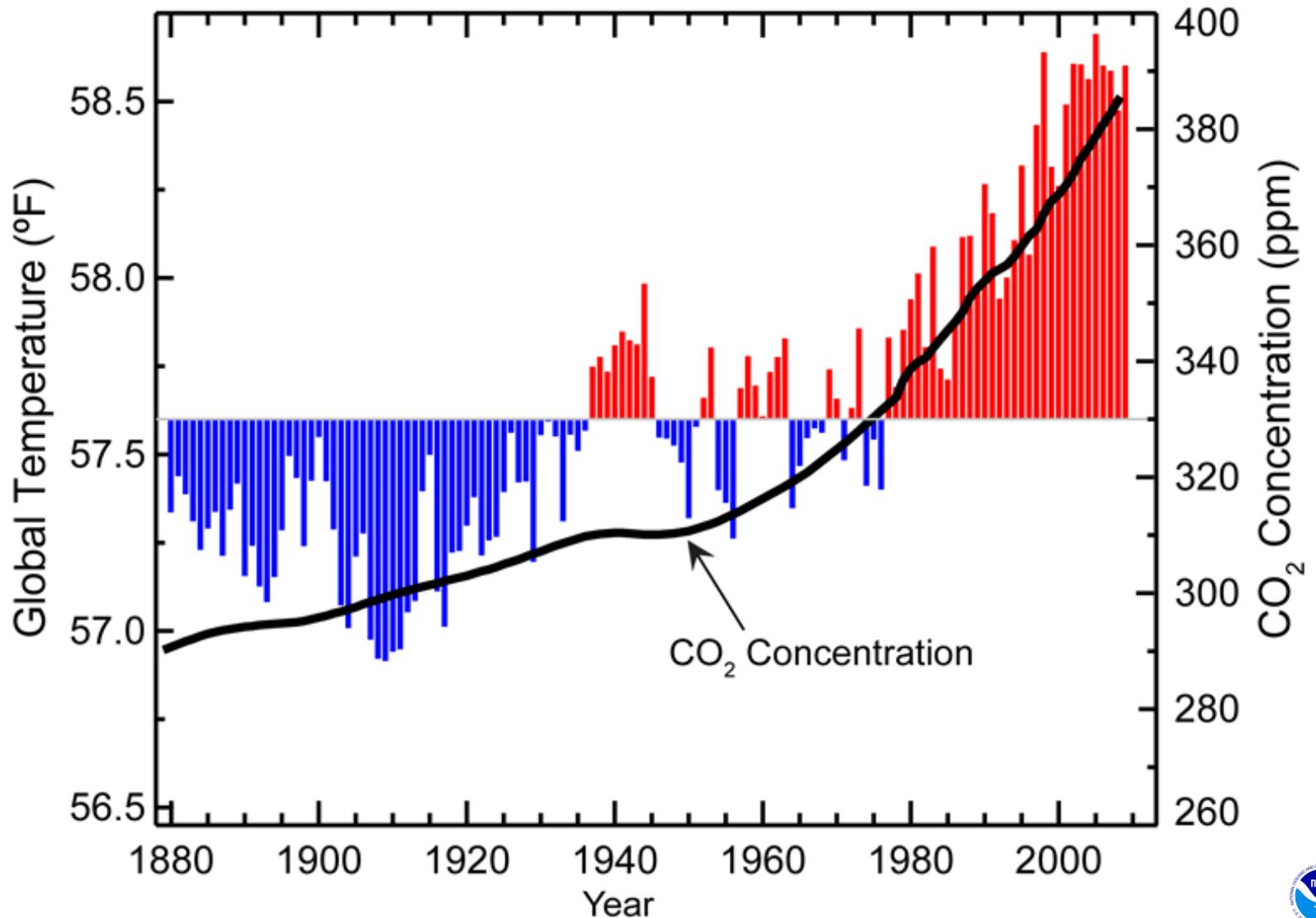


Combustion of Fossil Fuels



Global Warming

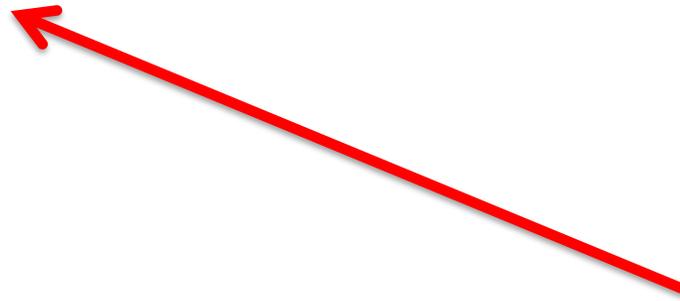
Global Temperature and Carbon Dioxide



Global Warming

**17 of the Hottest Years on Record
Have Occurred in last 19 years**

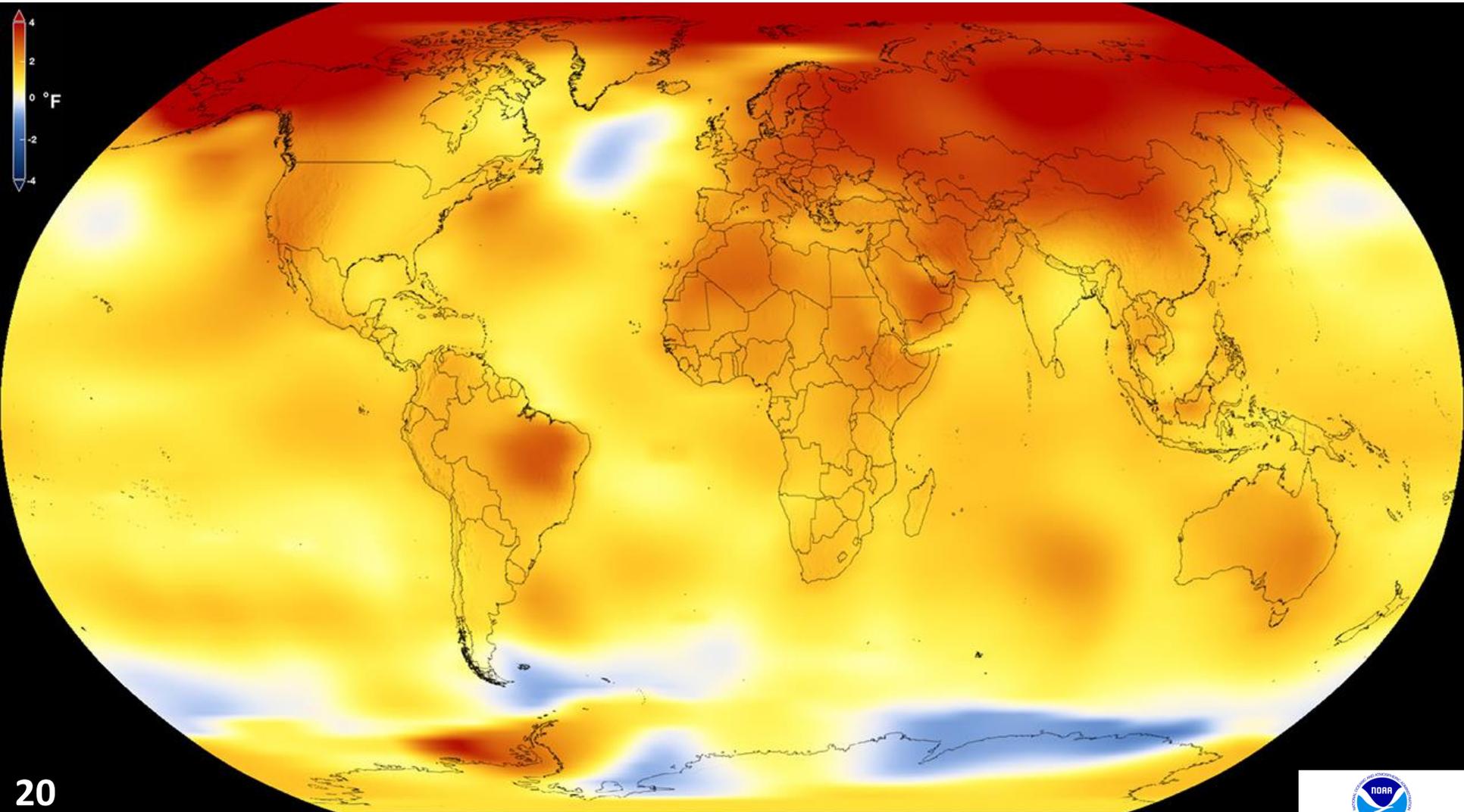
**2001 2004 2011 2003 2002 1998
2006 2012 2009 2013 2007 2005
2010 2014 2017 2015 2016**



2018

Average Global Temperature

2013-2017 compared to baseline 1951-1980



Middletown, Maryland

- in 1960 - we could expect **18** days above 90°F
- in 2018 - we now have **26** days above 90°F
- by 2100 - we can expect **51** days above 90°F



Global Warming **is causing** the Climate to Change

changes in

- **temperature** differentials
- **precipitation** patterns
- **humidity** levels
- **wind** patterns



WEATHER

Tells you what to wear each day



CLIMATE

Tells you what types of clothes to have in your closet



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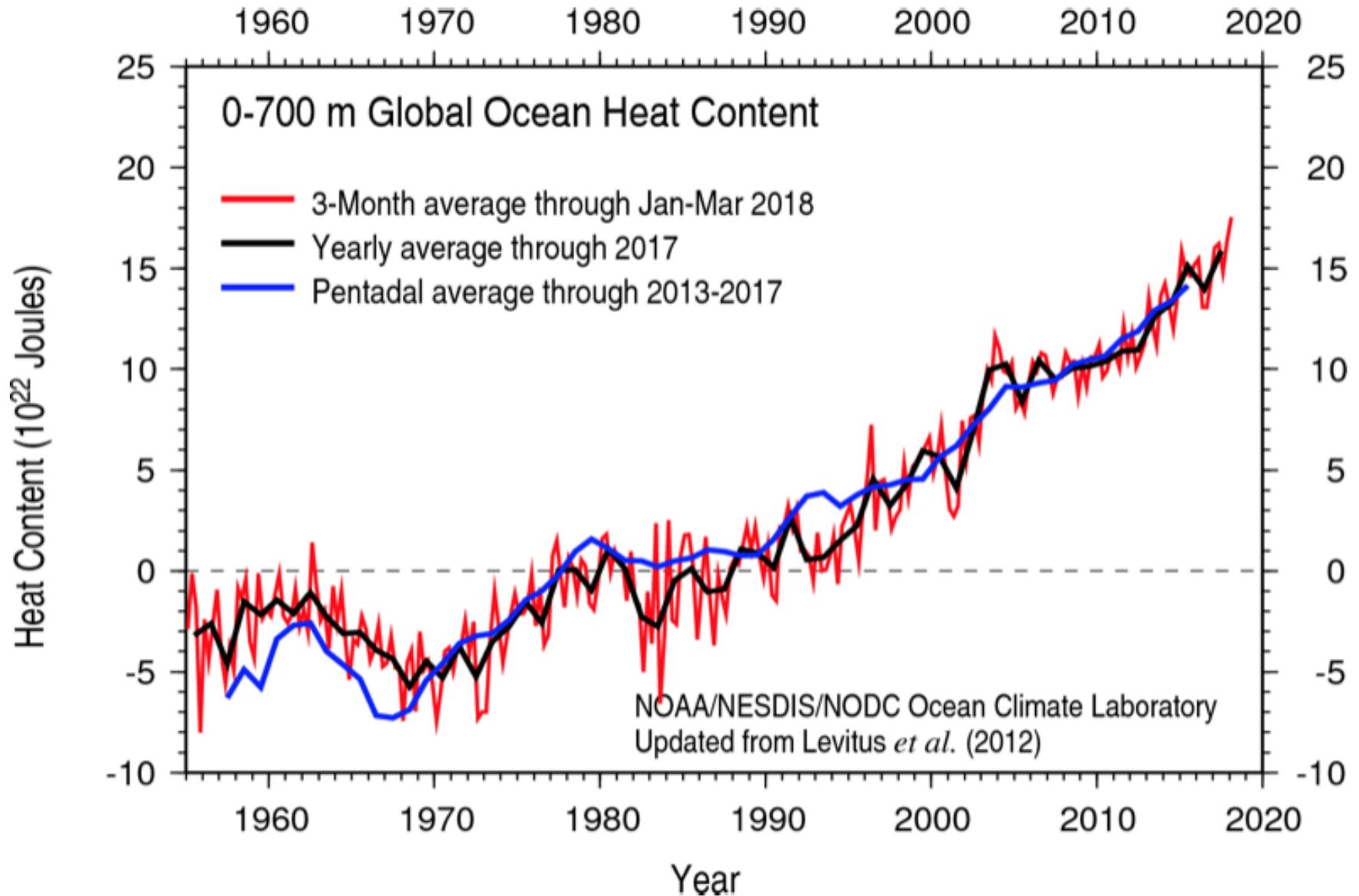
- Personal actions
- Government actions

- Questions

Part 2 – Impacts of Climate Change

1. Rising Ocean Heat Content
2. Stronger Hurricanes
3. Melting Sea Ice
4. Wind Impacts
5. Thawing Permafrost
6. Melting glaciers
7. Sea Level Rise
8. Climate Refugees
9. Coral Reef Destruction
10. Mass Extinction
11. Forest Fires
12. Larger Precipitation Events
13. Health Impacts
14. Agricultural Impacts

1. Increased Ocean Heat Content



2. Stronger Hurricanes

- strength increase 10%
- rainfall increase 10-15%

Hurricane Florence - 2018



Hurricane Michael- 2018



Hurricane Harvey - 2017

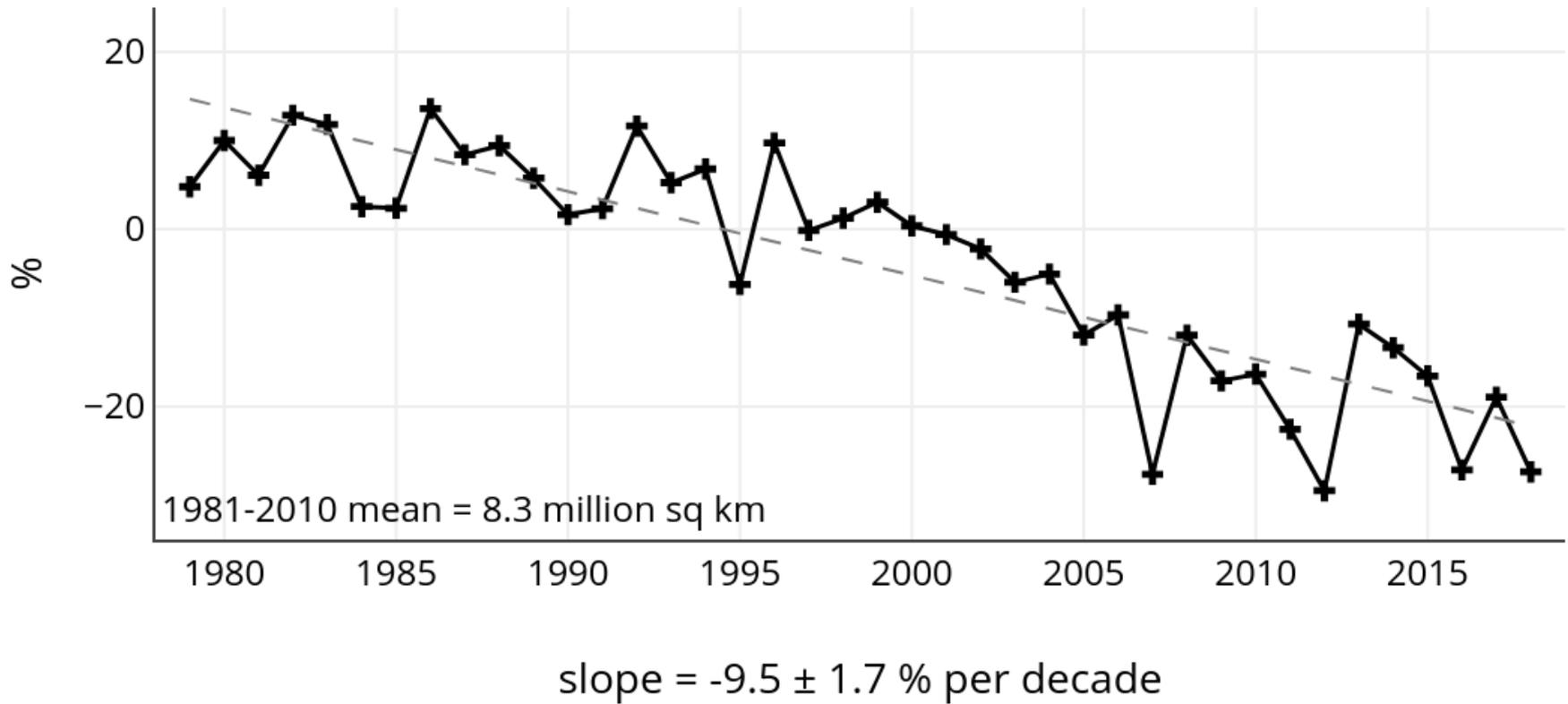


Hurricane Sandy - 2012



3. Melting Sea Ice

Northern Hemisphere Extent Anomalies Oct 1979 - 2018



Arctic could
have no
summer ice
by 2030

Sea Ice Extent, Oct 2018

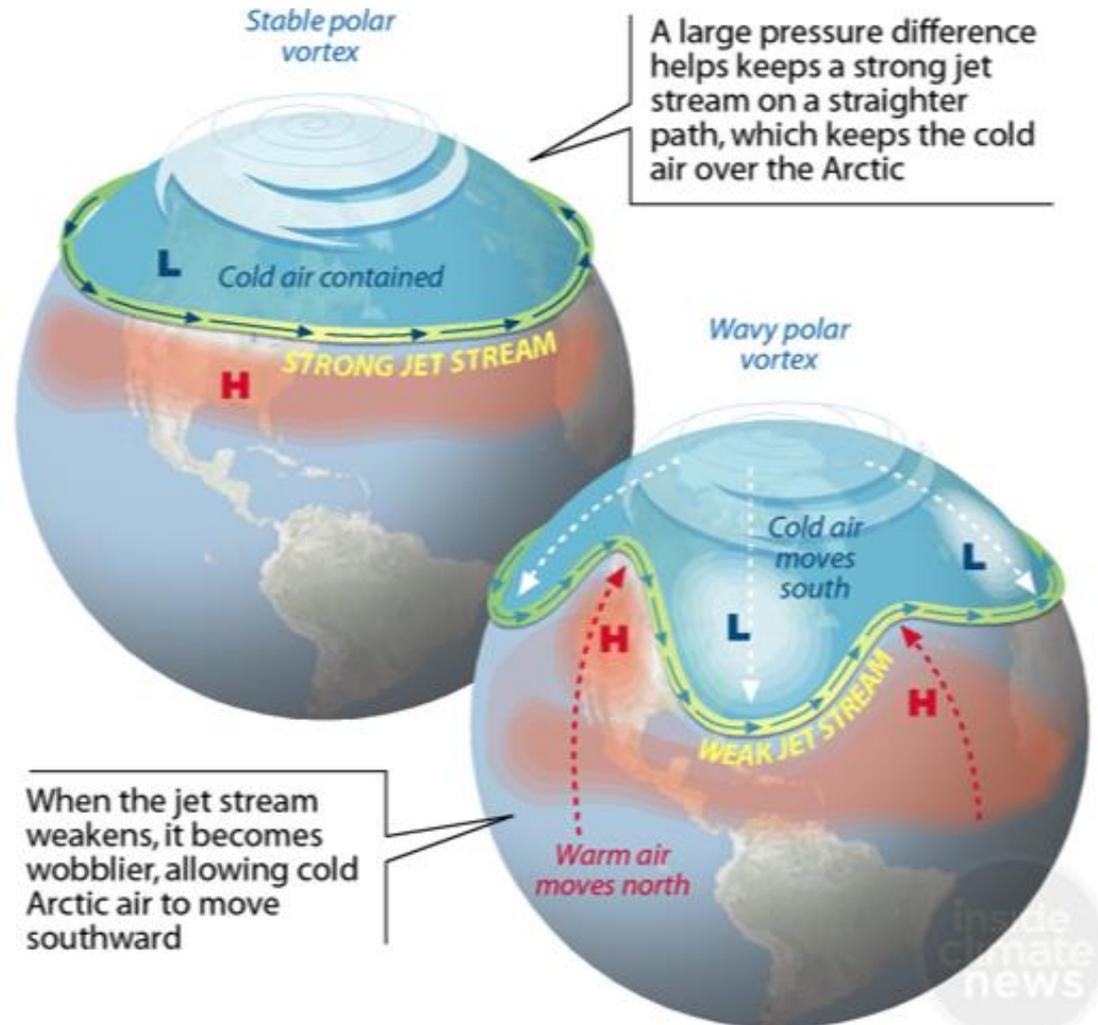


National Snow and Ice Data Center, University of Colorado Boulder

4. Wind Impacts

Polar Vortex Explained

The polar vortex is a large area of low pressure and cold air over Earth's North and South Poles. When the jet stream weakens, it becomes wavier, allowing that cold air to dip southward in places while warmer air pushes northward elsewhere.

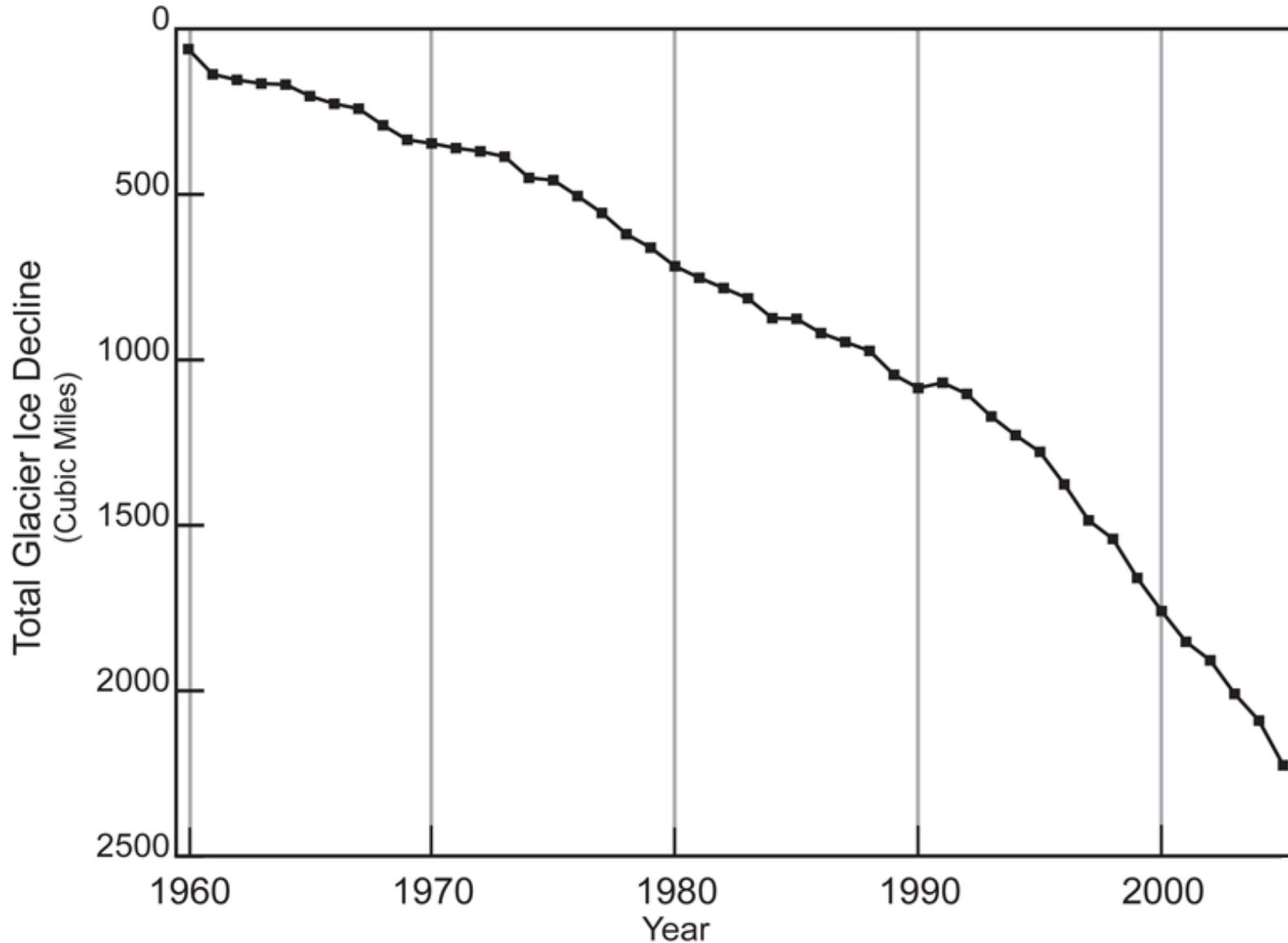


5. Thawing Permafrost

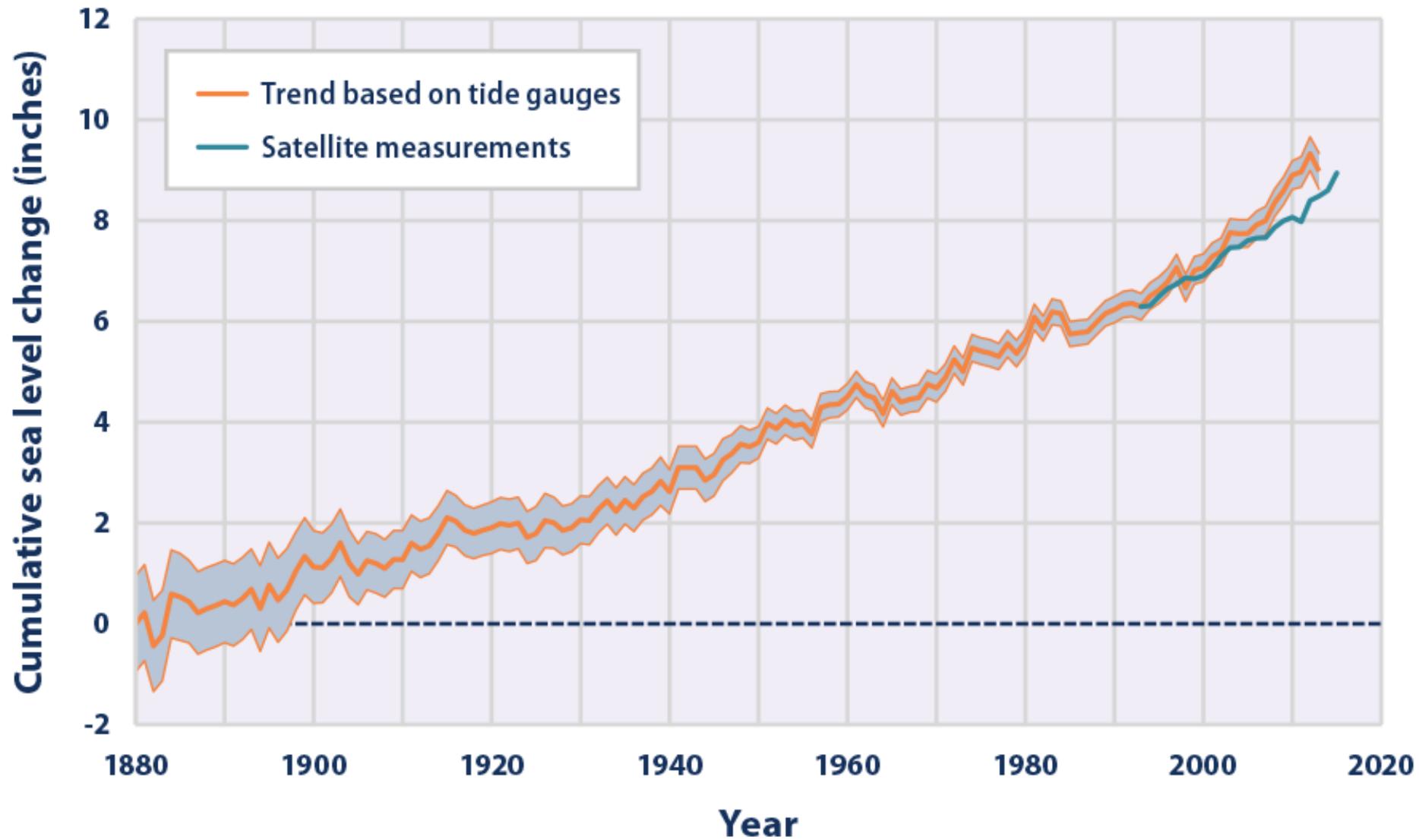


6. Melting Glaciers

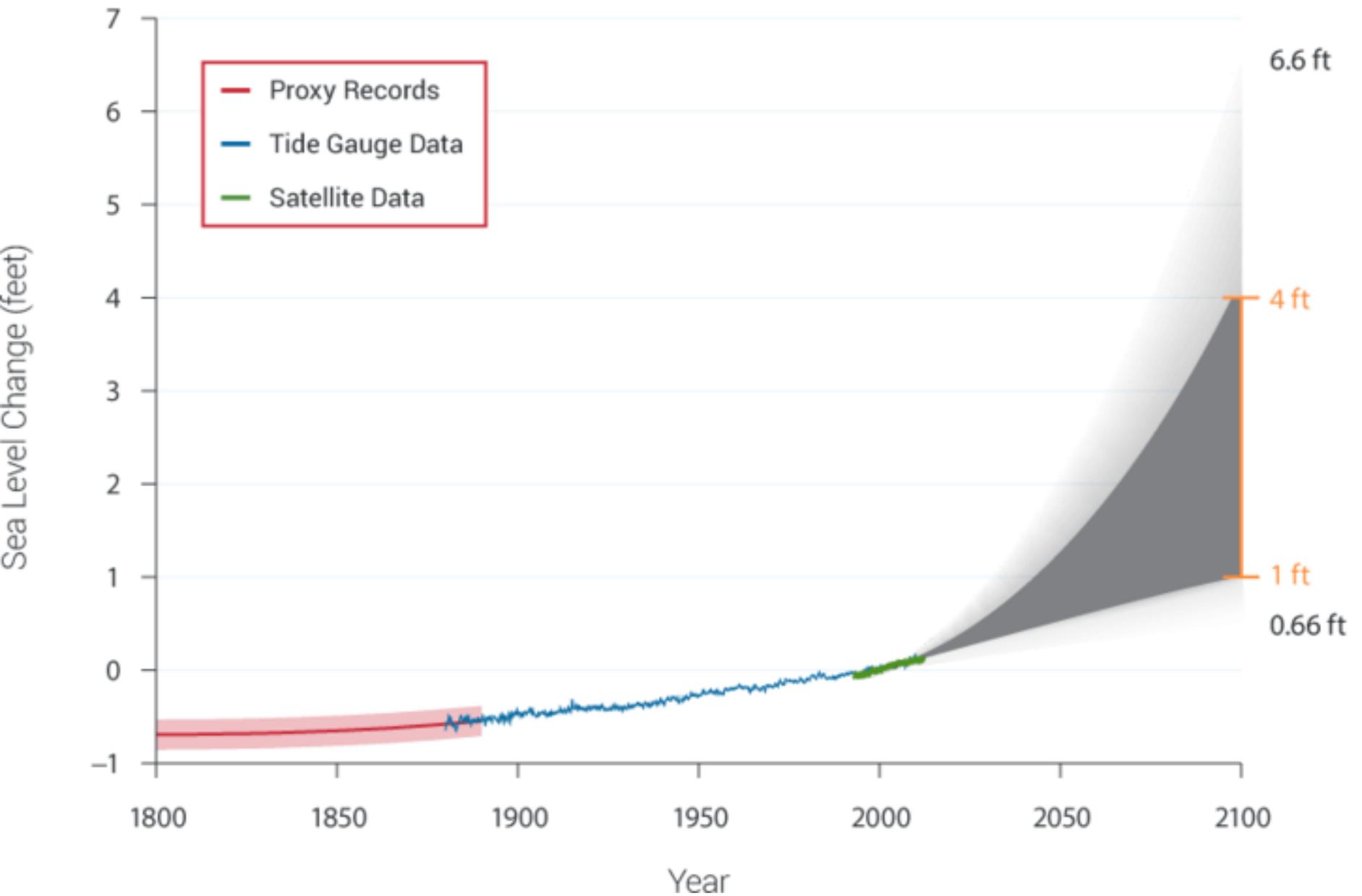
Global Glacier Volume



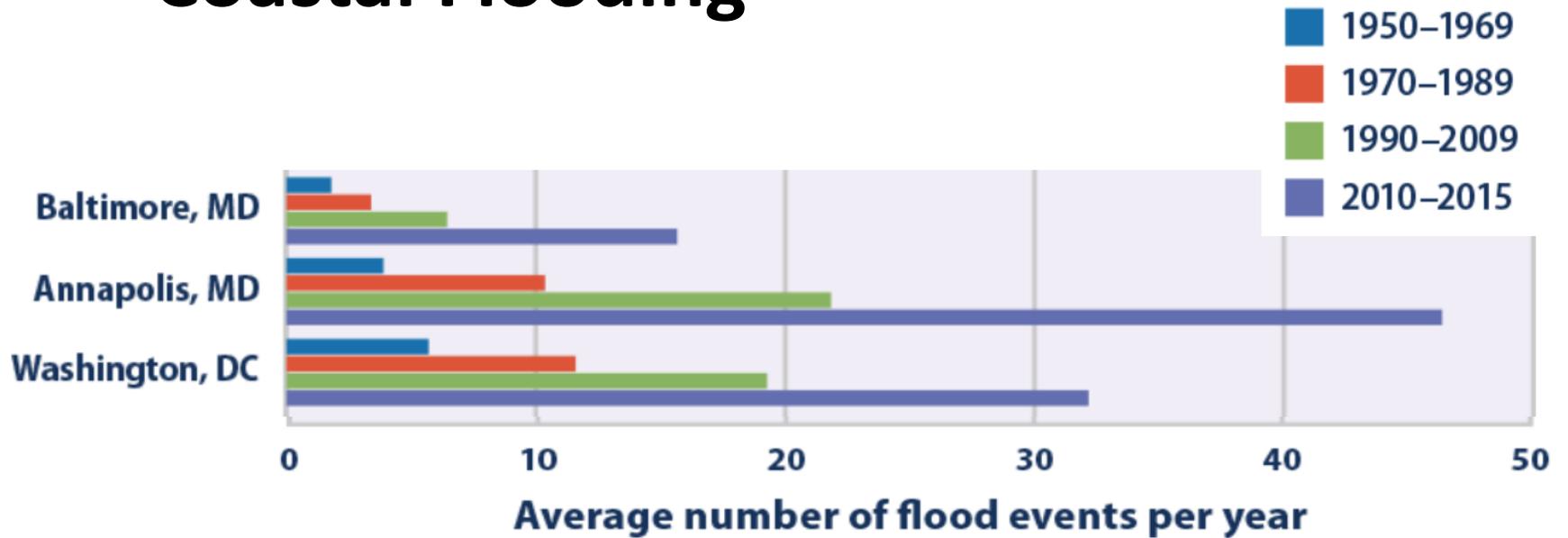
7. Sea Level Rise



Past and Projected Changes in Global Sea Level



Coastal Flooding



By 2065, **Annapolis** expected to have 365+ days of coastal flooding



Smith Island, Maryland – Chesapeake Bay

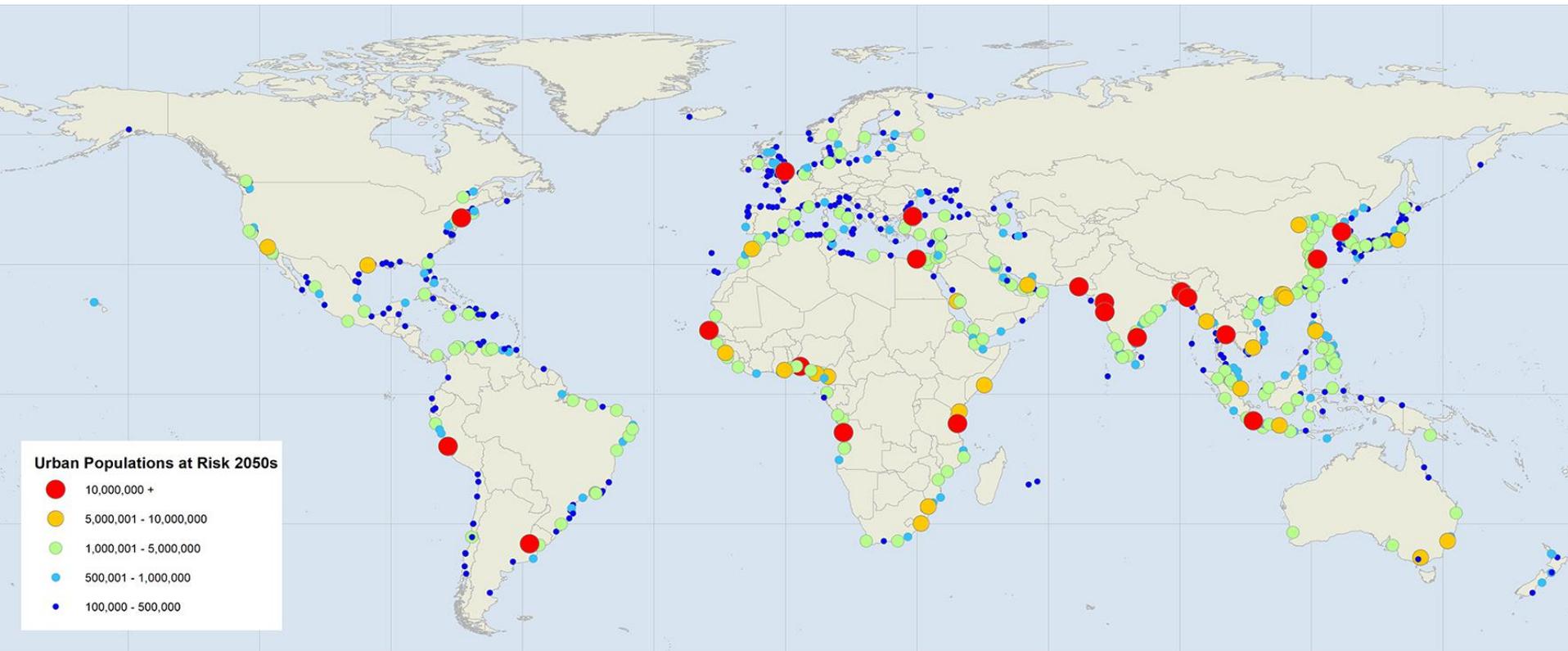


Rhodes
Point

Ewell

Tylerton

Urban Populations at Risk of Sea Level Rise



8. Climate Refugees

- **Isle de Jean Charles, Louisiana**

- \$48 million from HUD grants
- 25 families to be relocated

- **Shishmaref, Alaska**

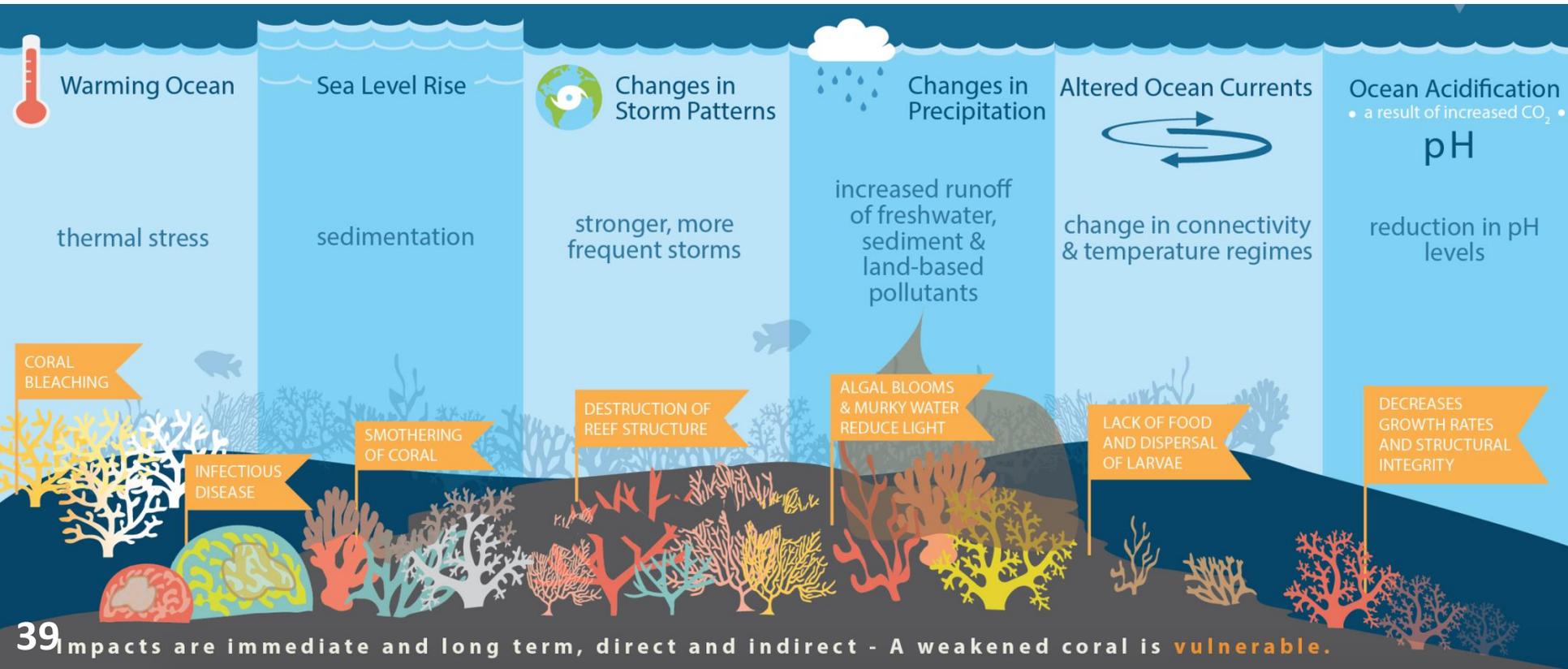
- \$200 million estimate
- 600 people

- UN estimates **200 million** climate refugees by 2050
(sea level rise, drought, heat)

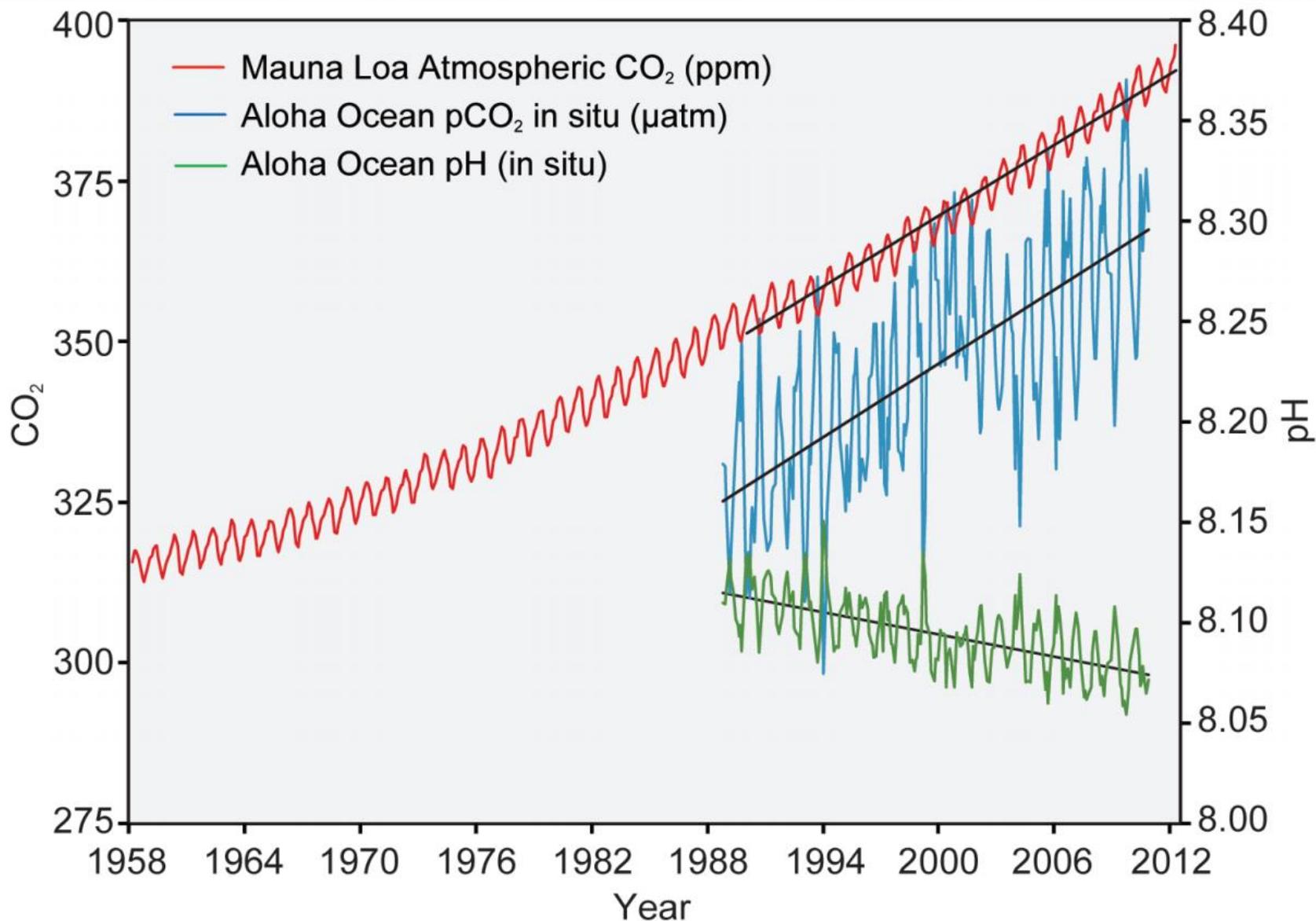


9. Coral Reef Destruction

70-90% of coral reefs lost by 2050



As Oceans Absorb CO₂ They Become More Acidic



10. Mass Extinction

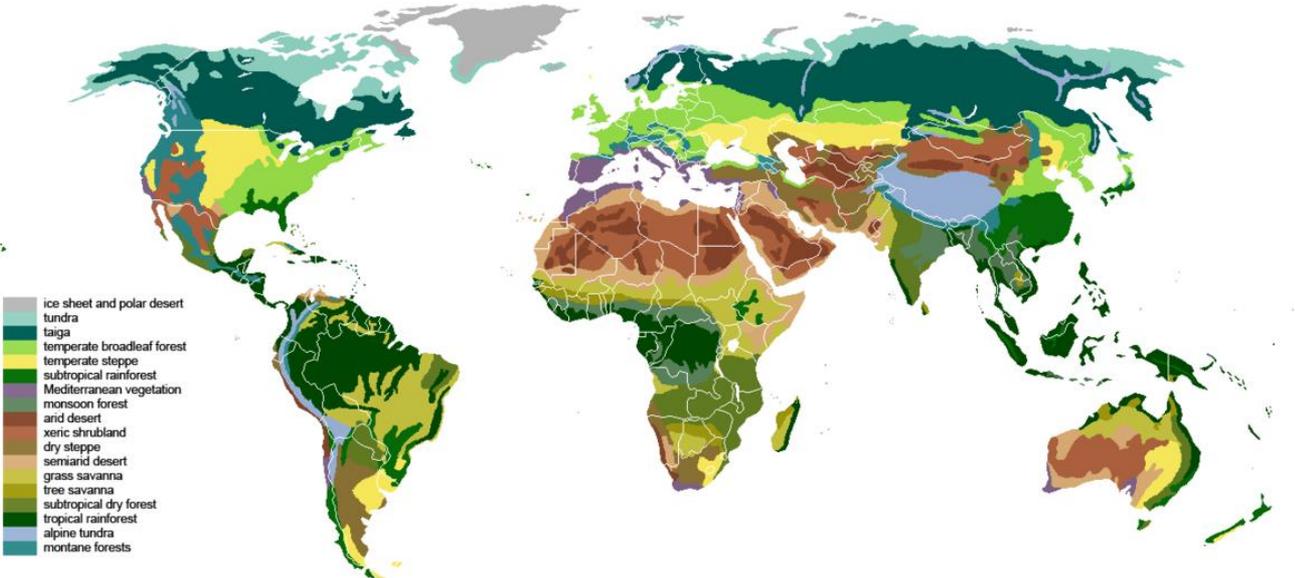


krill

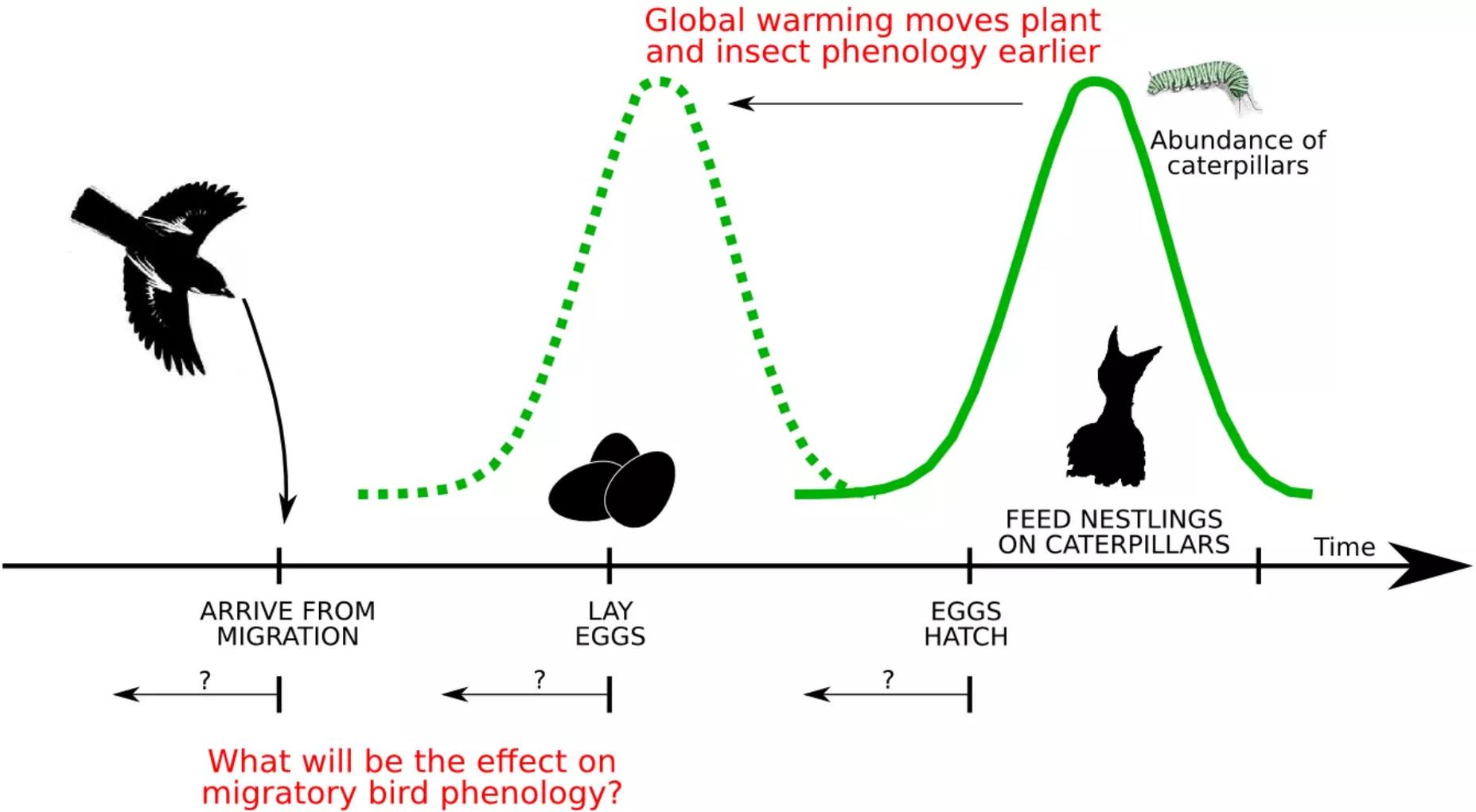


coral reef bleaching

Earth's Biomes



Phenological Mismatch



11. Larger Forest Fires

9 of the 10 largest fires in California have occurred in the last 10 years

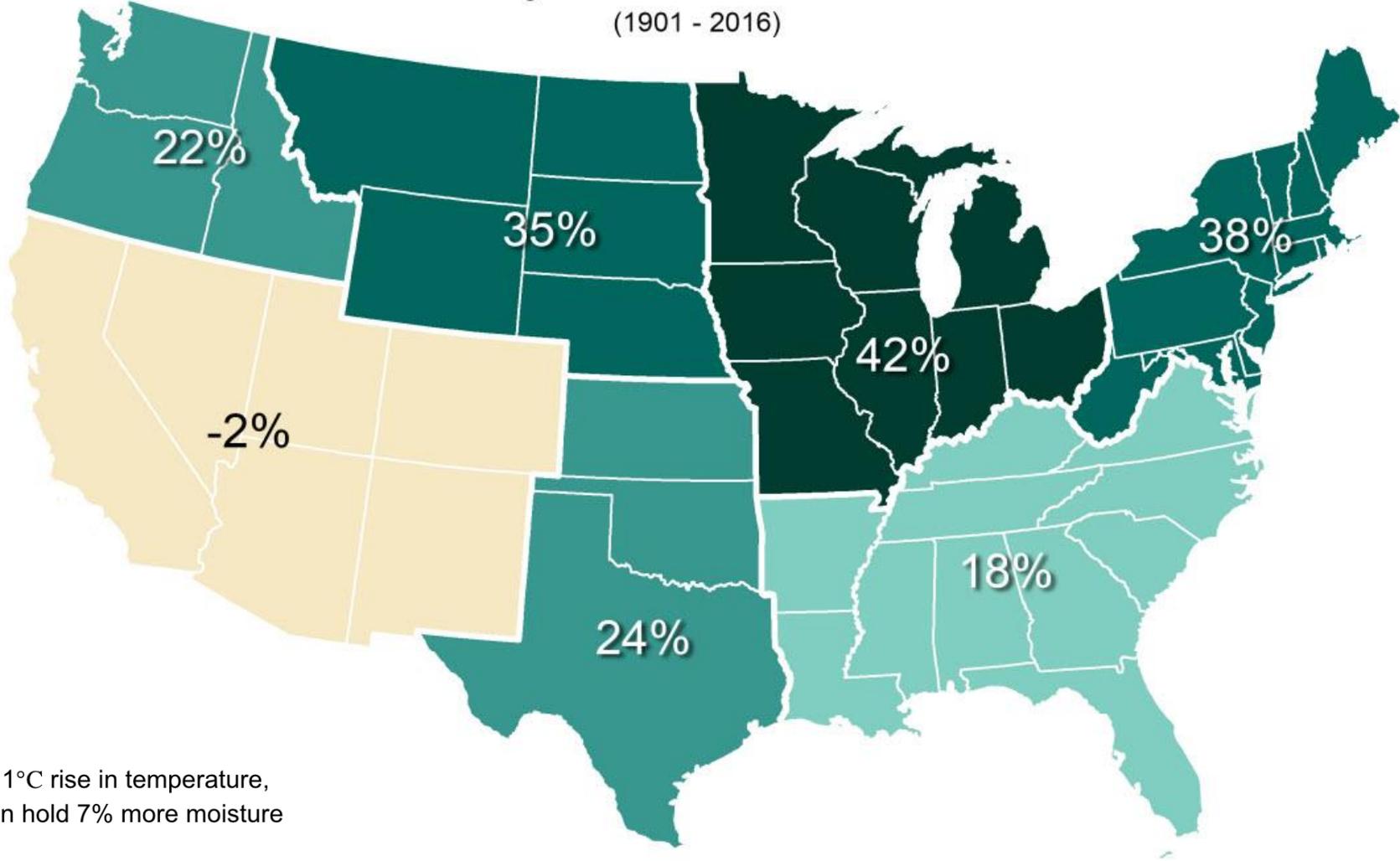


*since 1932
accurate records

Camp Fire, California

12. Larger Precipitation Events

Observed Change in Total Annual Precipitation
Falling in the Heaviest 1% of Events
(1901 - 2016)



for every 1°C rise in temperature,
the air can hold 7% more moisture

Percent Change (%)



13. Human Health Impacts

Heat Related Deaths

2003 – Europe – 35,000+ deaths

2010 – Northern Hemisphere – 16,000 deaths

2015 – India – 2,250 deaths

2015 – France – 3,275 deaths

Vector Borne Disease

Mosquito & tick ranges increase

Respiratory Diseases, Allergies, Cardiovascular disease

heat impacts

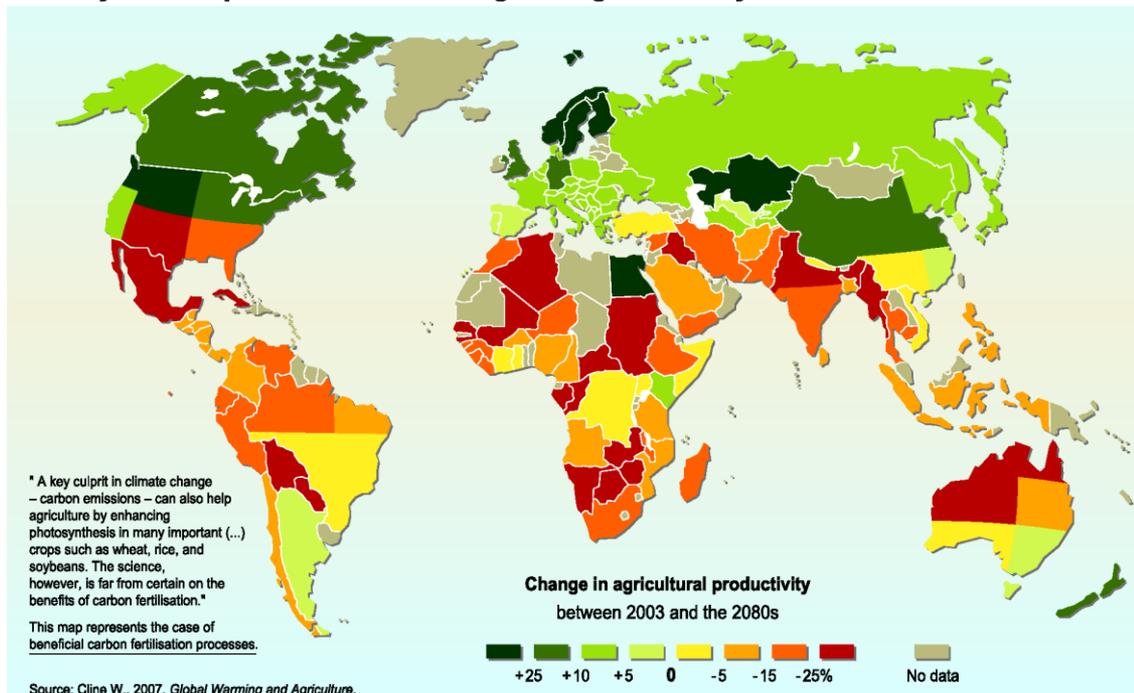
Mental Health

migration, storm injuries, disease, drought, civil conflict

14. Impacts on Agriculture

- fewer chilled nights
- drought/floods
- increased number of **consecutive dry days**
- **frost free nights**
- **pests**

Projected impact of climate change on agricultural yields



1991-2012 compared to 1901-1960

Observed Increase in Frost-Free Season Length

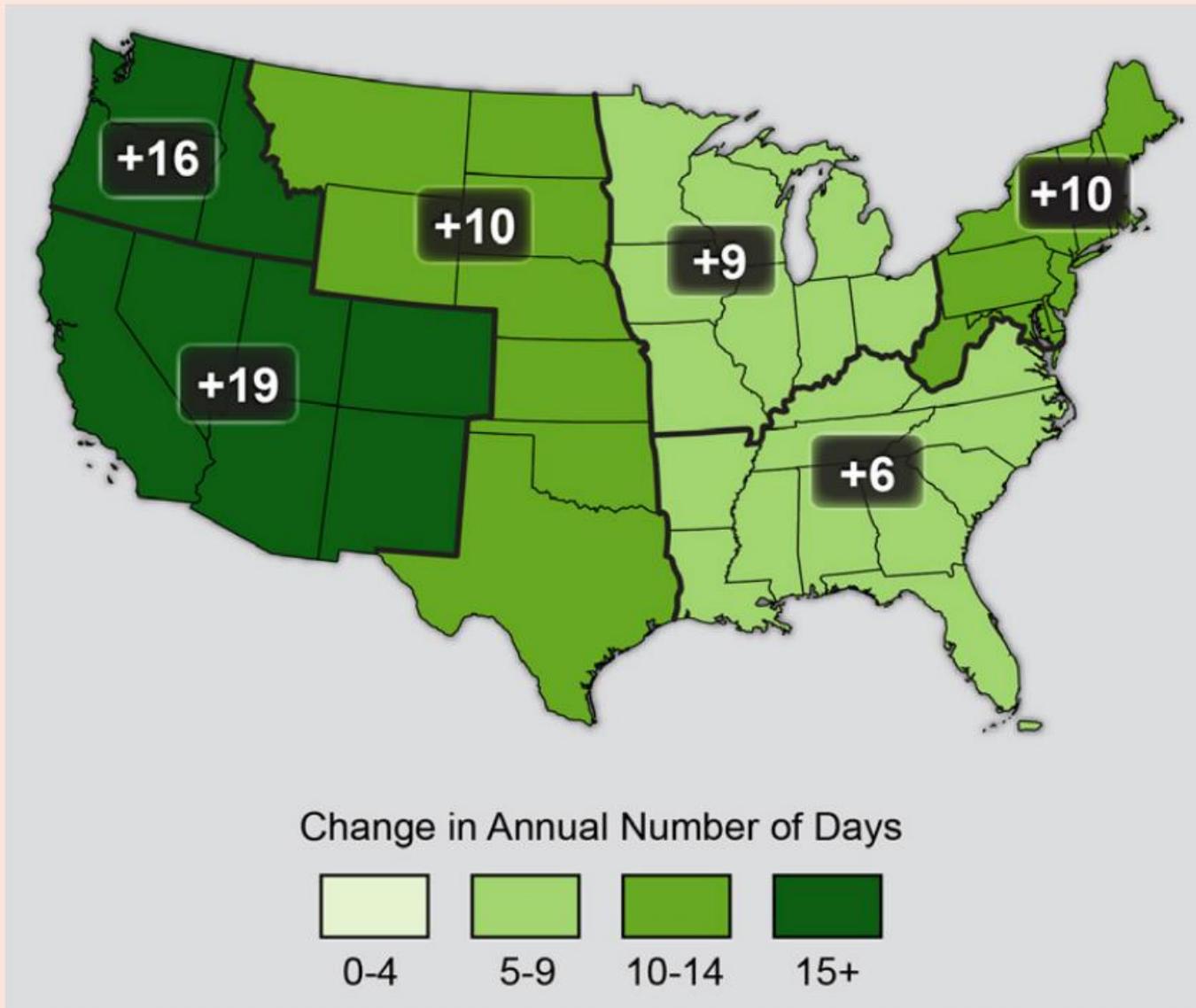
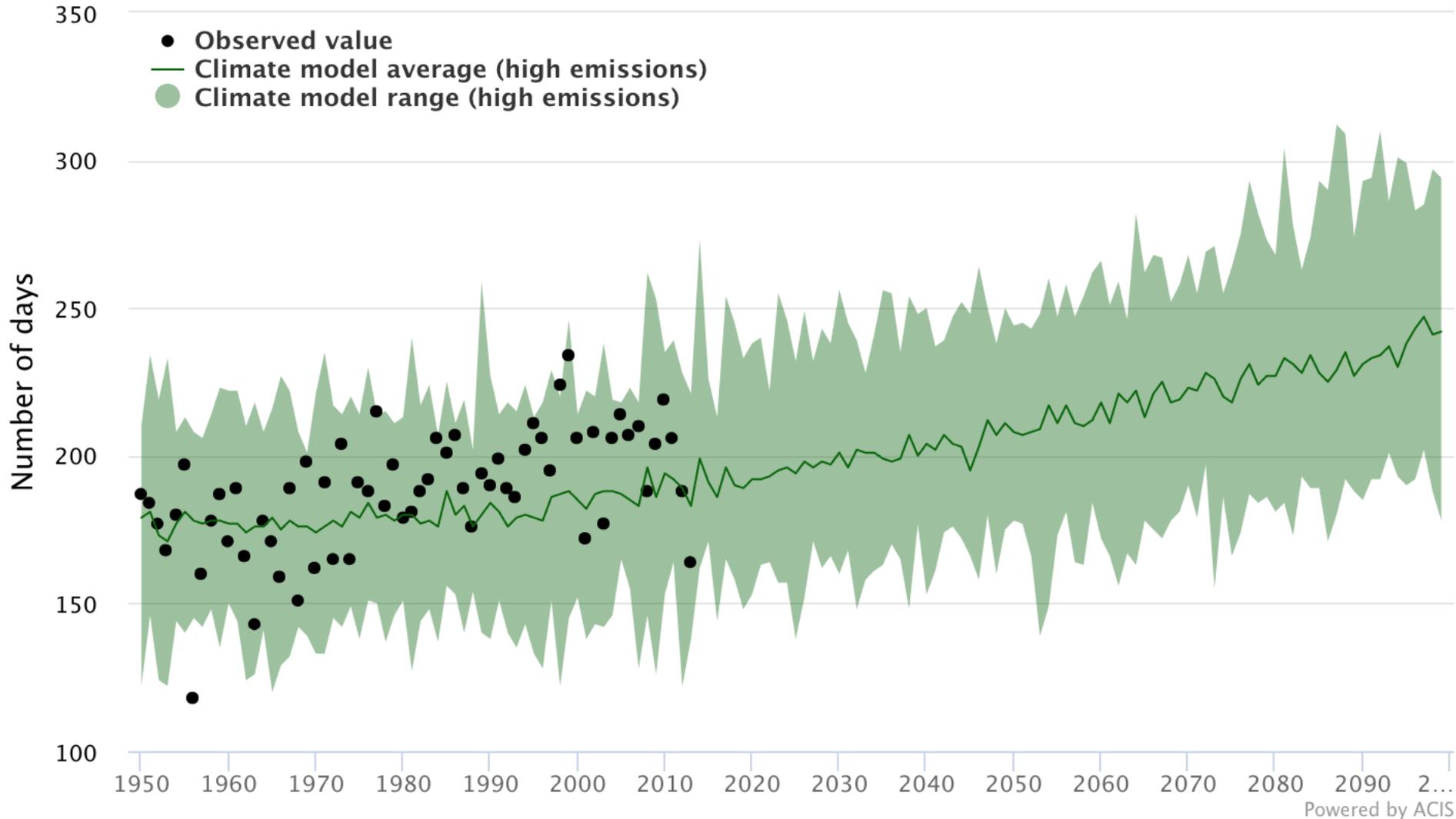


Figure 2.10. The frost free season length, defined as the

Growing Season – Frederick County, MD



Powered by ACIS

UN IPCC COP24

United Nations - Intergovernmental Panel on Climate Change

24th Conference of the Parties

Poland – December 2018

“When it comes to promises to begin cutting the greenhouse gas emissions that fuel climate change, the world remains well off target. We are in trouble. We are in deep trouble with climate change. It is hard to overstate the urgency of our situation.”

United Nations Secretary General António Guterres

December 4, 2018

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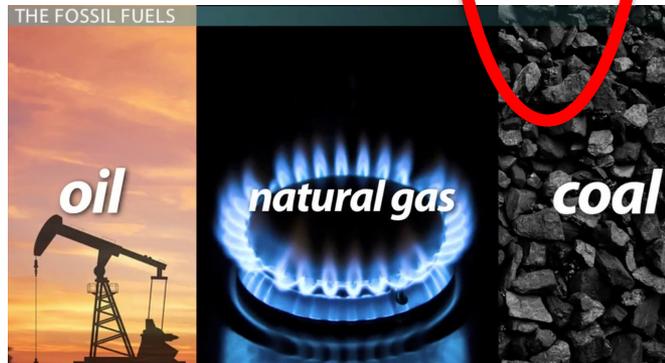
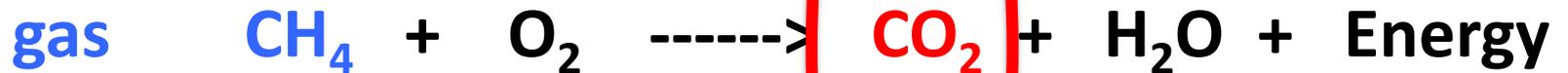
- Questions

Part 3 - Solutions

REDUCE CARBON EMISSIONS

45% by 2030

carbon neutral by 2050



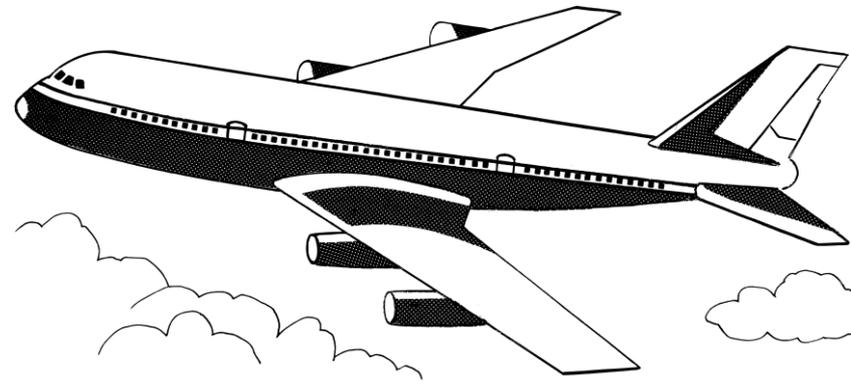
Carbon Emissions



**the average
American
emits 20 tons of
carbon/year**

**Burning 1 gallon of gasoline
emits 20 lbs of CO₂**

**DC to Orlando
emits 1000 lbs of CO₂**



2017 Electricity Fuel Source

RENEWABLE

5.0%

NUCLEAR

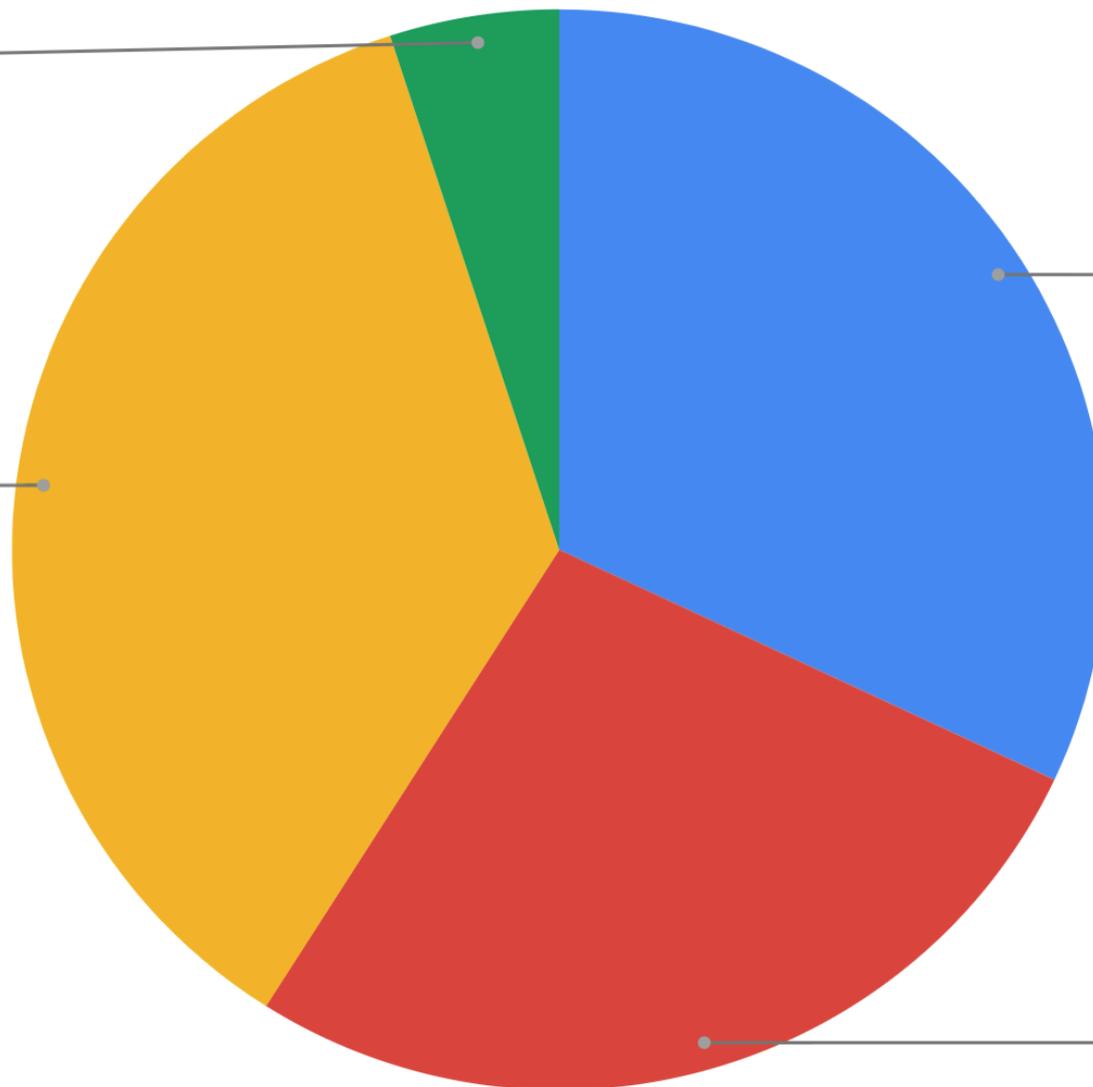
36.0%

COAL

32.0%

GAS

27.0%



Personal Solutions



**Everything
has an
energy cost**



Personal Solutions

Reduce
comes first



USE LESS STUFF

Personal Solutions

- Change bulbs to LED
- Buy local
- Eat less meat
- Plant a vegetable garden
- Avoid single-use items
- Adjust your thermostat
- Add blinds/curtains
- Remove your garage refrigerator
- Walk & carpool more



\$50
rebate



Personal Solutions



- Plant trees on your property
- Buy carbon offsets when you fly
- Insulate your house more
- Buy energy efficient appliances
- Buy an electric car
- Get solar on your roof
- Choose renewable electricity generation



Corporate Solutions

Companies that are carbon neutral

UPS

Google

Microsoft

Dell

Coca-Cola

PepsiCo

AVIS

Lyft

Government Solutions

1. Switch to renewable energy
2. Smart Grid technology
3. Improve Energy Efficiency
4. More Public Transportation
5. Reforestation
6. Carbon Tax & Dividend



RACE to ZERO EMISSIONS

US Department of Transportation

Government Solutions

Maryland Clean Energy Jobs Act

100% Renewable Energy Goals

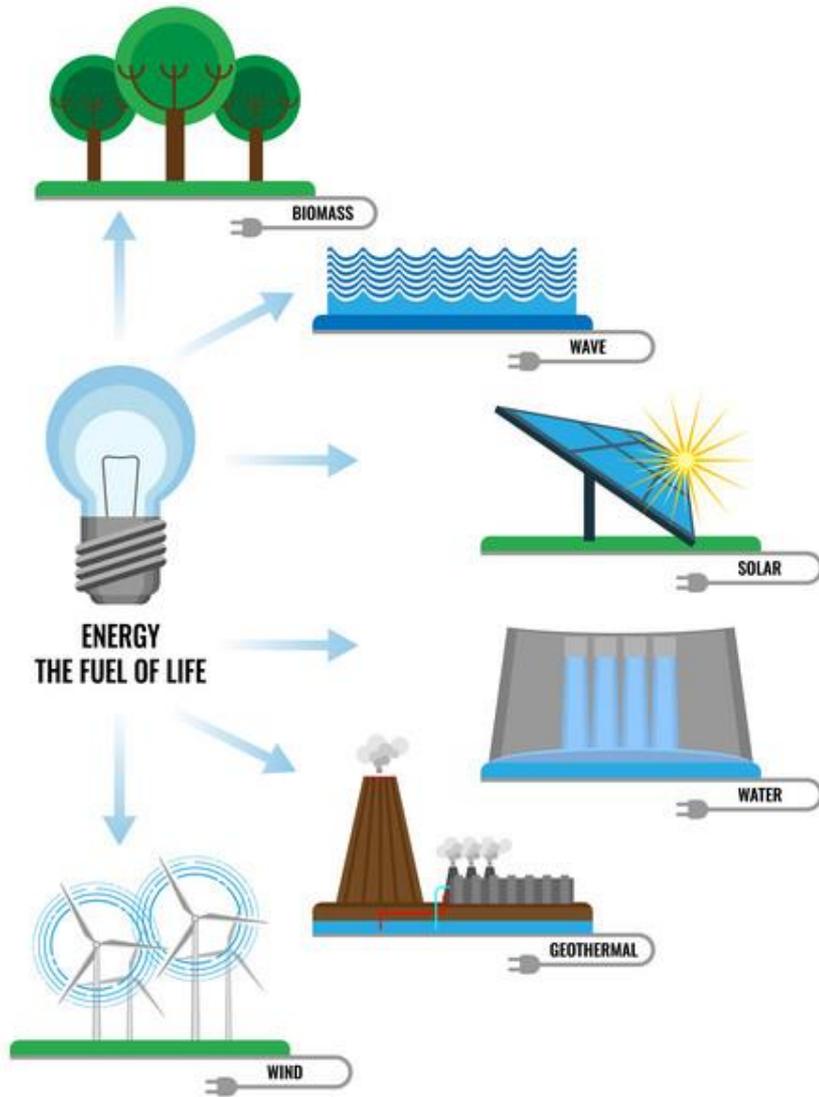
- Colorado 2035
- Maryland 2035
- New Hampshire 2040
- Hawaii 2045*
- Washington 2045
- California 2045
- Massachusetts 2050
- Pennsylvania 2050

Middletown – solar array

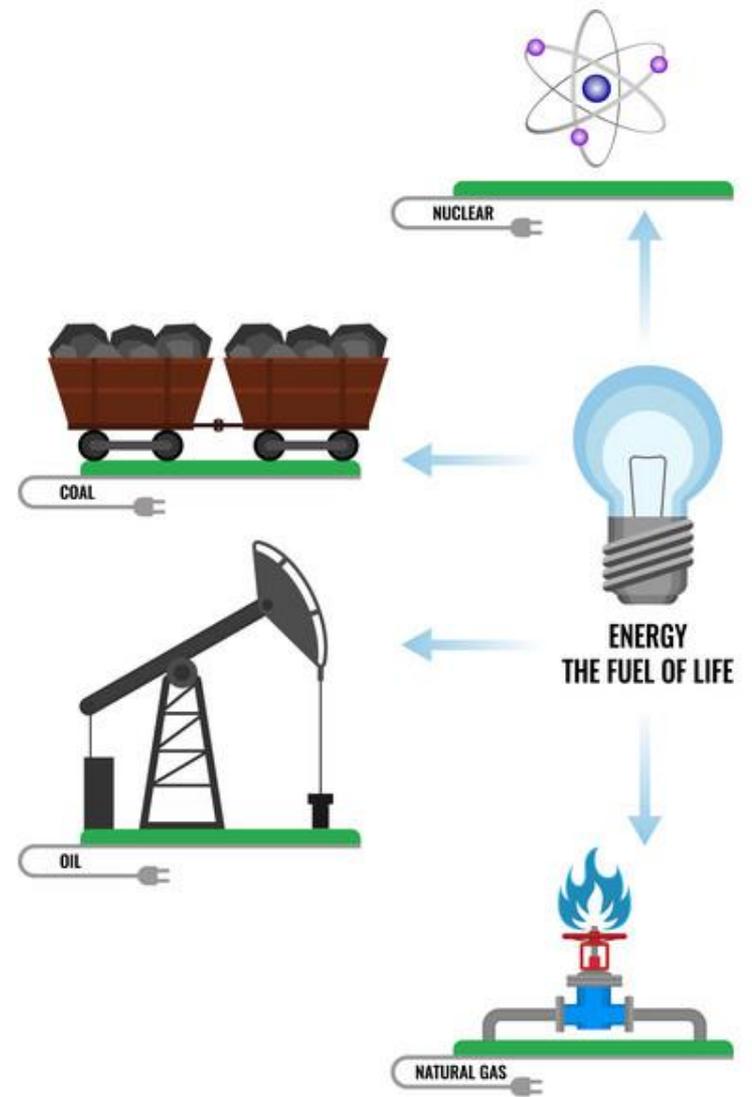


ENERGY SOURCES

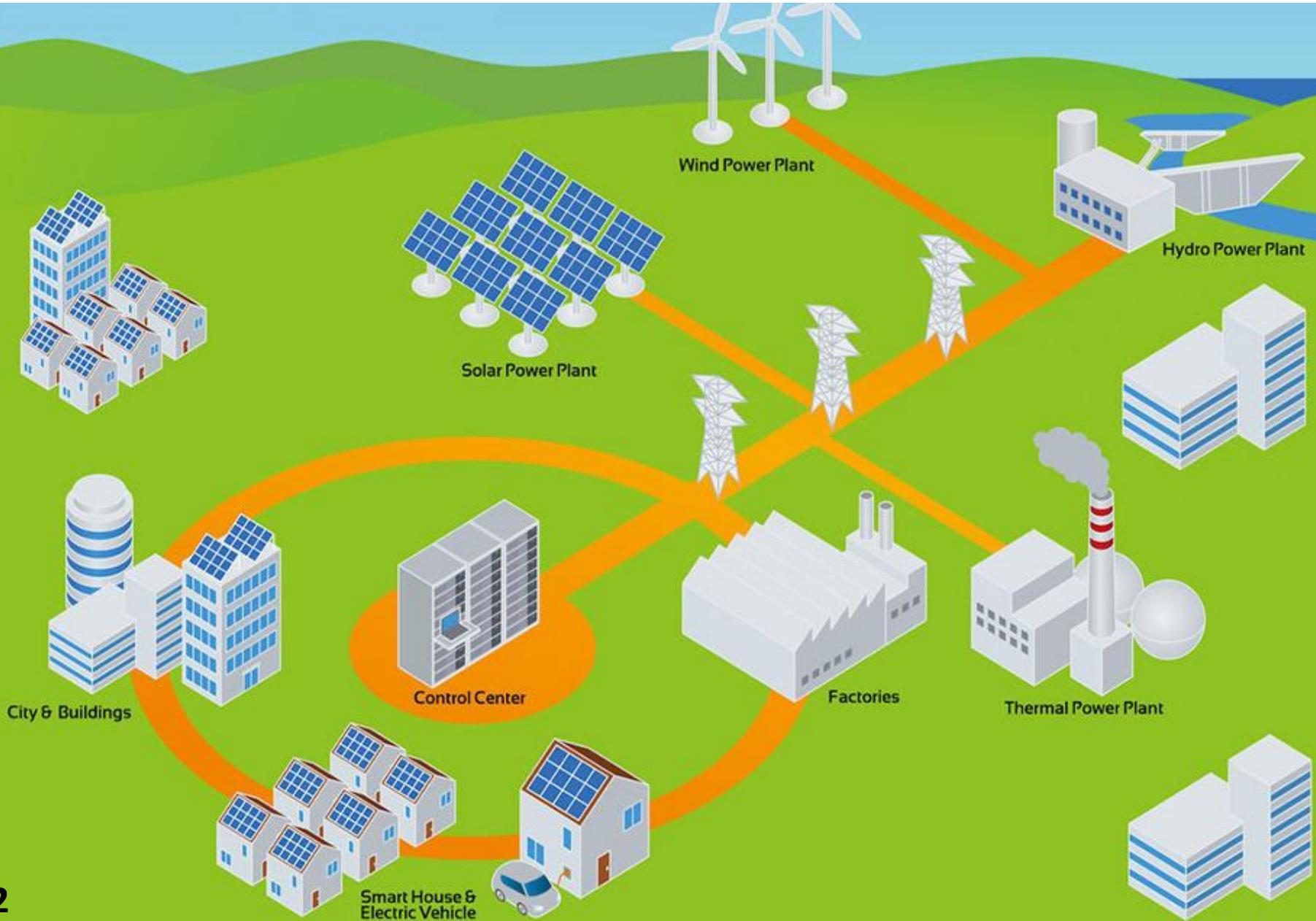
RENEWABLE ENERGY



NON-RENEWABLE ENERGY

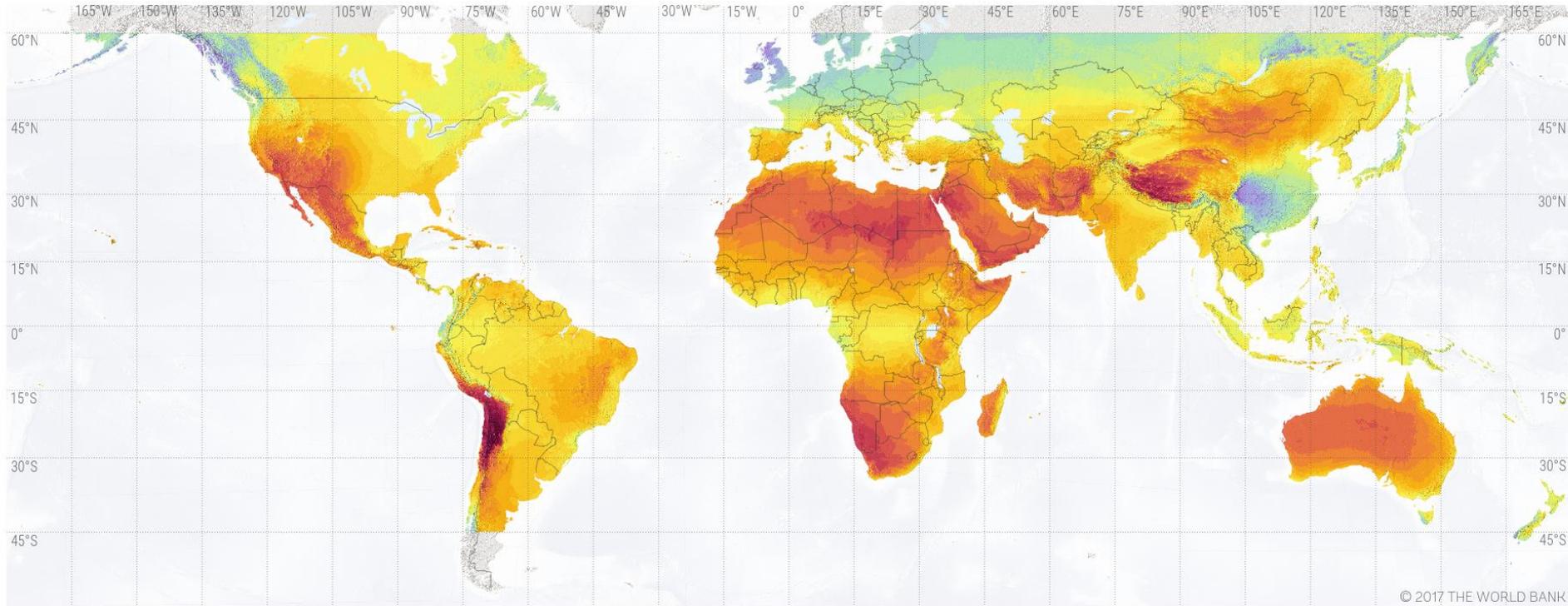


Renewable Energy & Smart Grid

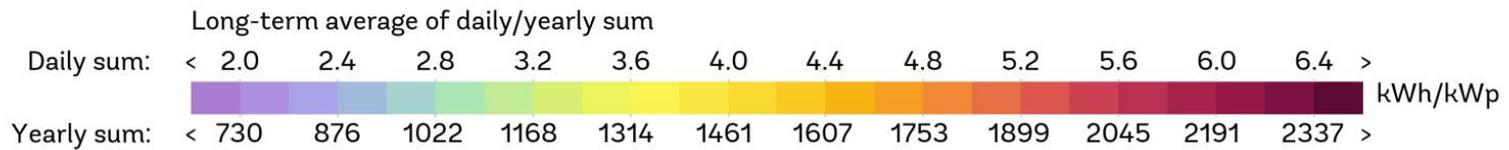


Solar Energy

SOLAR RESOURCE MAP PHOTOVOLTAIC POWER POTENTIAL

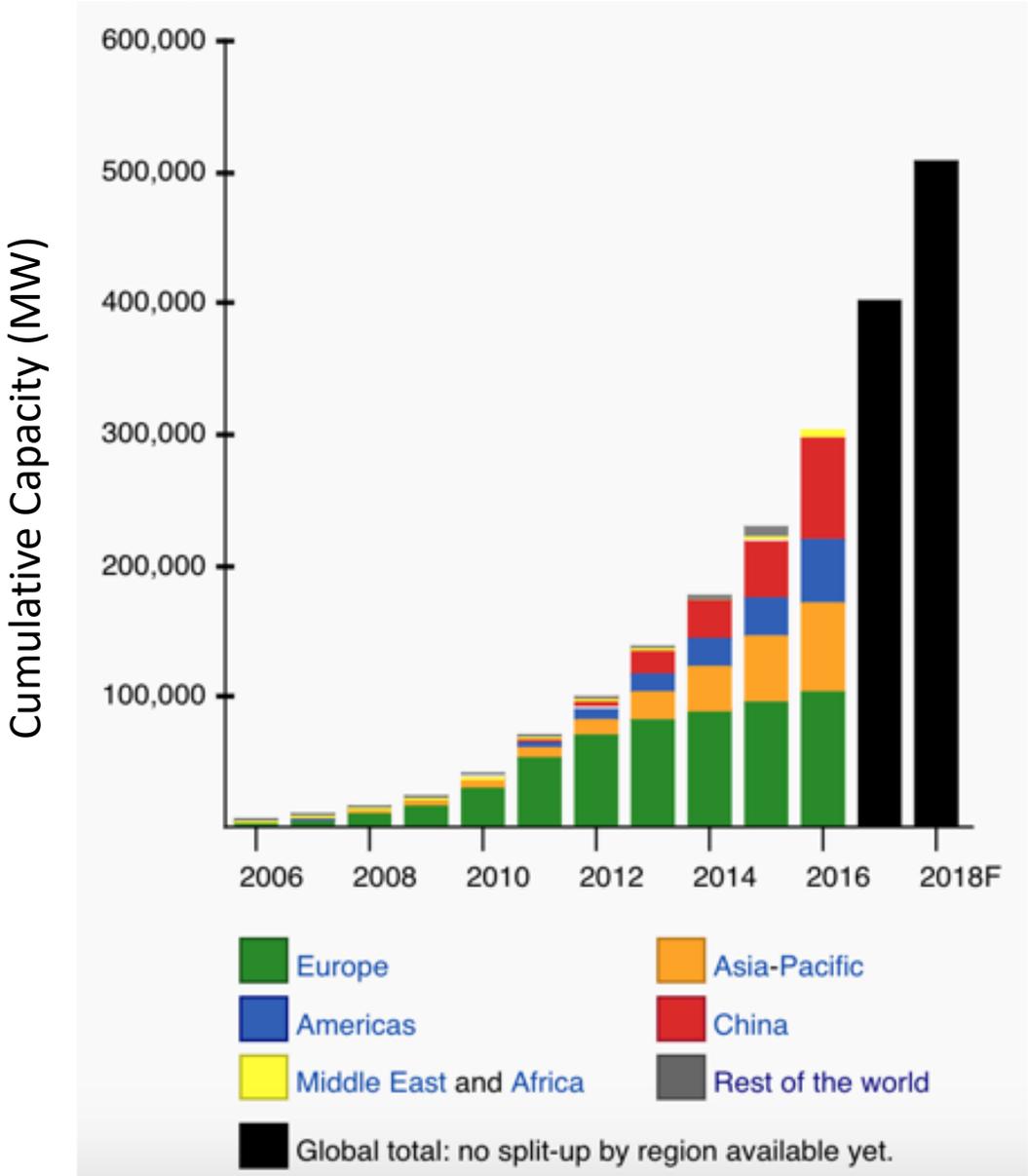


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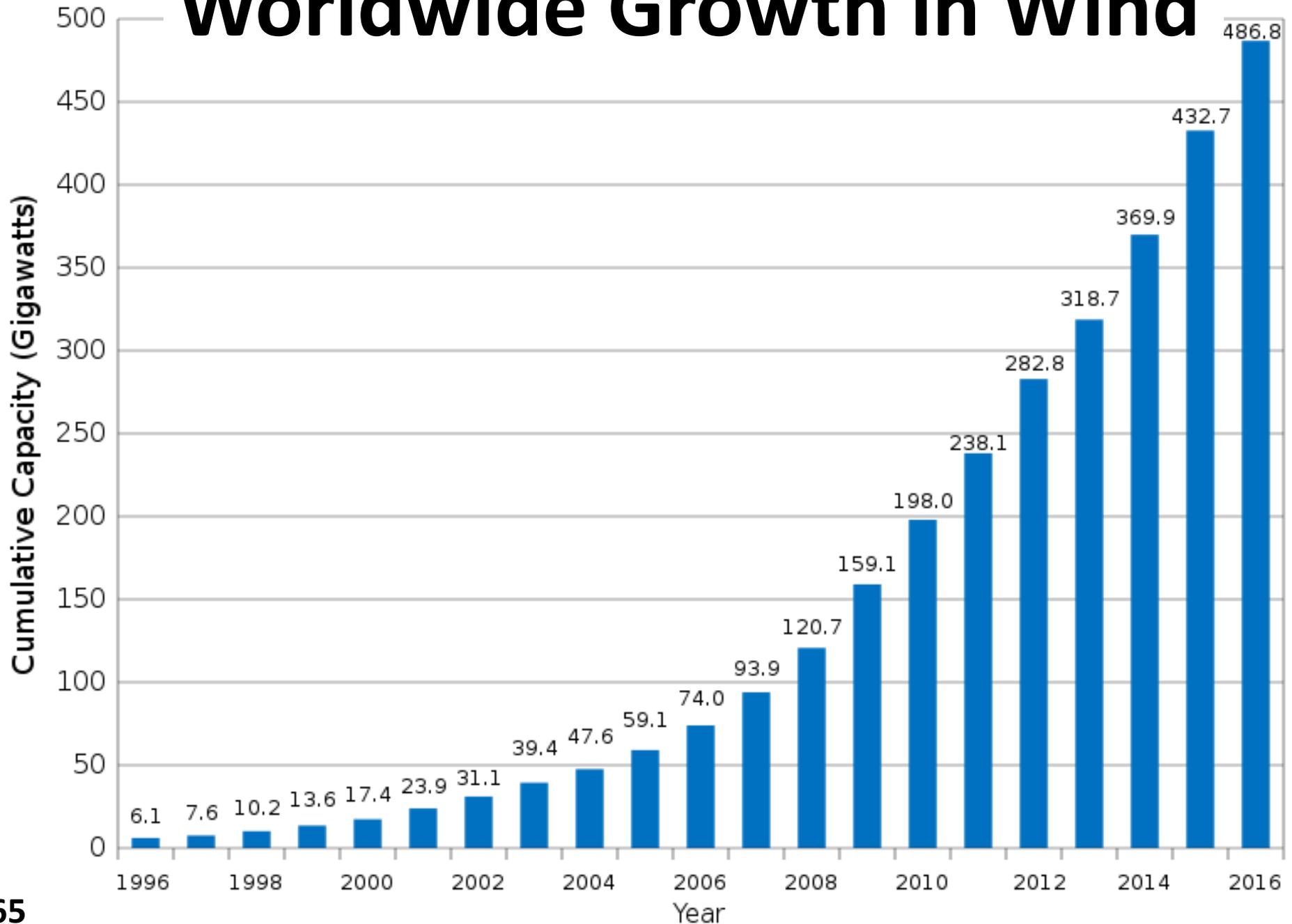


This map is published by the World Bank Group, funded by ESMAP, and prepared by Solargis. For more information and terms of use, please visit <http://globalsolaratlas.info>.

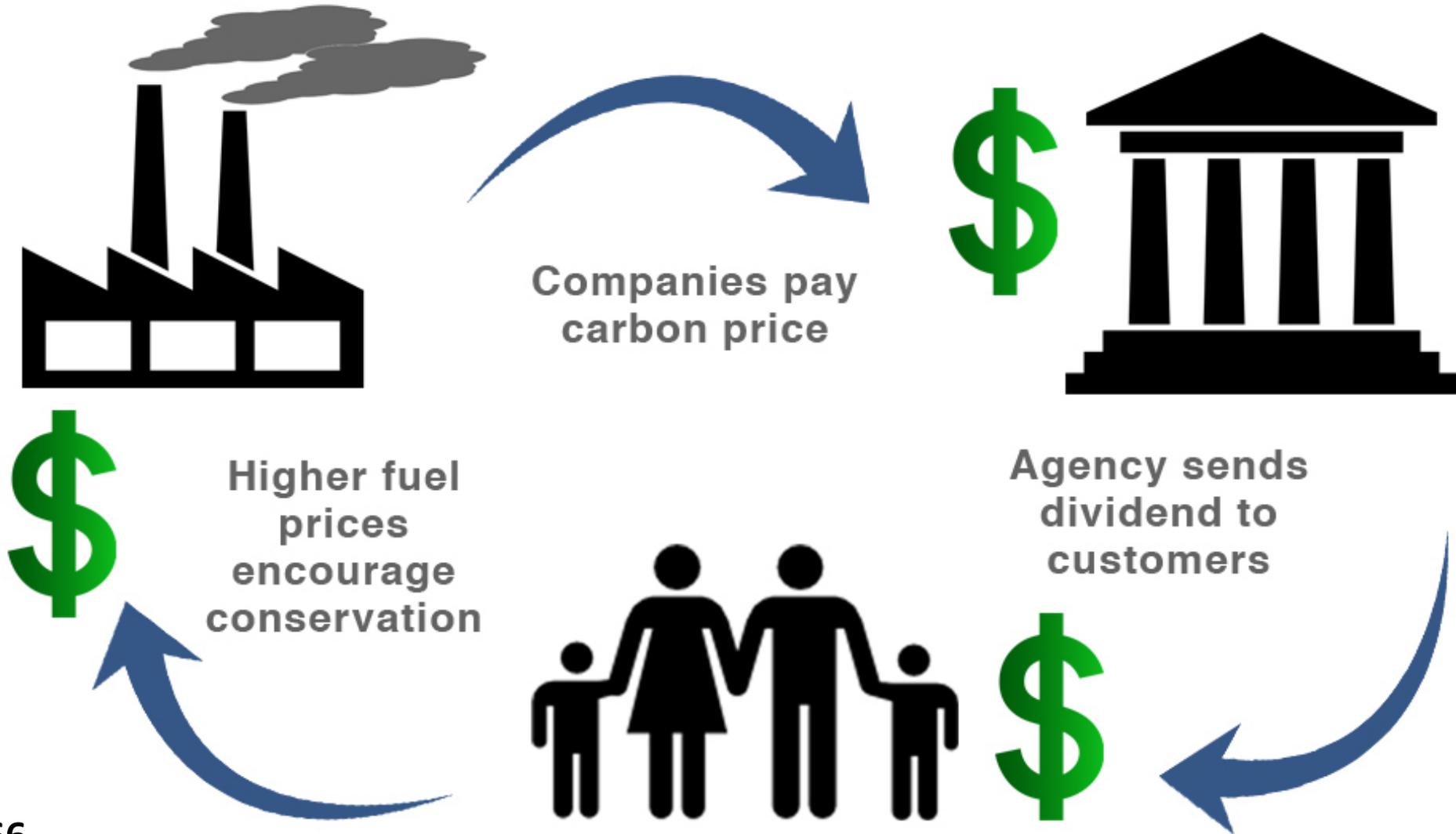
Worldwide Growth in Solar



Worldwide Growth in Wind



Carbon Tax & Dividend



Energy Innovation and Carbon Dividend Act

US House of Representatives – HR 7173

November 28, 2018

bipartisan Climate Solutions Caucus



“To create a Carbon Dividend Trust Fund for the American people in order to encourage market-driven innovation of clean energy technologies and market efficiencies which will reduce harmful pollution and leave a healthier, more stable, and more prosperous nation for future generations.”

The Paris Agreement

UN Framework Convention on Climate Change

December 12, 2015

COP21

- **Signed by 195 nations**

“Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change”



Must we change?

Can we change?

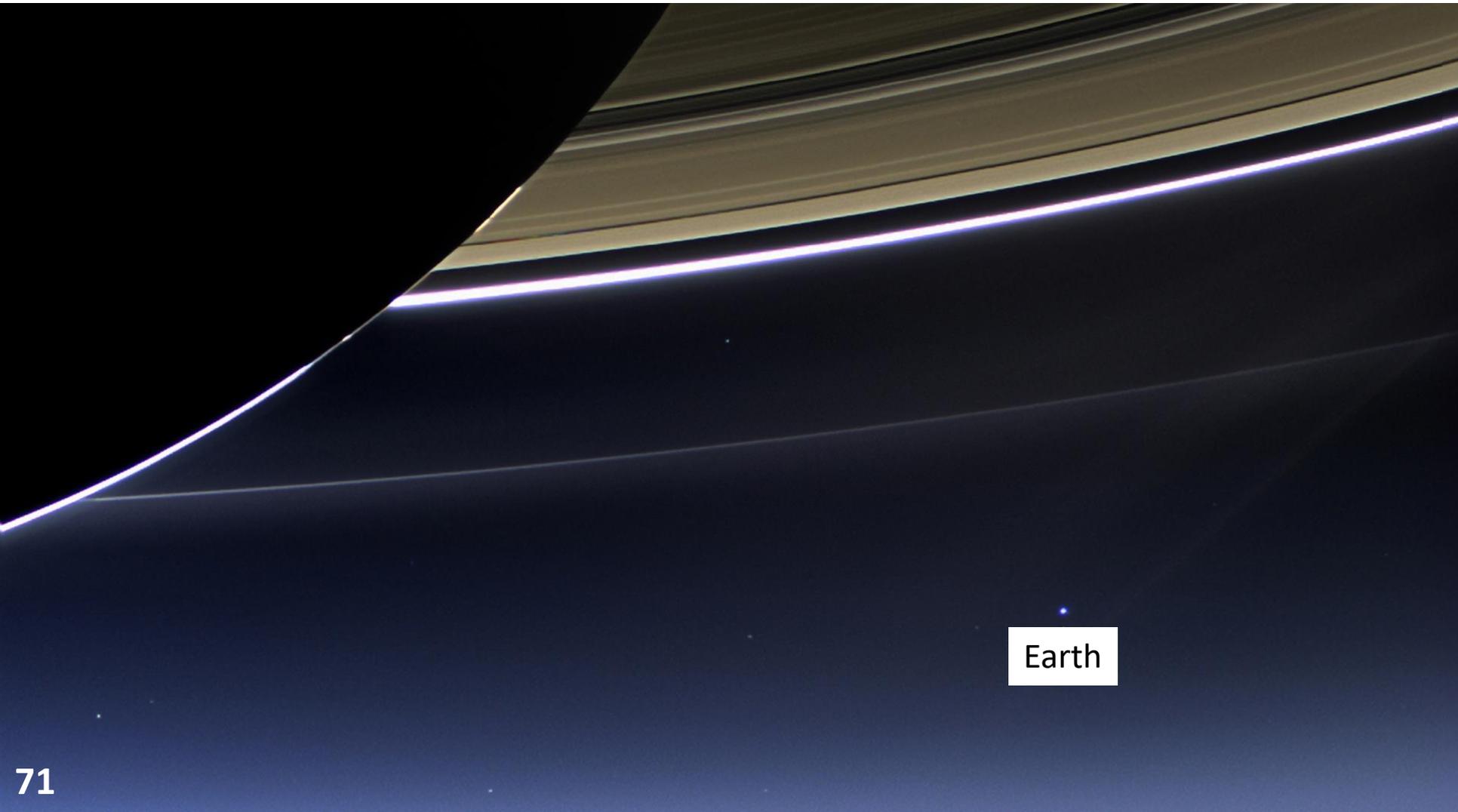
Will we change?

Must we change? YES!

Can we change? YES!

Will we change? YES!

Photo of Earth from Cassini Space Probe



Earth

Sources

- NOAA – National Oceanic & Atmospheric Administration
- NASA – National Aeronautics & Space Administration
- DOE – Department of Energy
- EPA – Environmental Protection Agency
- CDC – Centers for Disease Control
- US GCRP – US Global Change Research Program
- NSIDC – National Snow & Ice Data Center
- Maryland Dept of the Environment
- National Geographic
- Cornell University
- UN – United Nations
 - WMO – World Meteorological Organization
 - IPCC – Intergovernmental Panel on Climate Change
- ESA – European Space Agency