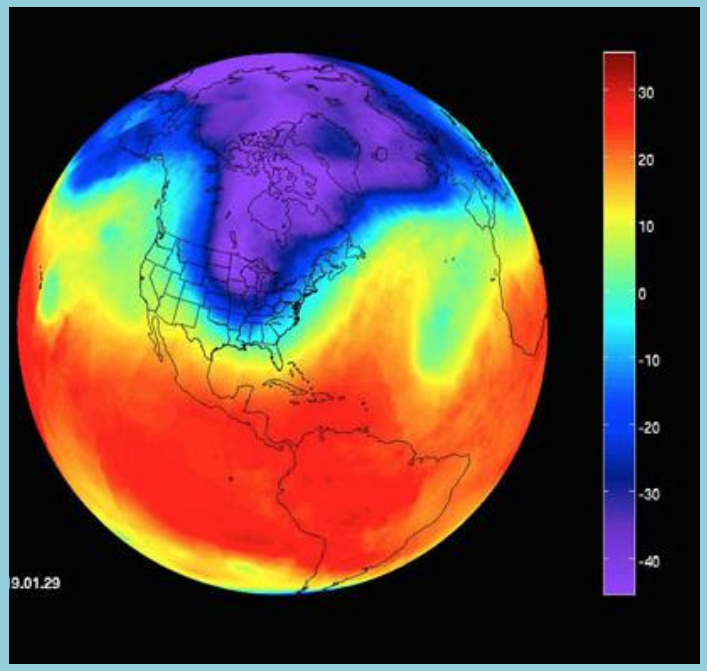

Meeting the Climate Change Challenge in the Pacific NW

Dr. Richard Gammon
UW Professor Emeritus
(gammon@u.washington.edu)

Bellingham City Club
Wednesday, February 27, 2019

"A clear and present danger, a grave and gathering threat…"

The Growing Certainty of IPCC Climate Models and Assessments

Relying on better and better climate models, the **Intergovernmental Panel on Climate Change** (IPCC) has expressed increasing confidence that human activity is driving global warming.

"It is **extremely likely** that human influence has been the dominant cause of the observed warming since the mid-20th century."

IPCC CONFIDENCE LEVEL: 95%

"Most of the observed increase in global average temperatures since the mid-20th century is **very likely** due to the observed increase in anthropogenic greenhouse gas concentrations."

IPCC CONFIDENCE LEVEL: 90%

"Most of the observed warming over the last 50 years is **likely** to have been due to the increase in greenhouse gas concentrations."

IPCC CONFIDENCE LEVEL: 66%

"The balance of evidence suggests that there is discernable human influence on global climate."

"It is not possible at this time to attribute all or even a large part of the observed global mean warming to the enhanced greenhouse effect on the basis of observational data currently available."

inside climate news

IPCC REPORT #2

1995

"The balance of evidence suggests that there is discernable human influence on global climate."

IPCC REPORT #1

1990

"It is not possible at this time to attribute all or even a large part of the observed global mean warming to the enhanced greenhouse effect on the basis of observational data currently available."

IPCC REPORT #4

2007

"Most of the observed increase in global average temperatures since the mid-20th century is **very likely** due to the observed increase in anthropogenic greenhouse gas concentrations."

IPCC CONFIDENCE LEVEL: 90%

IPCC REPORT #3

2001

"Most of the observed warming over the last 50 years is **likely** to have been due to the increase in greenhouse gas concentrations."

IPCC CONFIDENCE LEVEL: 66%

The Growing Certainty of IPCC Climate Models and Assessments

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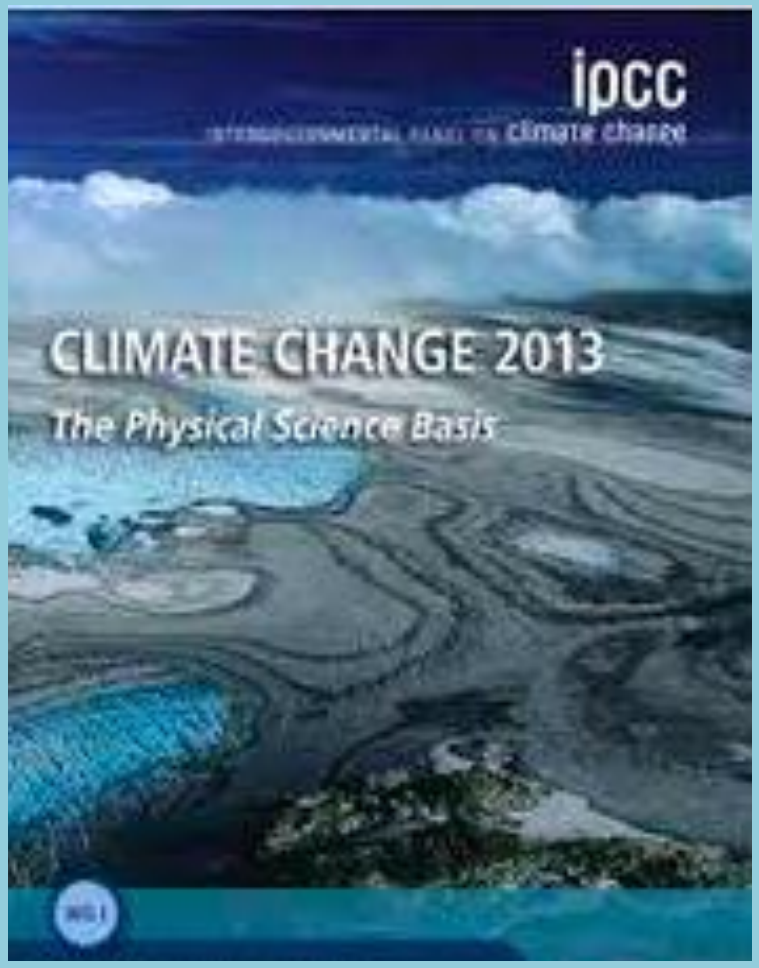
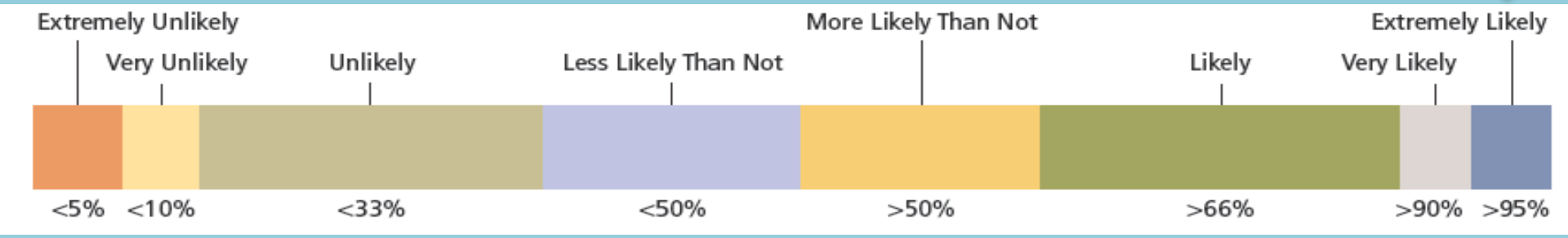


IPCC Summary for Policymakers

(Released 9.29.13)

It is extremely likely ***(95-100% confidence)*** that human influence has been the dominant cause of the observed warming since the mid-20th century.

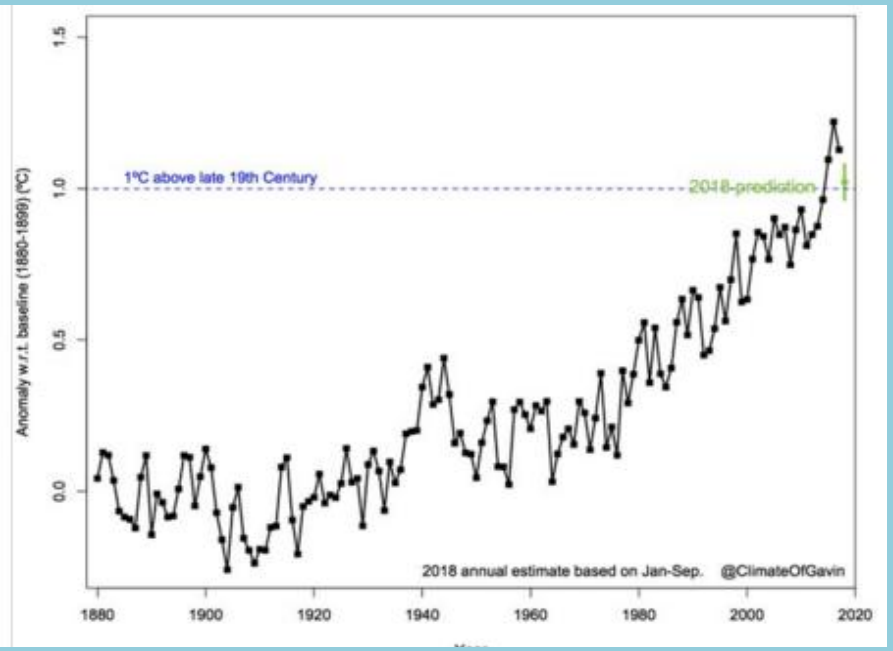
Stronger language, greater certainty

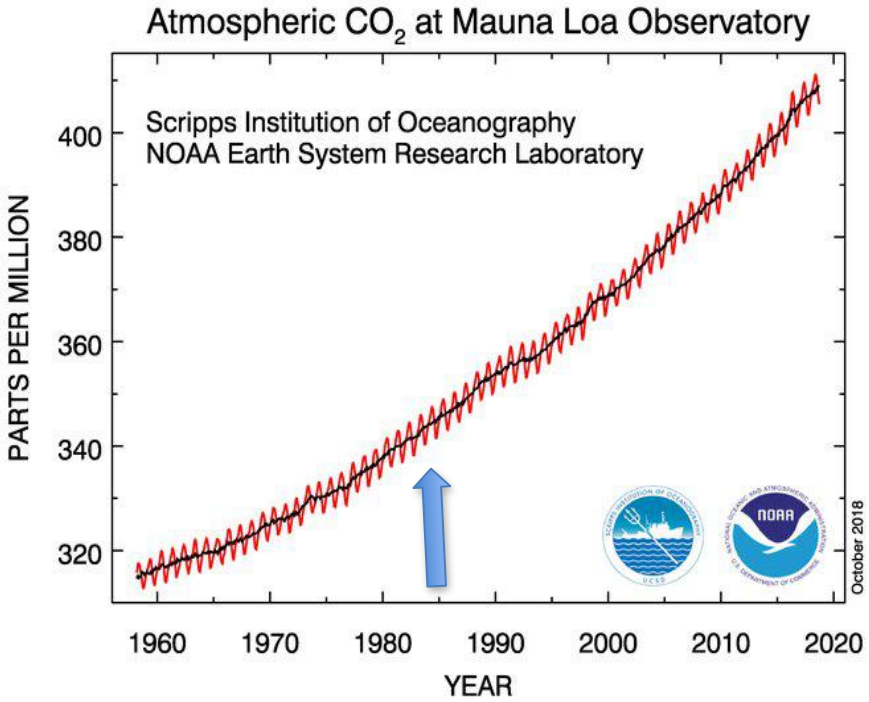


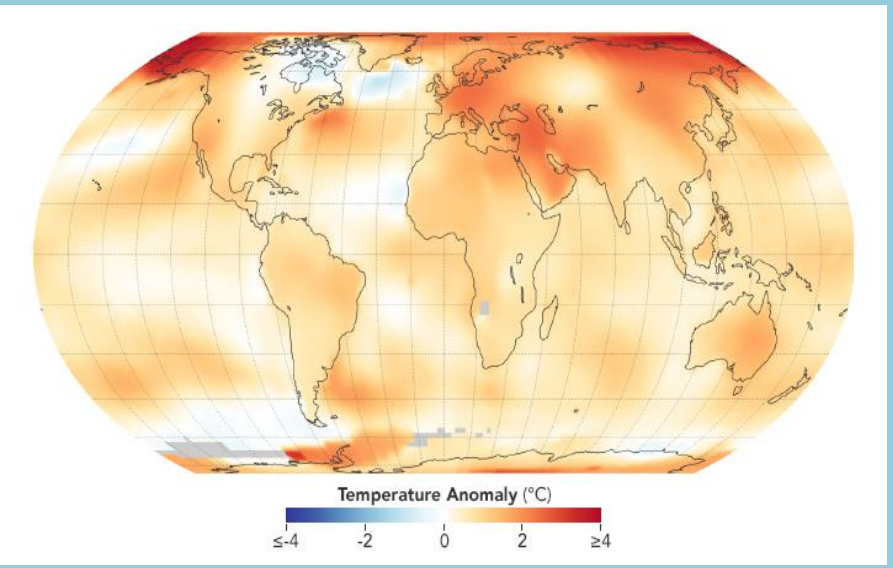
Basic science of human caused climate change is no longer in question

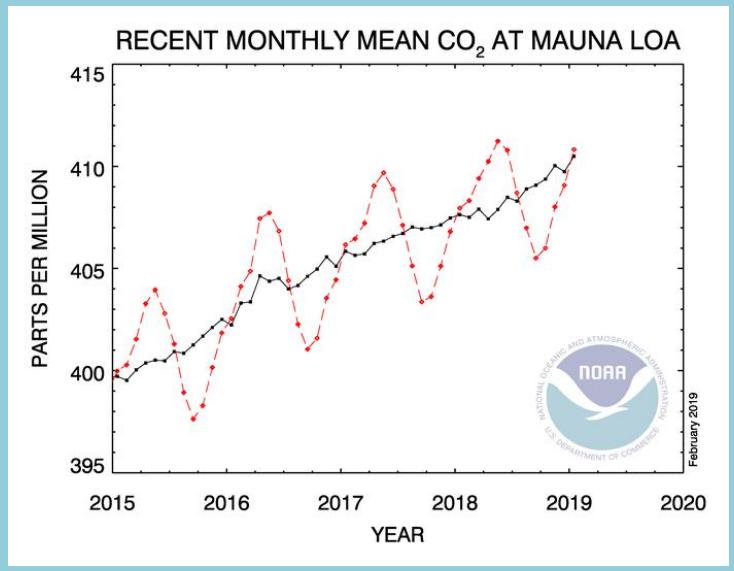
"Human-caused climate change now has a greater degree of scientific certainty than the long-accepted fact that smoking cigarettes causes cancer" (Gina McCarthy, former EPA Administrator)

A person is entitled to her own opinions, but not her own facts





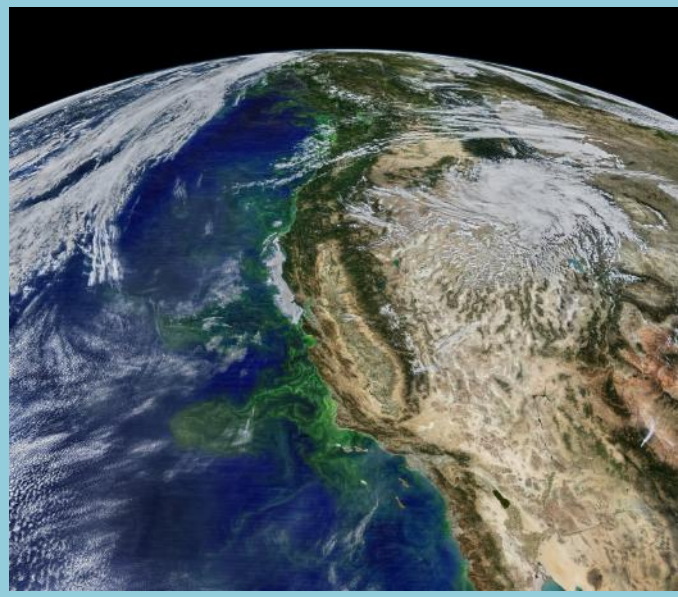


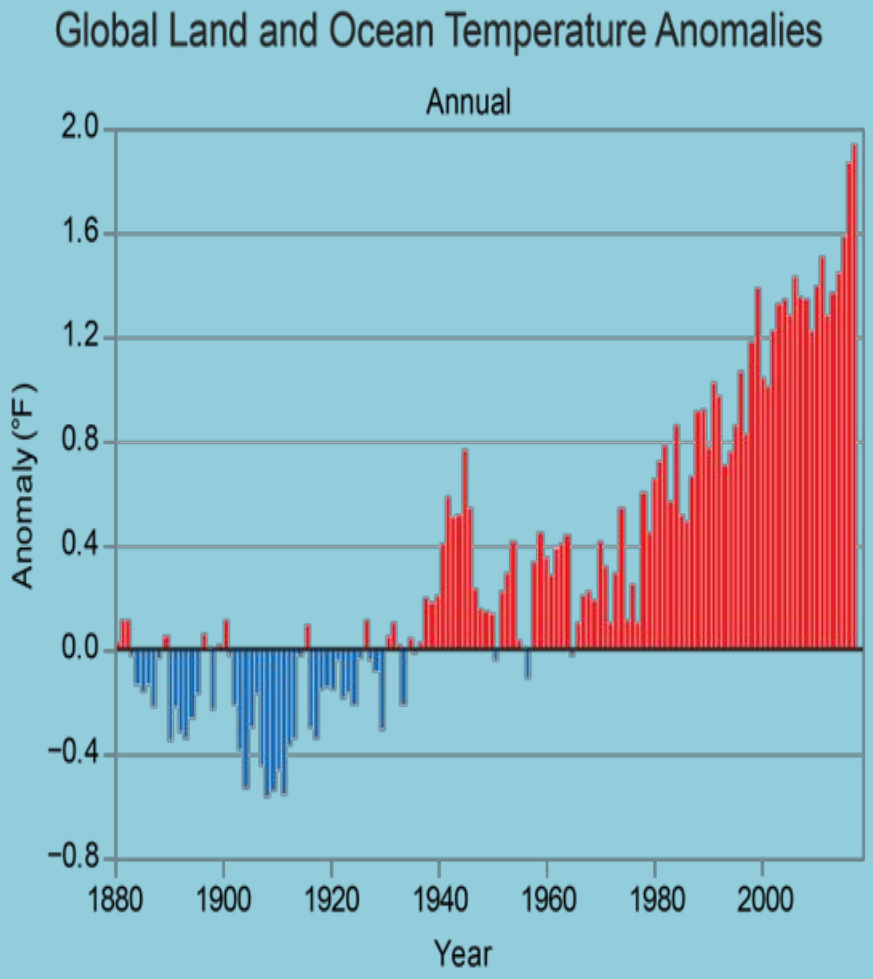


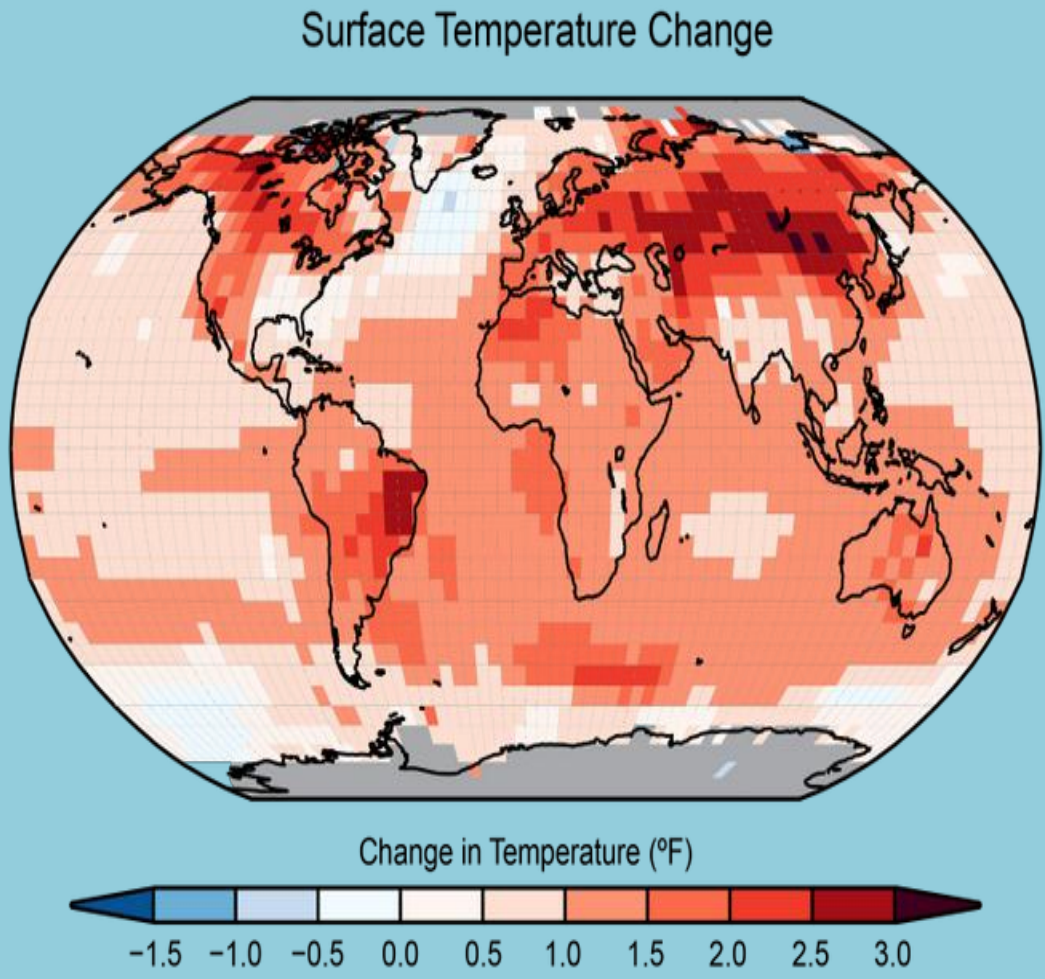
Global temp anomaly 2018

Latest US National Climate Assessment (2018)

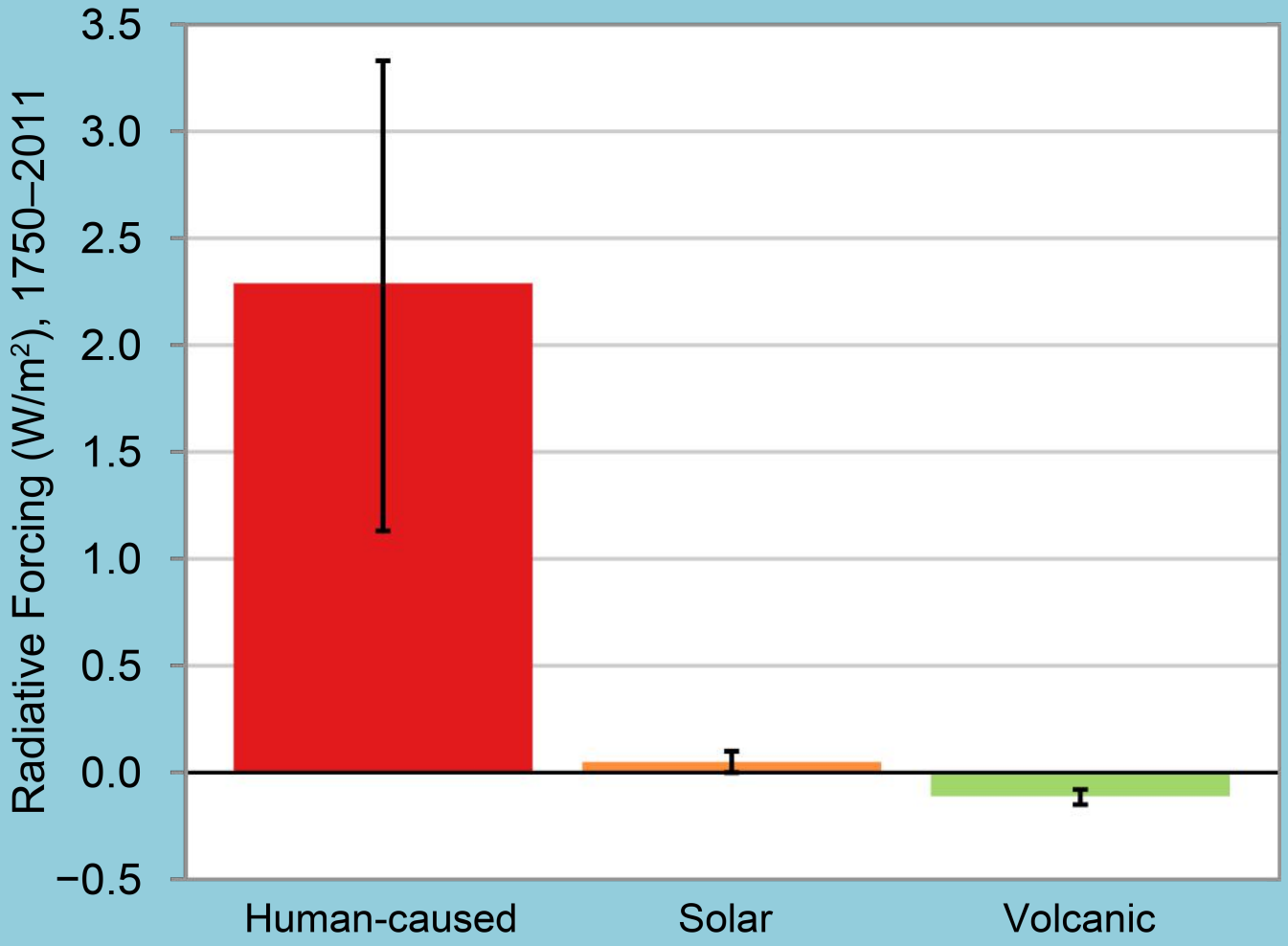
Chapter I: Climate Science Special Report





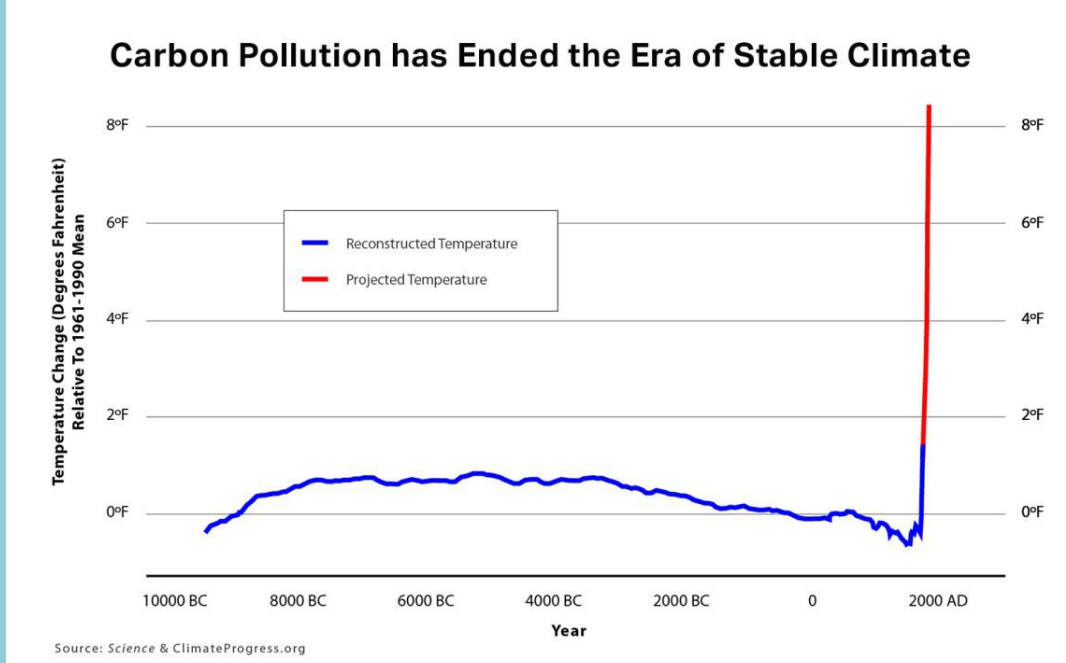


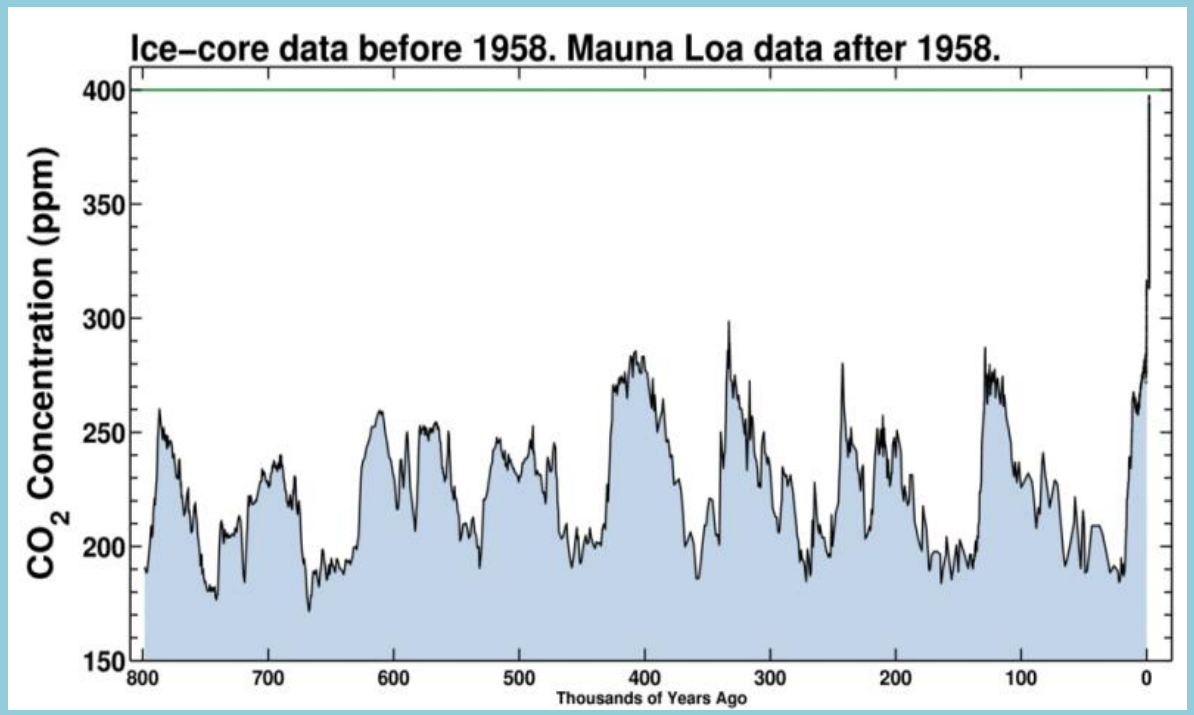
"Global surface air temperature has increased by about 1.8°F (1.0°C) over the last 115 years (1901–2016). **This period is now the warmest in the history of modern civilization.** … the last three years have been the warmest years on record for the globe". (CSSR).



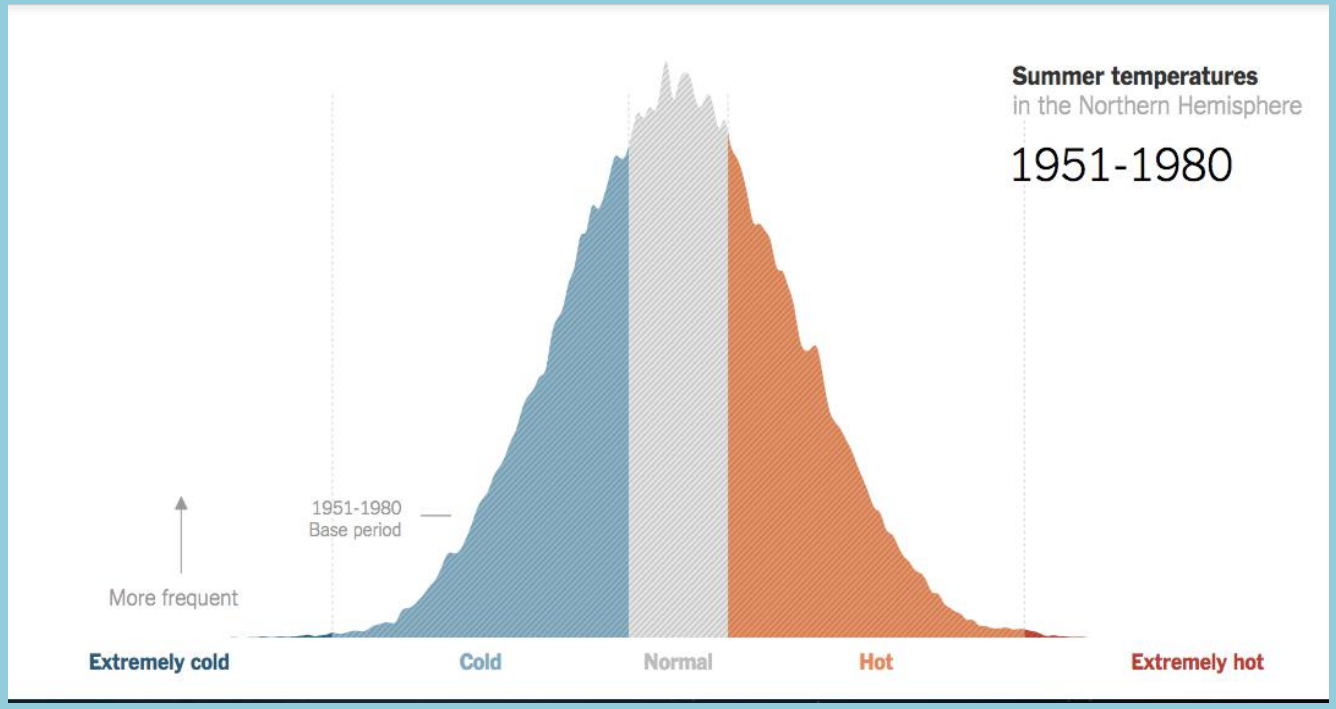
"Based on extensive evidence, it is **extremely likely that human activities, especially emissions of greenhouse gases, are the dominant cause of the observed warming since the mid-20th century**. For the warming over the last century, **there is no convincing alternative explanation**". (CCSR)

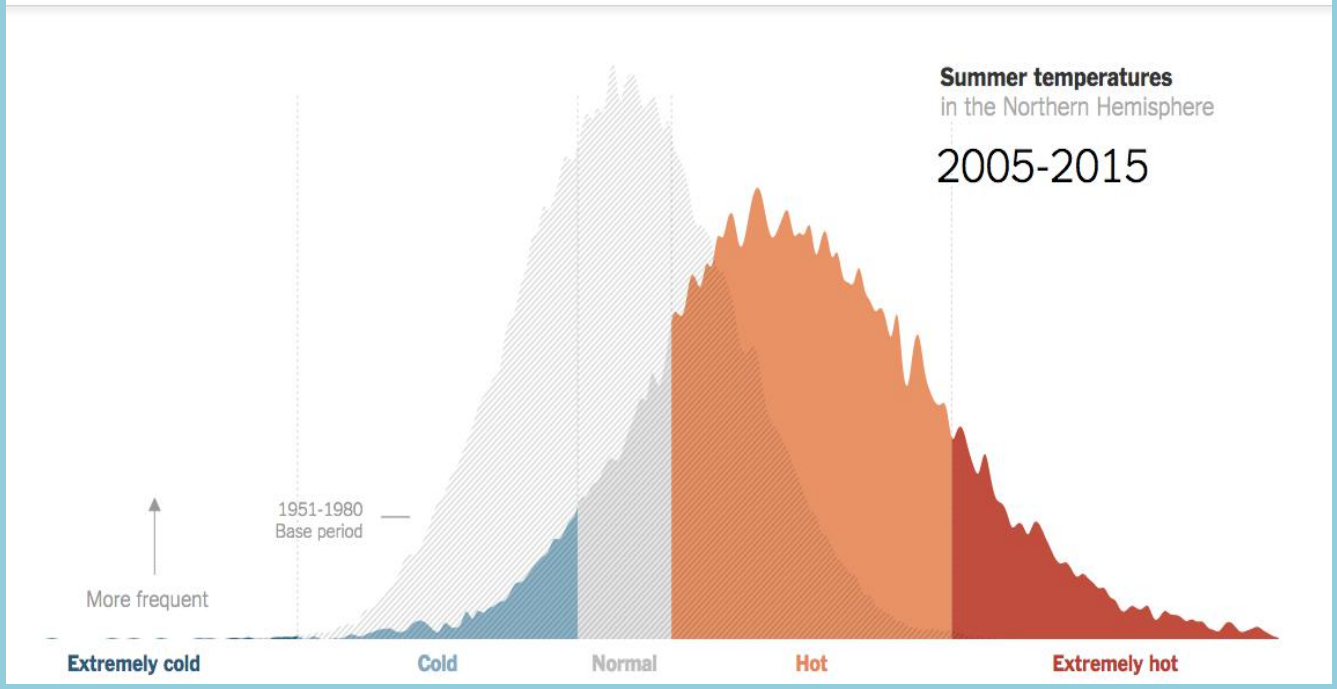
In global temperature, we are now 1 oC (2 oF) warmer than pre-industrial… back to a prehistoric time.. long before the rise of cities, before written language, before agriculture.



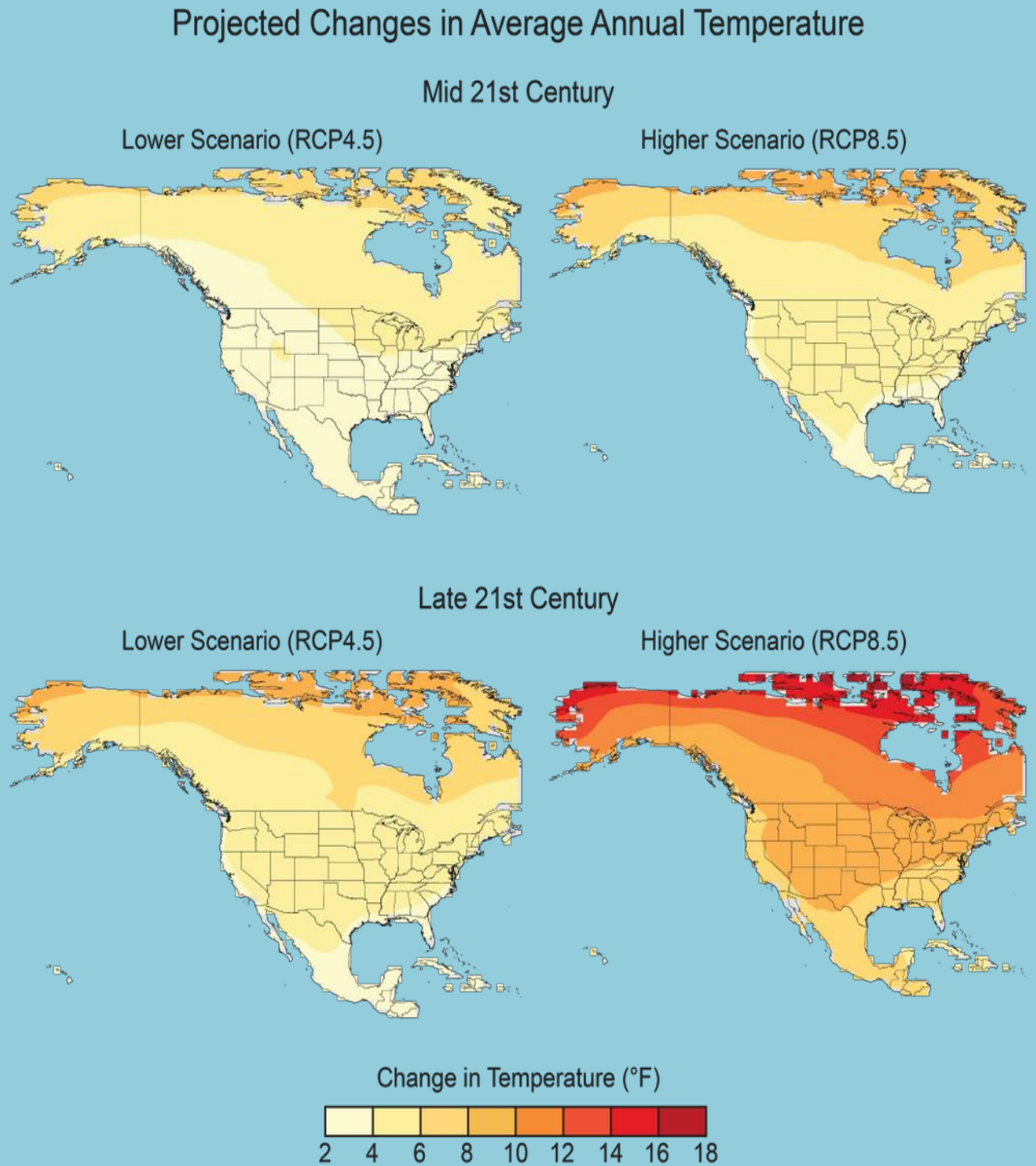


Measured atmospheric CO2 over the past 800,000 yrs of ice-age cycles





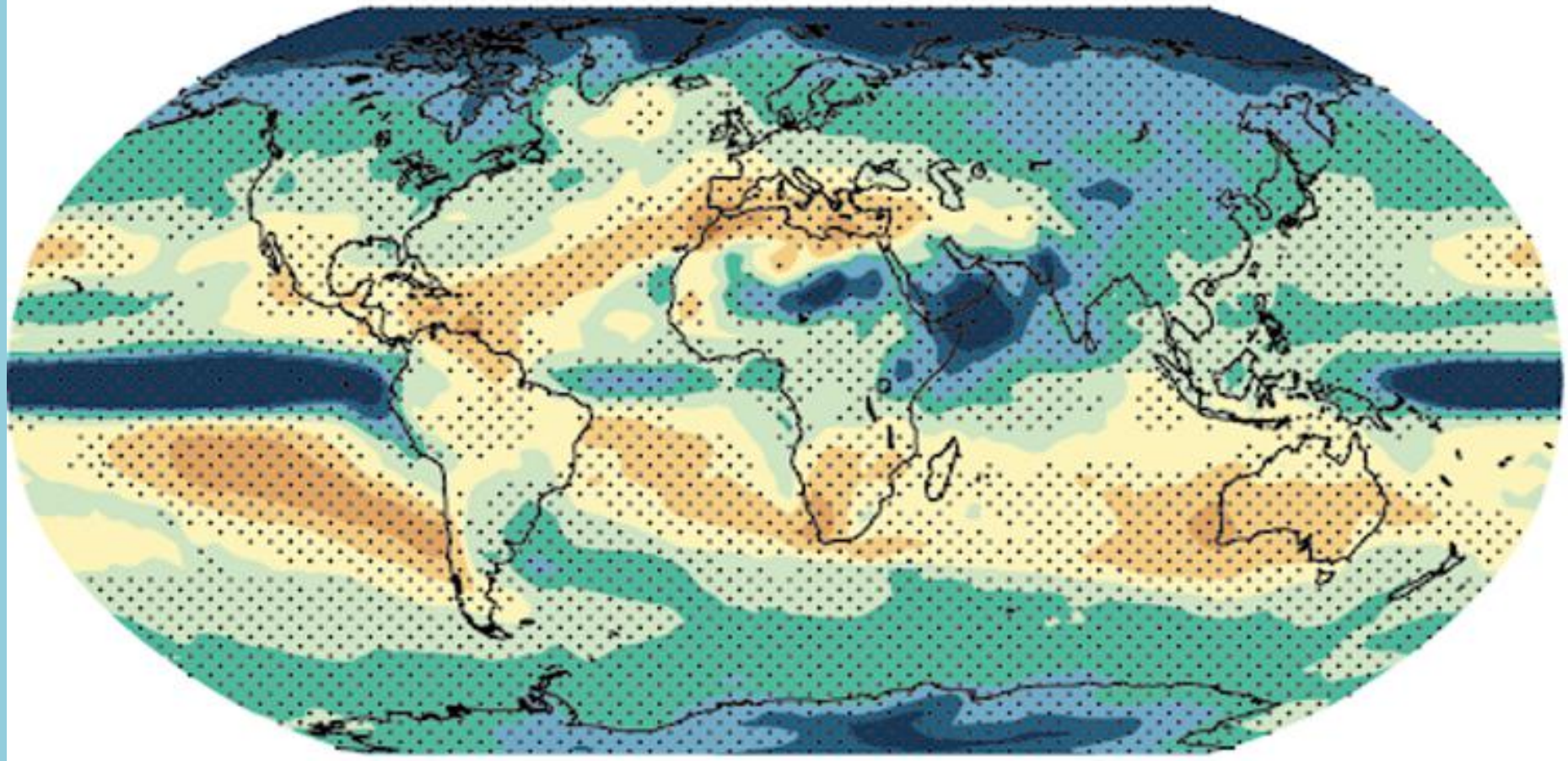
Rapid warming of the Northern Hemisphere land in the past decade

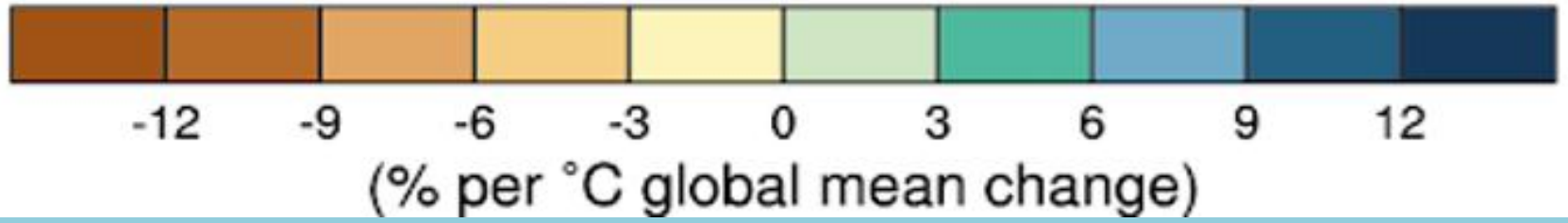


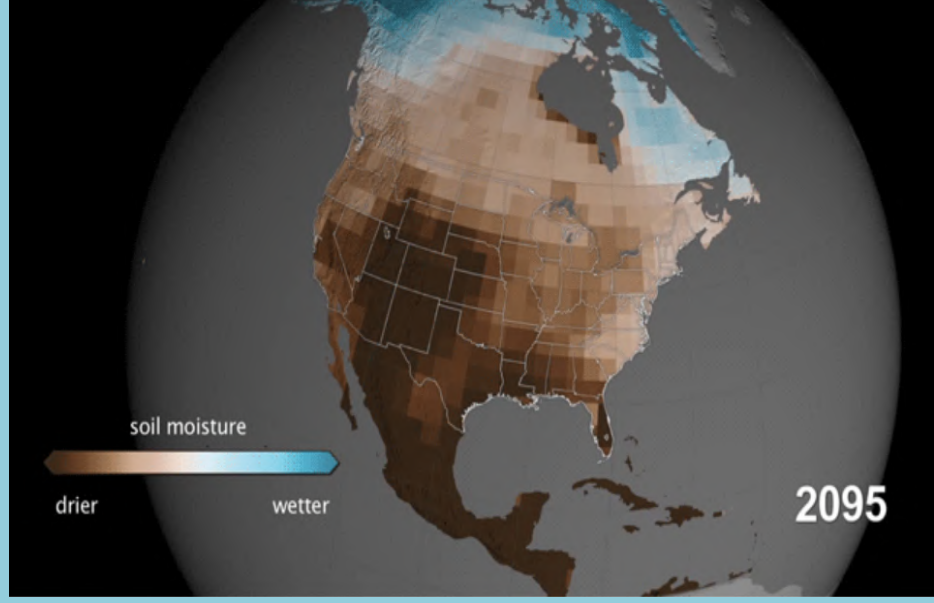
"Annual average temperature over the United States has increased by 1.8°F (1.0°C) for the period 1901–2016; over the next few decades, annual average temps are expected to rise by 2.5°F **under all plausible future climate scenarios**" CSSR.

Precipitation scaled by global T (% per °C)

2081-2100

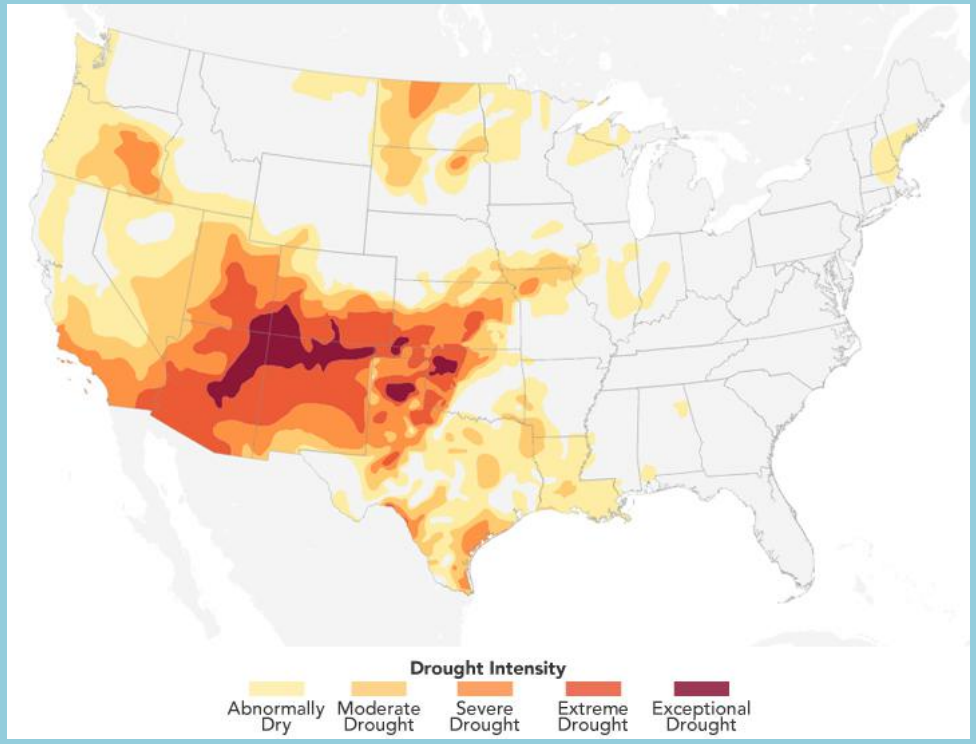




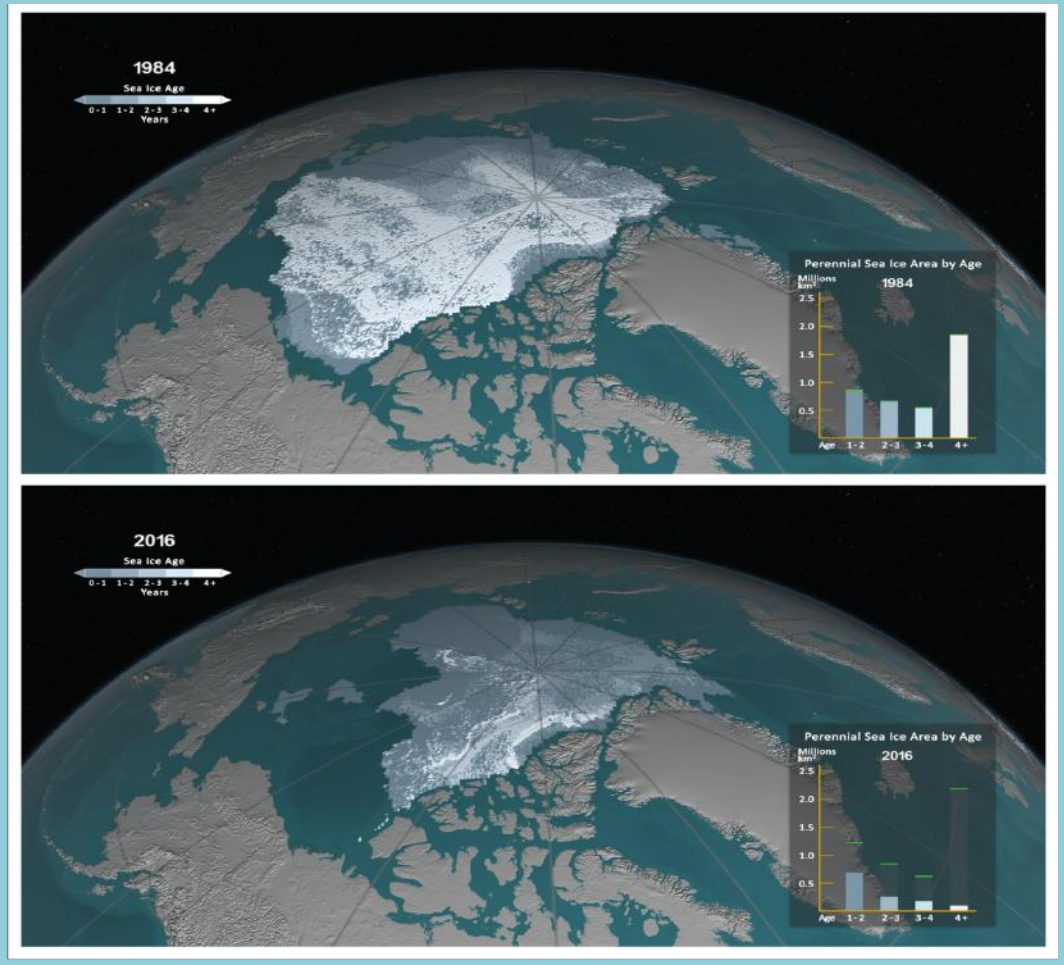


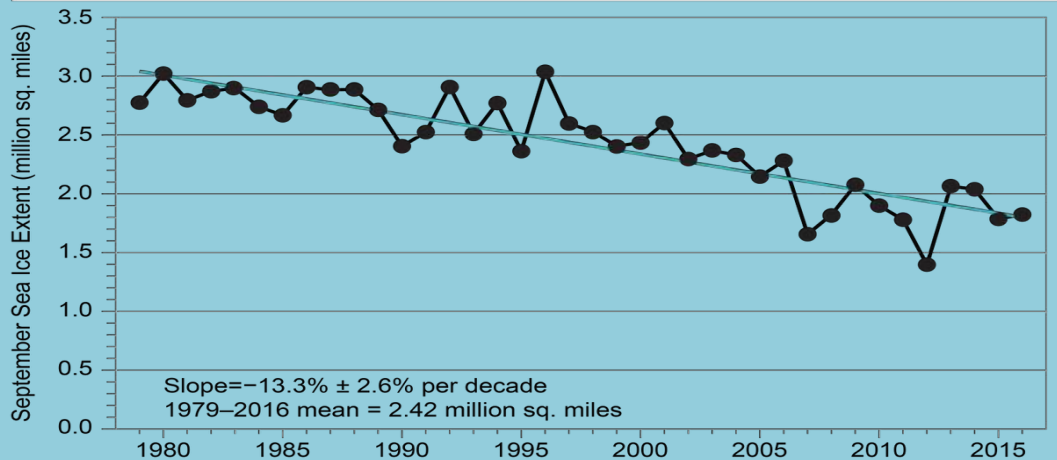
Extreme drought predicted throughout North and Central America by 2095, especially Central Plains and Southwest (NASA)

Under higher scenarios, and assuming no change to current water resources management,
chronic, long-duration hydrological drought is increasingly possible before 2100” (CSSR)



US drought map (June, 2018)



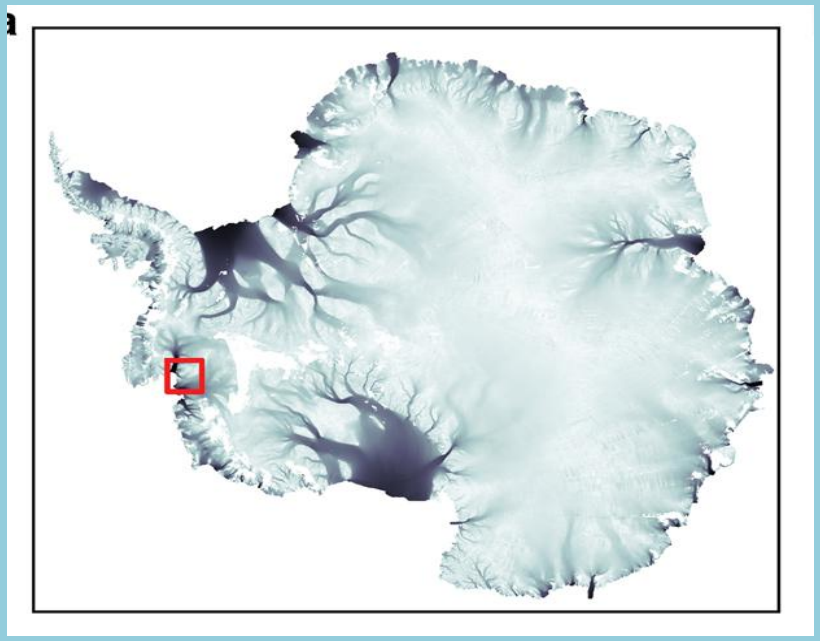


"Since the early 1980s, annual average arctic sea ice has decreased in extent by 3.5% to 4.1% per decade, has become thinner by 4.3 to 7.5 feet, and is melting at least 15 more days each year. September sea ice extent has decreased by 10.7% to 15.9% per decade. (very high confidence)

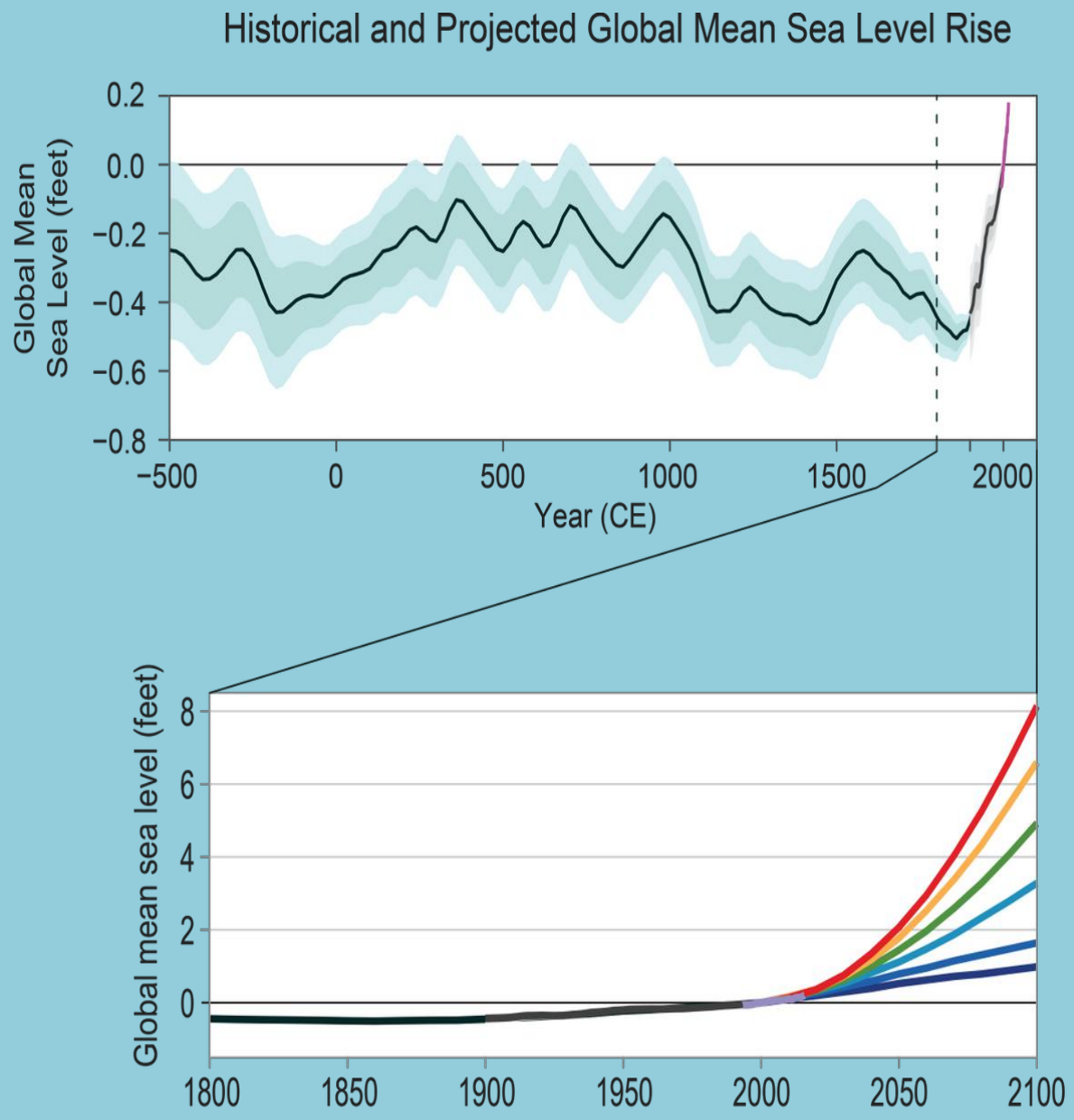
Arctic sea ice loss is expected to continue through the 21st century, very likely resulting in ***nearly sea ice-free late summers by the 2040s*** (very high confidence)". (CSSR)
"

"Emerging science regarding Antarctic ice sheet stability suggests that, for higher scenarios, **a GMSL rise exceeding 8 feet (2.4 m) by 2100 is physically possible, although the probability of such an extreme outcome cannot currently be assessed"** (CSSR)

"West Antarctic Glacier Loss Appears Unstoppable"
Eric Rignot, NASA, 2014



Pine Island Glacier (PIG) and Thwaites Glacier, Antarctica

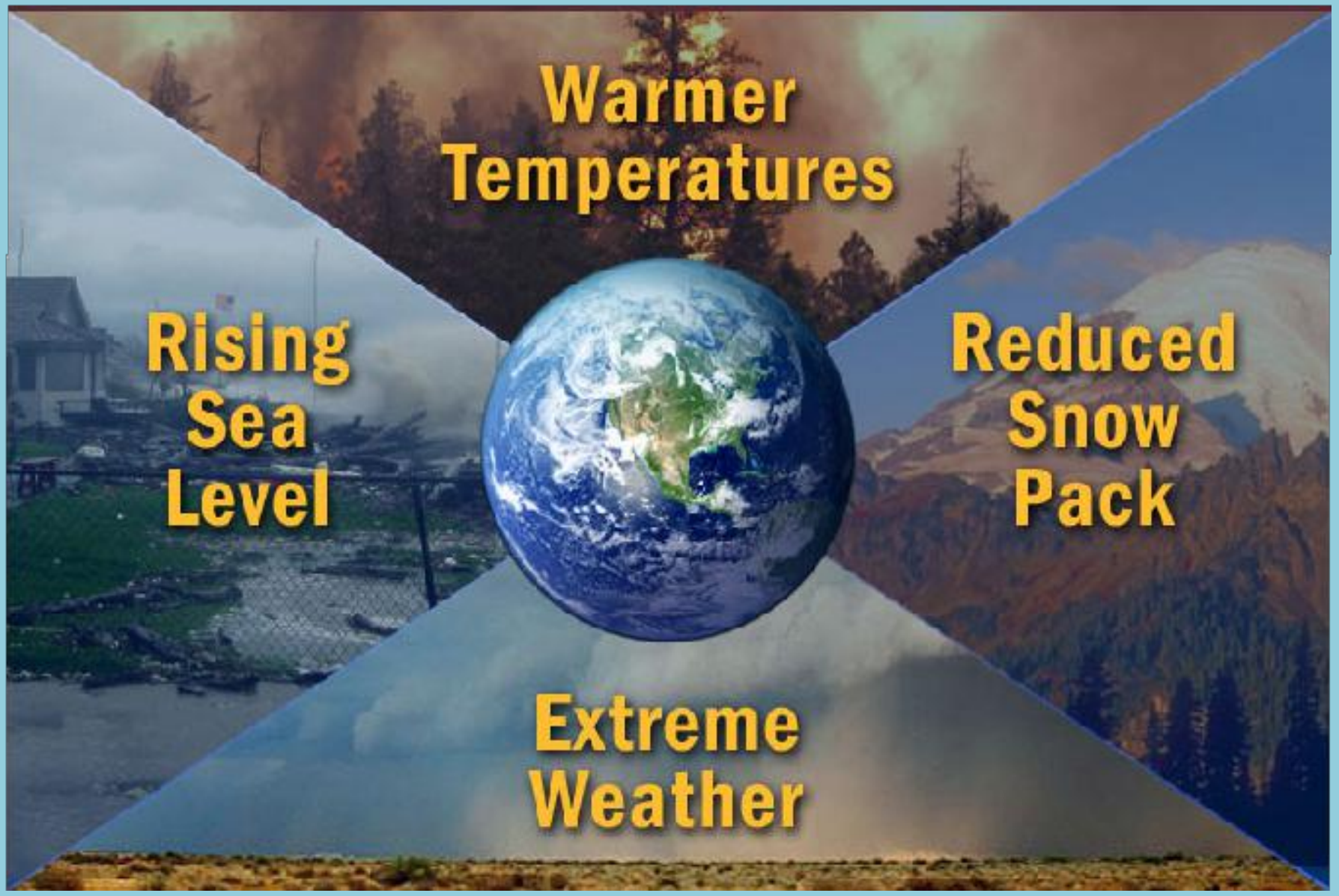


“Global average sea level has risen by about 7-8 inches since 1900, with almost half (~3 inches) of that rise occurring since 1993. Human -caused climate change has made a substantial contribution to this rise since 1900, contributing to a rate of rise greater than during any precedingcentury in at least 2,800 years”

Global average sea levels are expected to continue to rise —by at least several inches in the next 15 years and by 1-4 ft by 2100.

A rise of as much as 8 feet by 2100 cannot be ruled out”. (CSSR)

Impacts in the Pacific NW and Washington State (Dept of Ecology)



State of Knowledge Report

Climate Change Impacts and Adaptation in Washington State:
Technical Summaries for Decision Makers

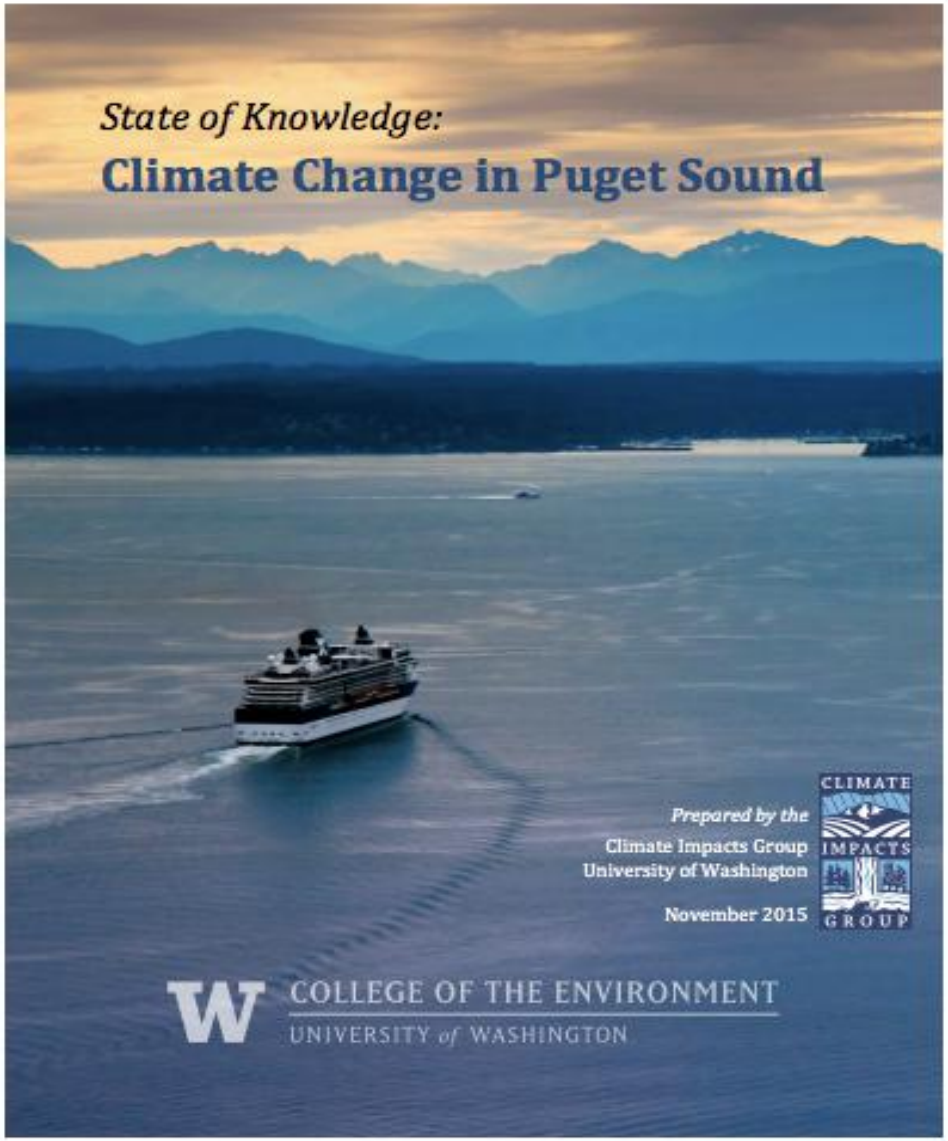
Executive Summary

Prepared by the
Climate Impacts Group
University of Washington

December 2013

CLIMATE IMPACTS GROUP

COLLEGE OF THE ENVIRONMENT
UNIVERSITY of WASHINGTON



Visible impacts

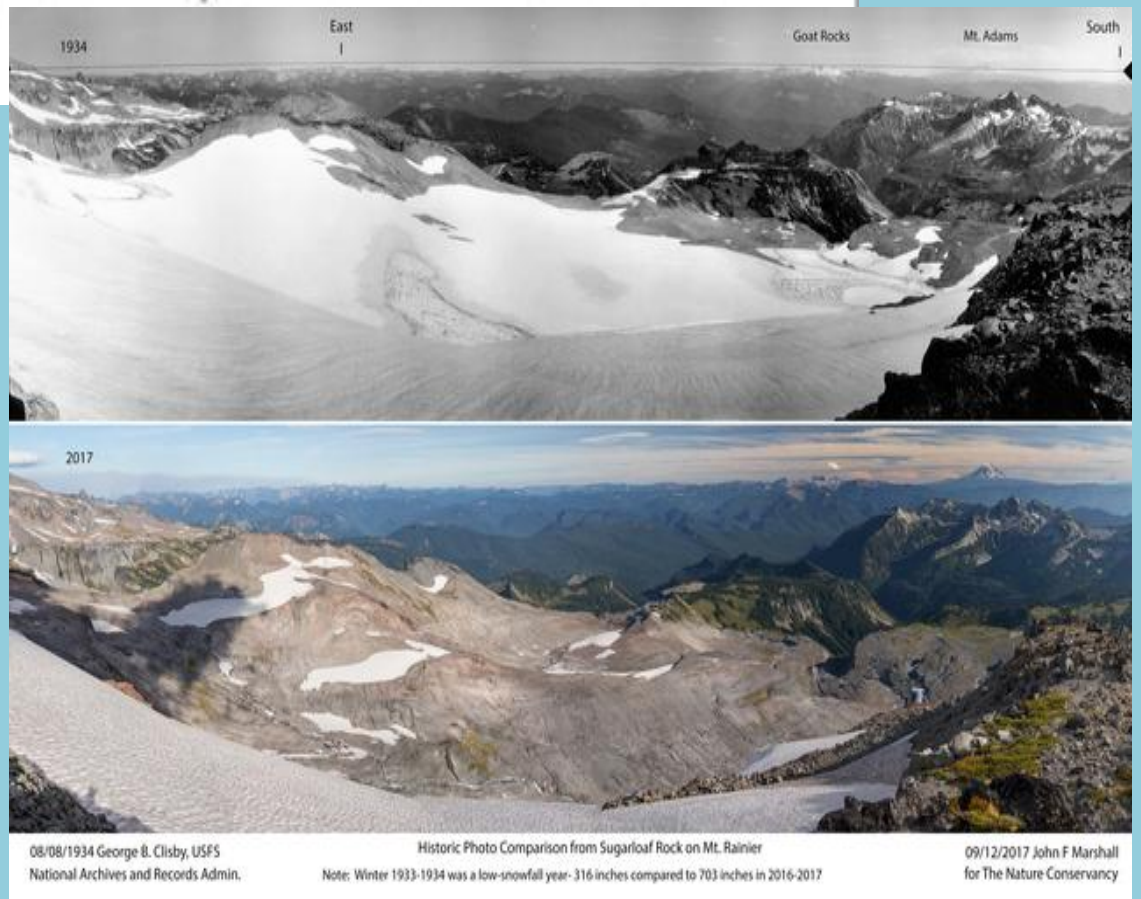
Glaciers: Mountain glaciers in the North Cascades have lost 18 to 32 percent of their total volume since 1983.

Snow-pack: The average mountain snow-pack in the North Cascades (critical to summer stream-flows) has declined at 73 percent of mountain sites studied. Spring runoff is occurring earlier each year.

Wildfires: The number of large (more than 500 acres) wildfires has increased from an average of 6 per year in the 1970s to 21 per year in the first part of the 21st century.

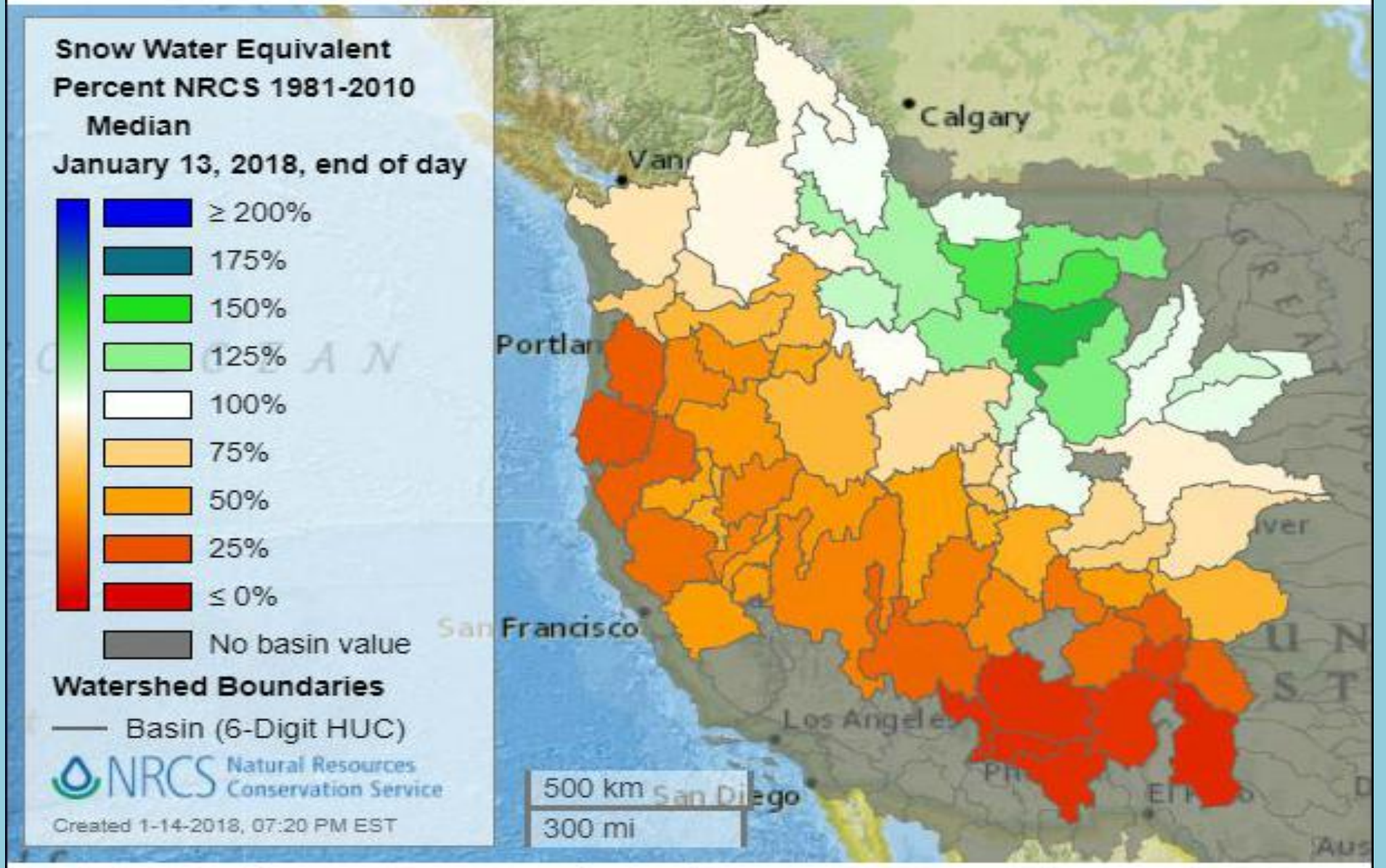
Rising sea levels: In Puget Sound, tectonic subsidence will combine with rising sea levels to create a 1 to 5 inch sea level rise each decade. Other areas will have a smaller impact.

Receding Mt Rainier glacier

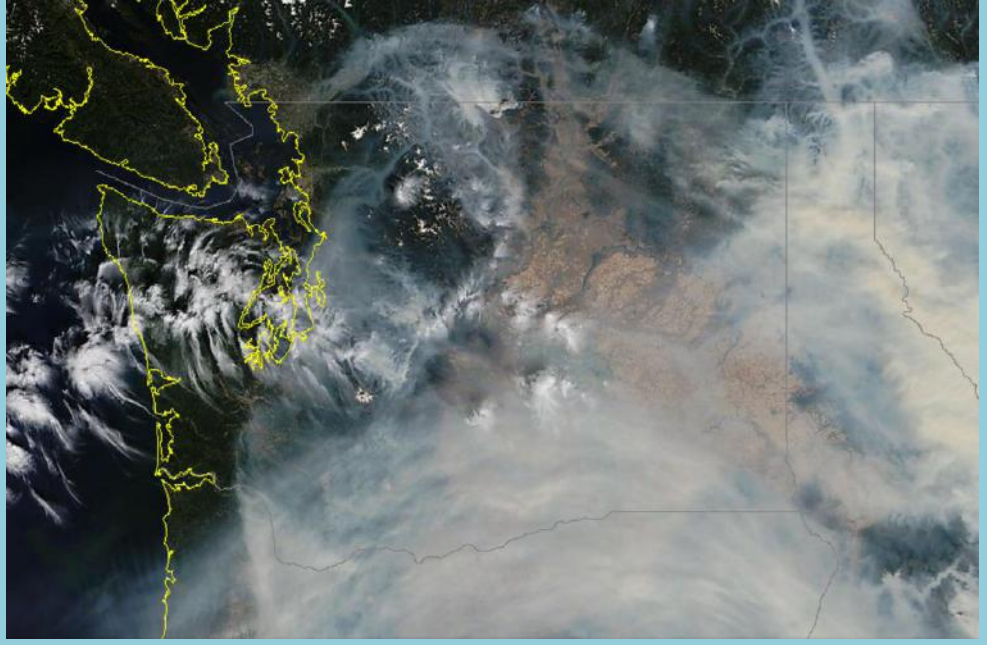


Snow Drought in the Western U.S.

Amount of water in the snowpack as percentage of 1981-2010 average, Jan. 13, 2018

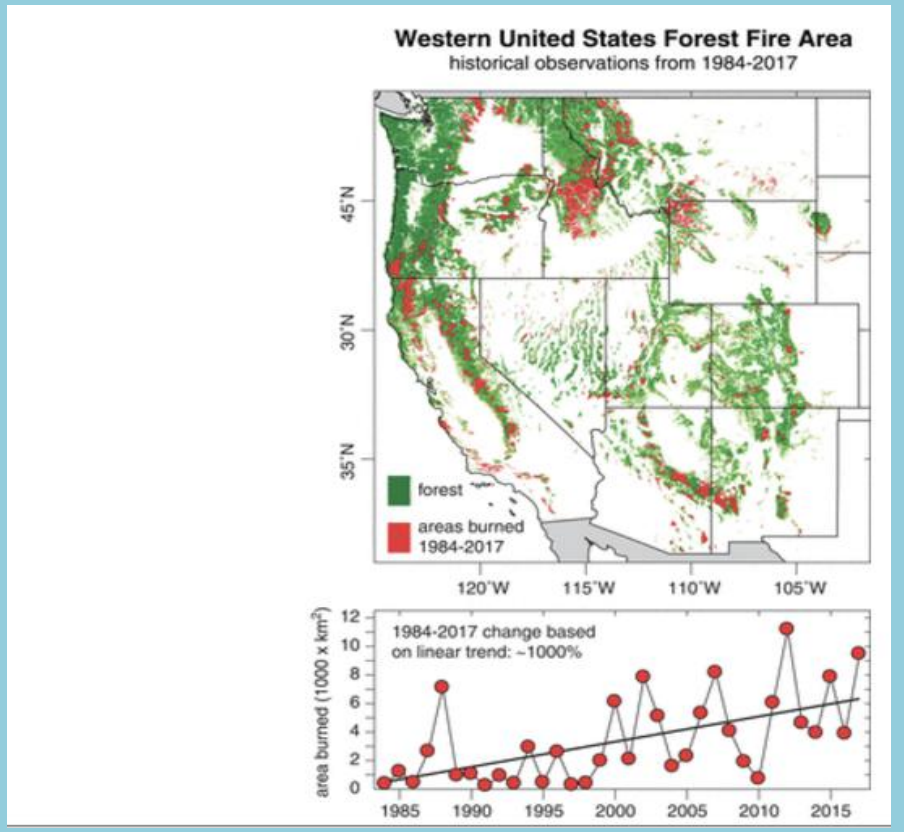


Source: Natural Resources Conservation Service

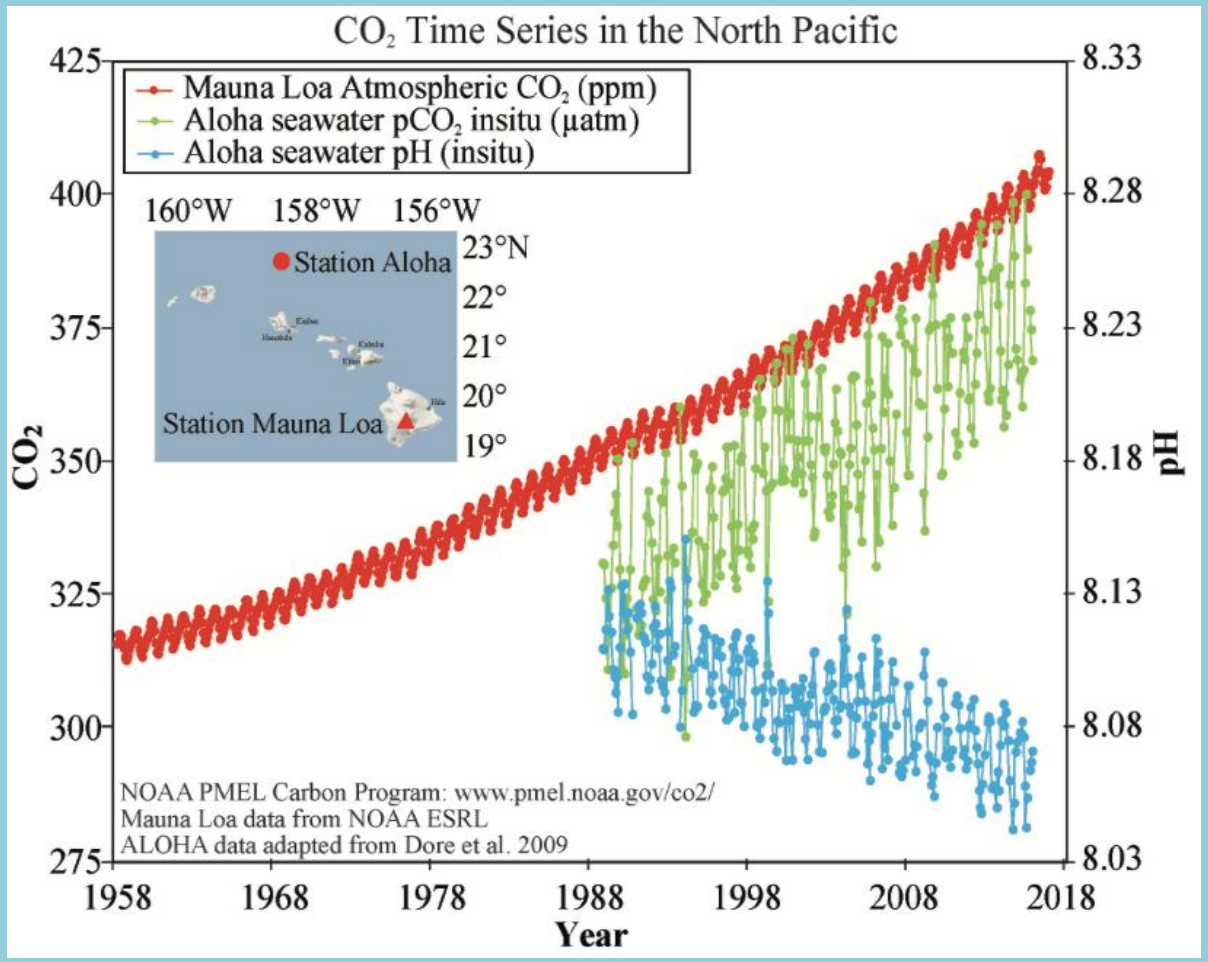


Smoke from PNW forest fires (9.4.17), again this past summer of 2018.
Will this be every summer from now on??
What happened to our blue sky summers??

"The incidence of large forest fires in the western United States and Alaska has increased since the early 1980s and is projected to further increase in those regions as the climate changes, with profound changes to regional ecosystems".(CSSR)



"The world's oceans are currently absorbing more than a quarter of the CO2 emitted to the atmosphere annually from human activities, making them more acidic (very high confidence), with potential detrimental impacts to marine ecosystems".



"Higher-latitude systems have a lower buffering capacity against changing acidity, exhibiting seasonally corrosive conditions sooner than low-latitude systems.

The rate of acidification is unparalleled in at least the past 66 million years. Under the higher emission scenario, the global average surface ocean acidity is projected to increase by 100% to 150%". (CSSR)

Local News Business Sports Life Opinion Obituaries Classi

Changes in ocean put shellfish business in jeopardy

By Bill Sheets Herald Writer

Thursday, January 31, 2013 9:07pm | LOCAL NEWS | LOCAL NEWS

- 30% of anthropogenic co2 emissions are absorbed into oceans

"One oyster farm, Goose Point Oysters in Willapa Bay, has begun raising oyster larvae in Hawaii because it can no longer grow them here.

The reason, scientists say, is ocean acidification.

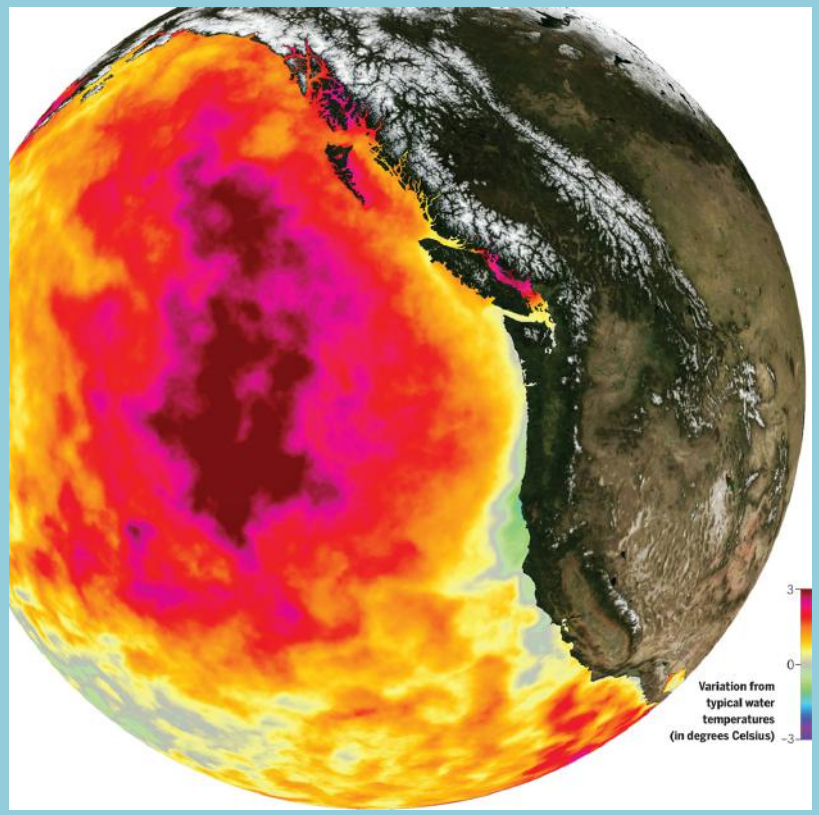
"The problem's not going away," said Ian Jefferds, general manager and co-owner of Penn Cove Shellfish in Coupeville."

"Acidification is regionally greater than the global average along U.S. coastal systems as a result of upwelling (e.g., in the Pacific Northwest.)

("high confidence" CSSR)

Eel grass and kelp protect shellfish from too acidic waters

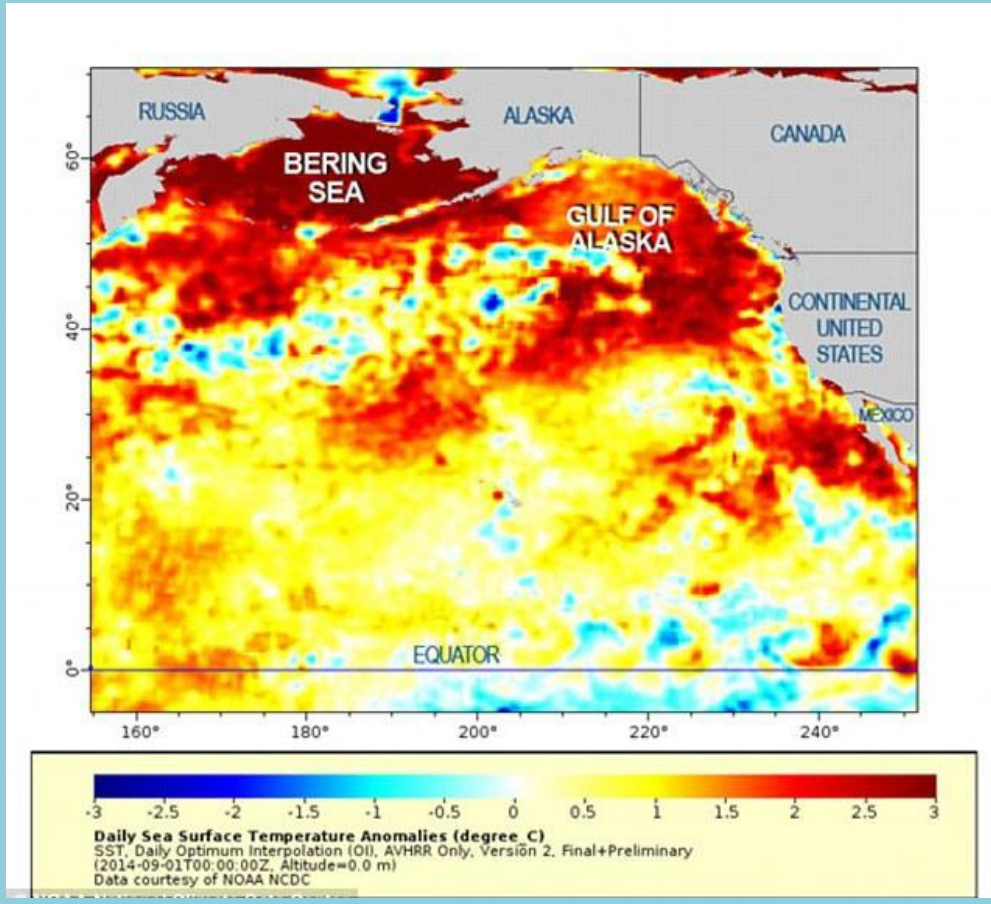
Strange algal bloom in Hood Canal (summer, 2017)



The “BLOB’ of very warm water off the west coast could not have occurred naturally, but only because of global climate change.

(American Meteorological Society 11.17)

Poor ocean conditions (2014/15) has led to poor salmon return runs (2017/18)



“It’s a long canoe, and we are all in it”

Lower Elwa, Klallam Elder

Our beloved Southern Resident Orcas are starving for lack of (king) salmon. Population down to 74, still falling, toward extinction

Q?: Time to take out the Lower Snake River Dams ? Prohibit all orca watching Tour boats? Provide protected habitat?

Tahlequah carried her dead calf, 17 days and 1000 miles, grieving

2015 was brutal in PNW

Too dry to plant winter wheat in Eastern Washington

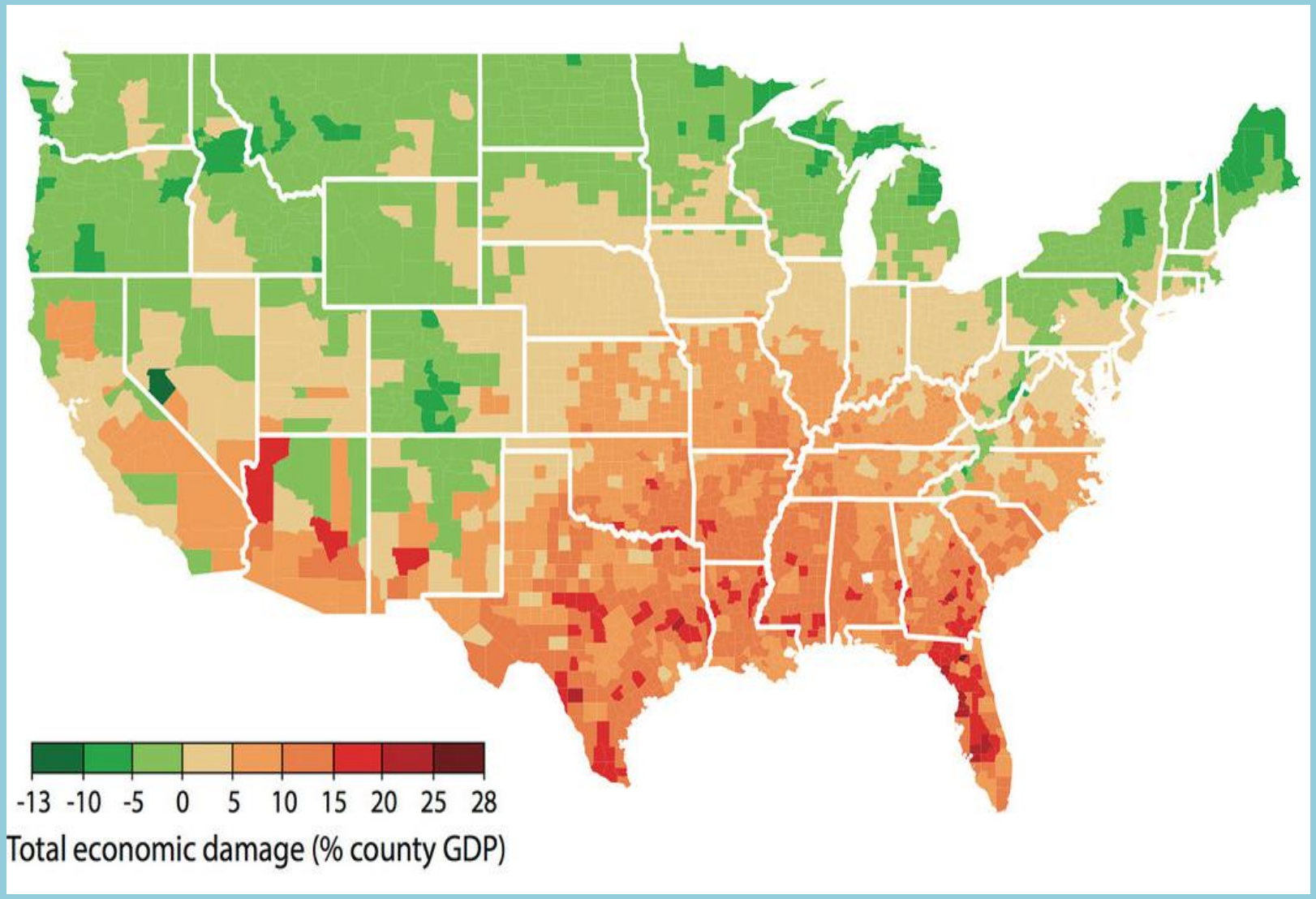
Streams too low, too warm
Massive sockeye loss
(Columbia River)

Sunflower seastar dying

Seastar wasting disease
Seastars down
Urchins up
Kelp beds disappearing

Invasive species:
European green crab

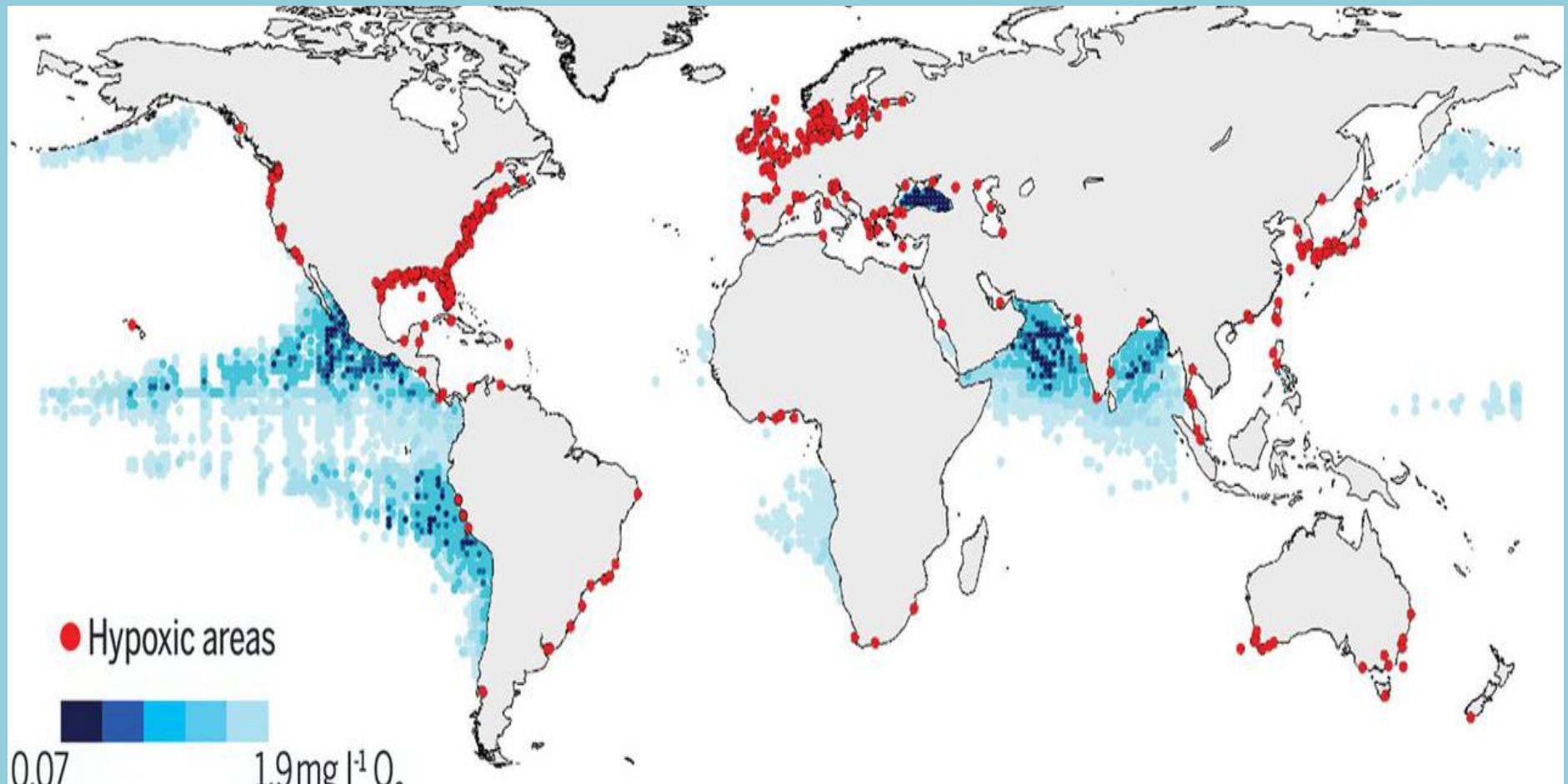
Guess where these climate migrants (refugees?) will be moving?



One view of economic impact of climate change on USA by county by 2100: economic loss in the poorer regions of the SE, gain in wealthier NE and NW regions.

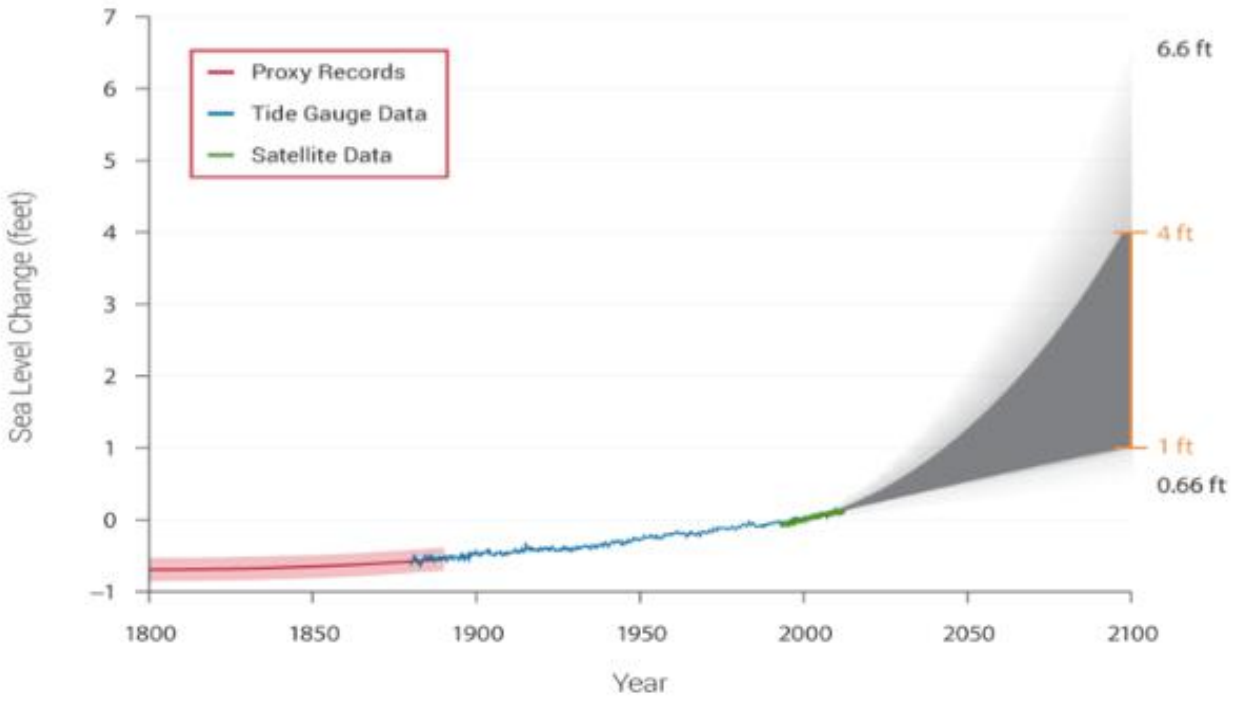
“Increasing sea surface temperatures, rising sea levels, and changing patterns of precipitation, winds, nutrients, and ocean circulation are contributing to overall declining oxygen concentrations at intermediate depths in various ocean locations and in many coastal areas. Over the last half century, major oxygen losses have occurred in inland seas, estuaries, and in the coastal and open ocean” (CSSR)

Oceans are becoming hot, sour, and breathless



Warming of 2degC by 2100 means the loss of almost all (>99%) coral reefs
Holding warming to 1.5degC, we only lose ~ 75% !? (IPCC 2018)

...Sea level rise outcomes by 2100

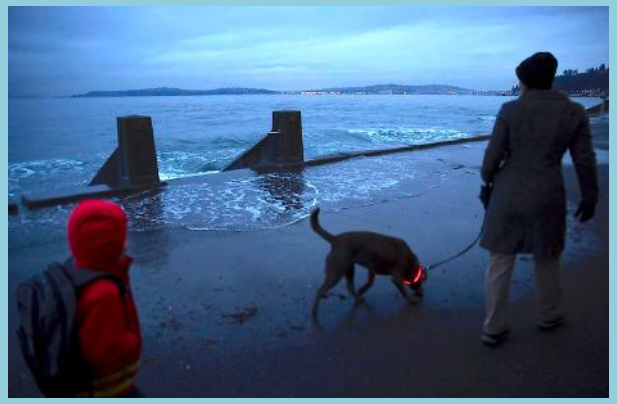


And after 2100 ??

Our responsibility extends to seven generations, and beyond

How to discount the future??

Global sea level rise may be 1 to 4 feet, but could be 8 feet or more by 2100 (odds? 1 in 1000?)



Scenarios from NOAA for 2013 are calculated using tidegauge observations from 1983-2001, taking the midway point (1992) as the starting point.

Low-lying land in the U.S.

The areas that would be most affected by sea rise in the Mid-Atlantic and Southeastern regions.

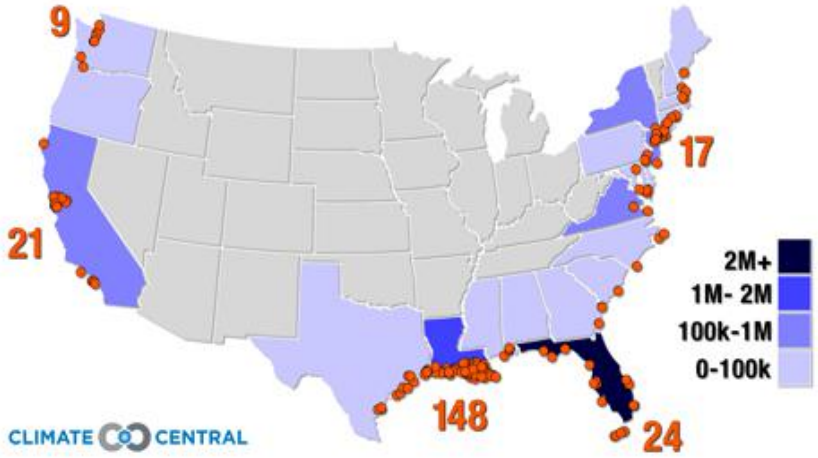
Dry land area less than 3.3 feet above high tide

Five most-vulnerable states

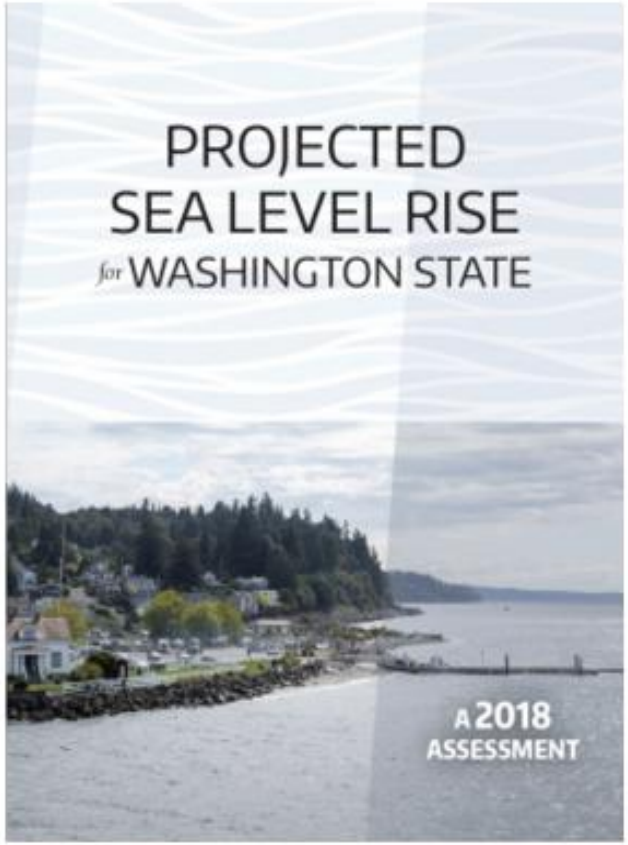
Source: National Oceanic and

Population below 4 ft: 4.9M

Energy facilities below 4 ft: 287



ABOUT THIS REPORT

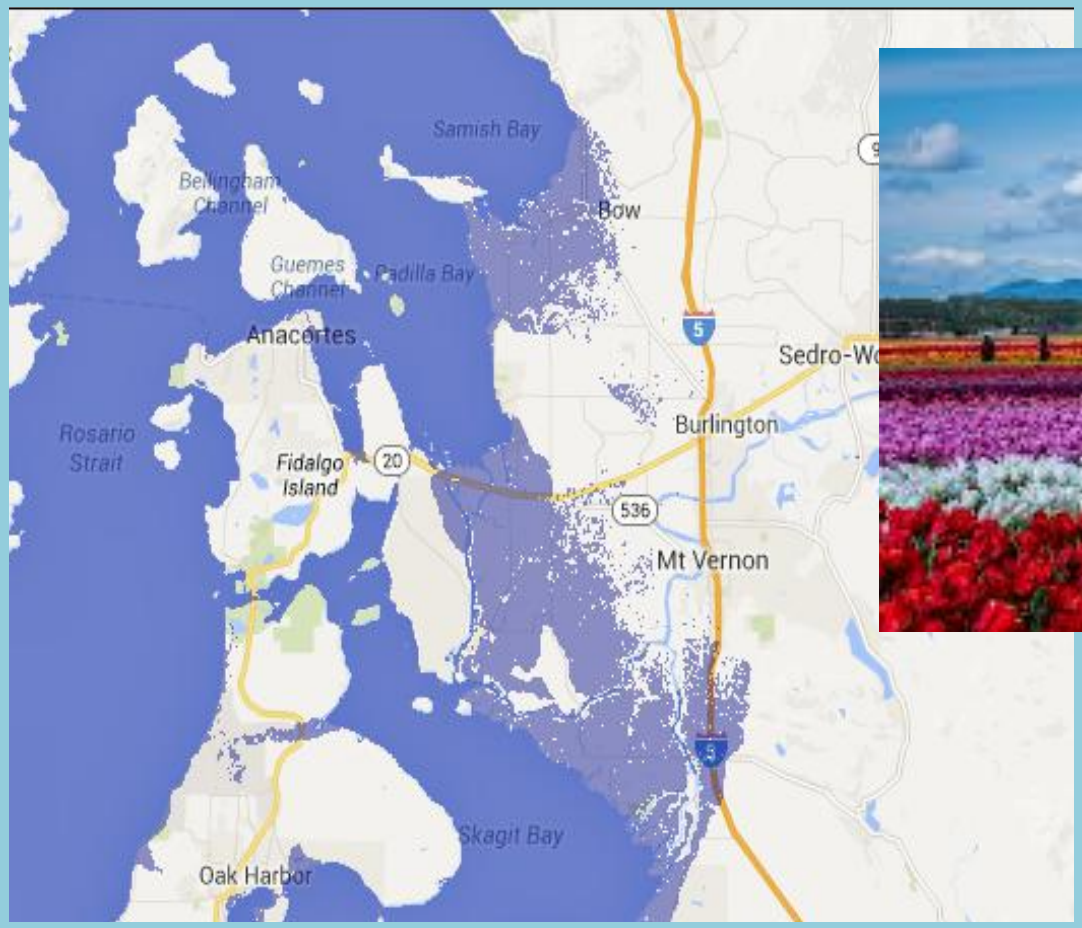


This report provides an updated set of absolute and relative sea level rise projections out to 2150 for Washington State. These probabilistic projections incorporate the latest climate science, are available for 171 locations across Washington State, and are designed for direct application to risk management and planning. These new projections incorporate the latest sea level rise science and account for the geographic variability in the vertical movement of the land surface.

Therefore, this new assessment of sea level rise for Washington State is an improvement over previous assessments. Comparing the projections for 2100, the central estimate of these new projections (1.6-2.0 ft) is lower than the central estimate from the last regional report on sea level rise (2.3 ft; NRC, 2012). Previous studies did not include an estimate of likelihoods, but the high end from the NRC (2012) report (4.5 ft) is much lower than in the new projections (7.2-8.3 ft), and instead corresponds to about the 1% probability of exceedance in our current study (4.1-4.8 ft). A more in-depth review of the science, including comparisons with previous work, can be found in Appendix B of the report (see below).

When Rising Seas Hit Home: Hard Choices Ahead for Hundreds of US Coastal Communities (2017)

> There comes a threshold of chronic flooding that makes normal routines impossible and forces communities to make difficult, often costly choices.



With 2 meters of sea level rise,
we lose the Skagit delta.

good bye tulip fields,
good bye La Conner.

This is certain to happen, just a question of time (possibly in the lifetime of children born today)

Aberdeen, Bay Center, Chinook, Cohassett Beach, Conway, Copalis Beach, Edison, Fife, Grayland, Hoquiam, Jamestown,, Kelso, La Conner, Long Beach, Longview, Neah Bay, Ocean City, Ocean Park, Ocean Shores, Oyehut, Puget Island, Silvana, Skokomish, South Bend, Taholah, Tokeland, Westport, Whidbey Island Station, Willapa, Woodland

John Holdren Presidential Science Advisor,
Head of Office of Science and Technology Policy
(Obama Adm)

Our choices now (Mitigation, Adaptation, Suffering)

Burning fossil fuels:

Who suffers?
Who benefits?

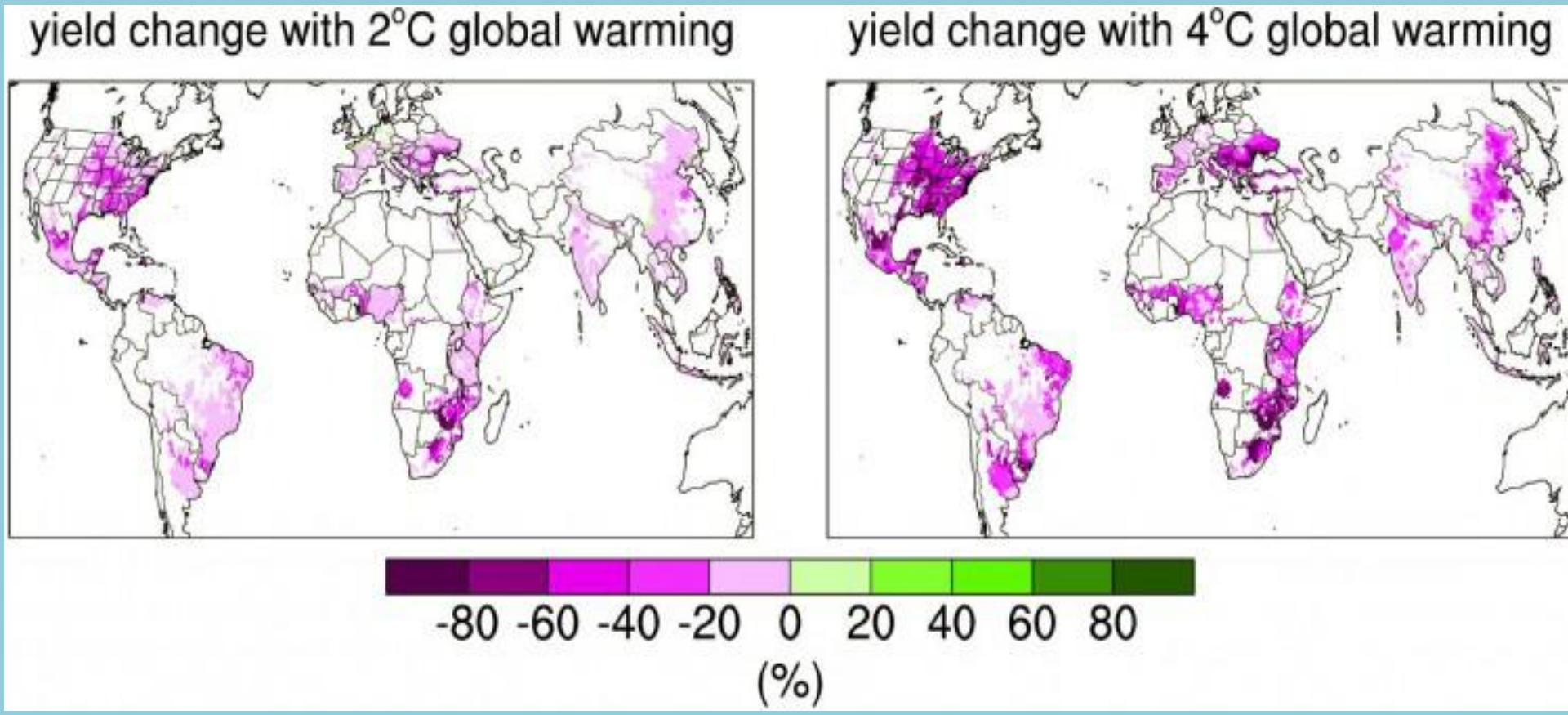
* Avoiding the change to which we cannot adapt (>5 ^{o}C warming?)

* Preparing for the change we can no longer avoid (~2 ^{o}C warming ?)

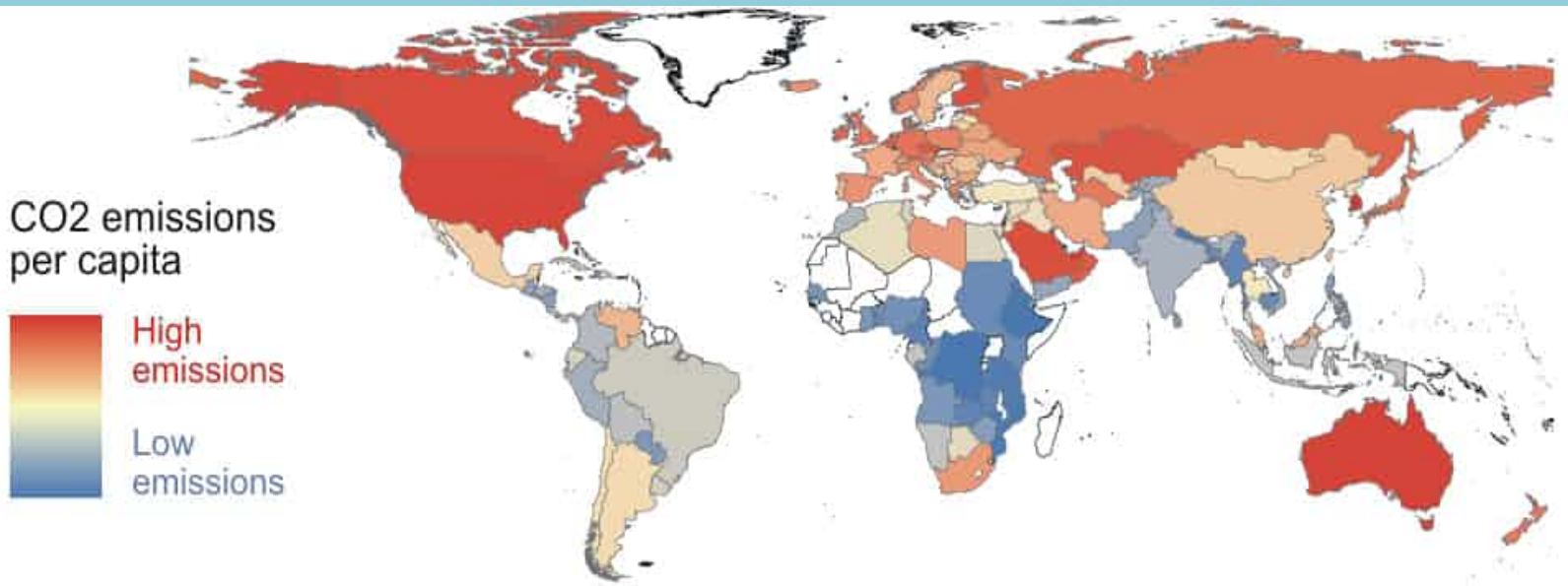
* Minimizing human suffering, damage to the natural world (save all you can)

Intergenerational climate justice

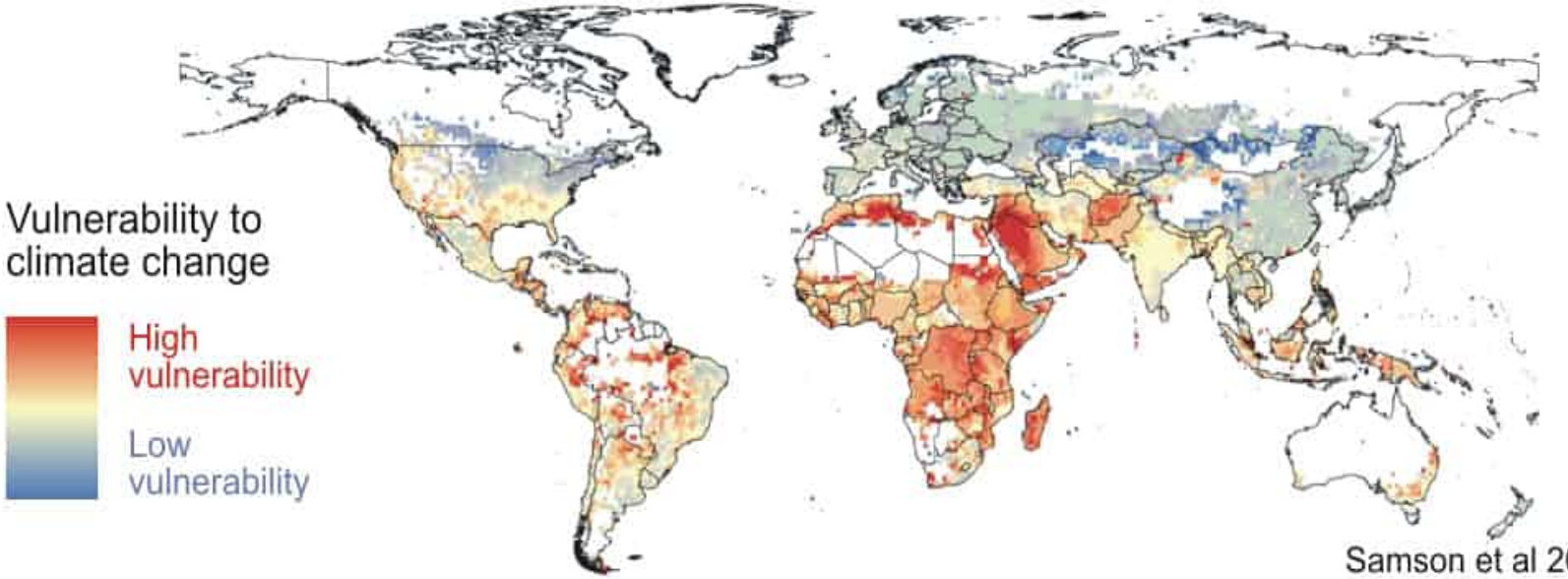
Prediction: corn yields decrease (~10%) per 1 oC warming



Adaptive response: newer corn hybrids (better drought, pest resistant), improve water storage capacity, increase soil carbon/ water retention.

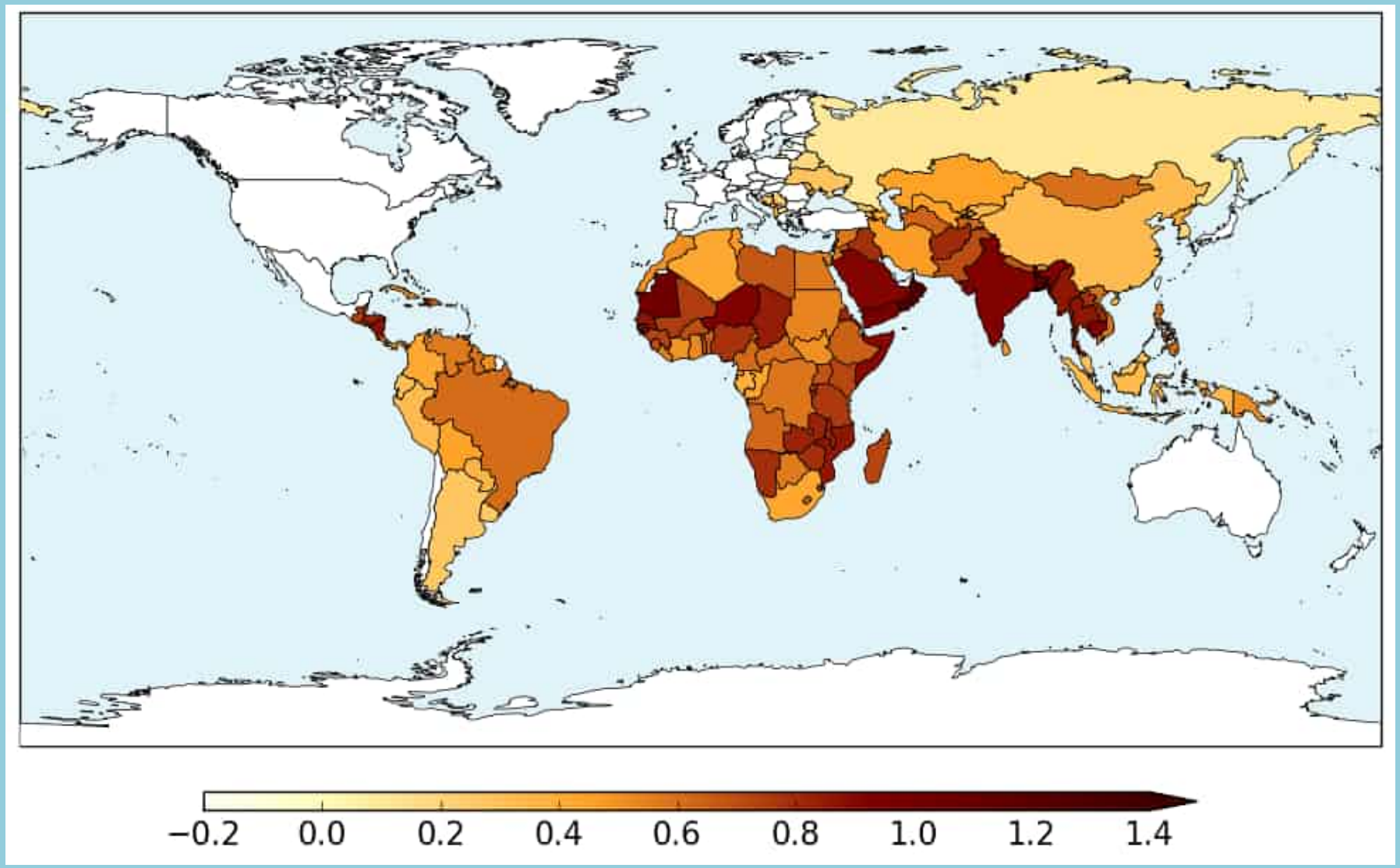


Those who contribute the least greenhouse gases will be most impacted by climate change

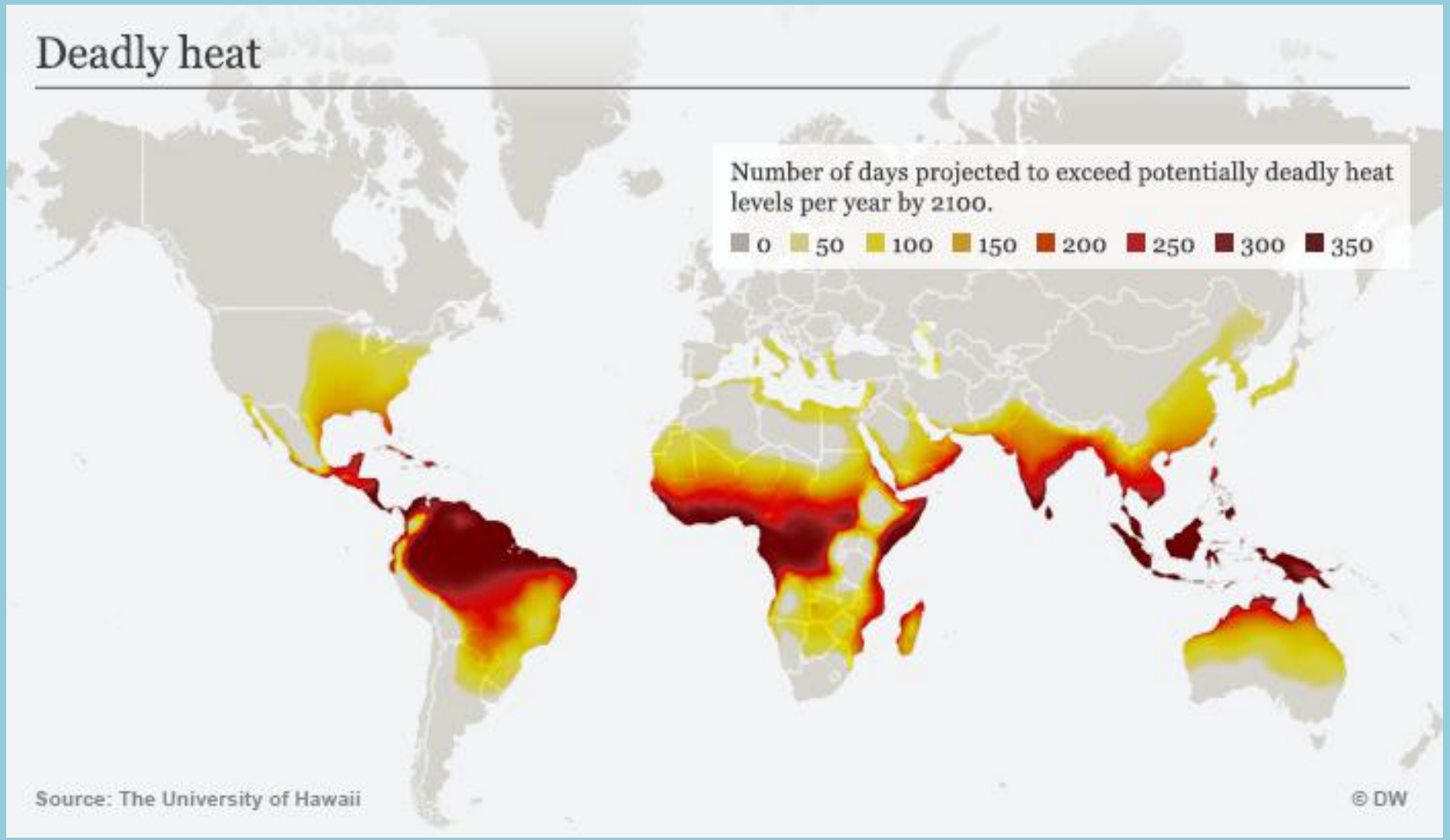


Samson et al 2011

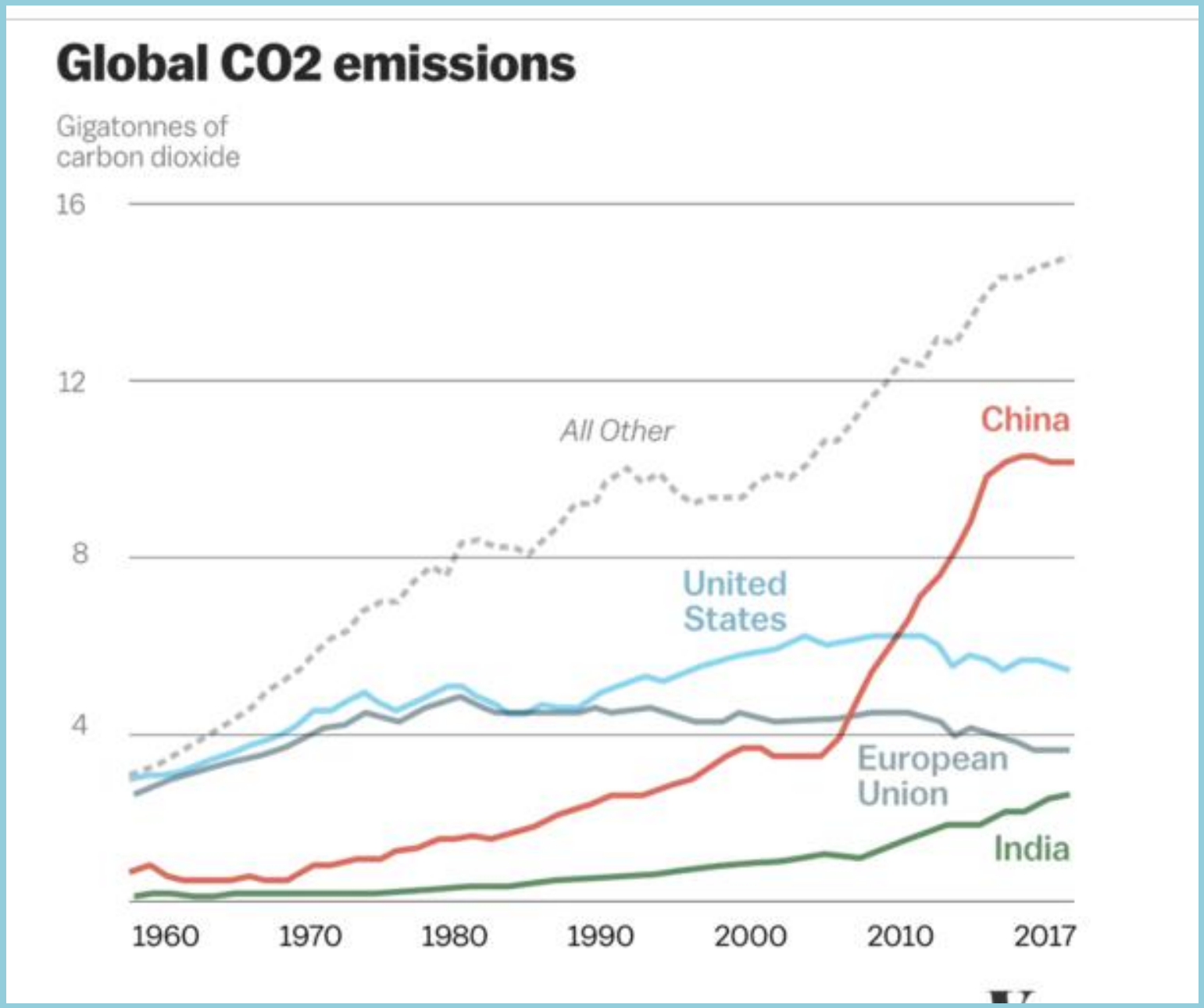
Hunger climate vulnerability index.
Note: greatest risk for those least responsible



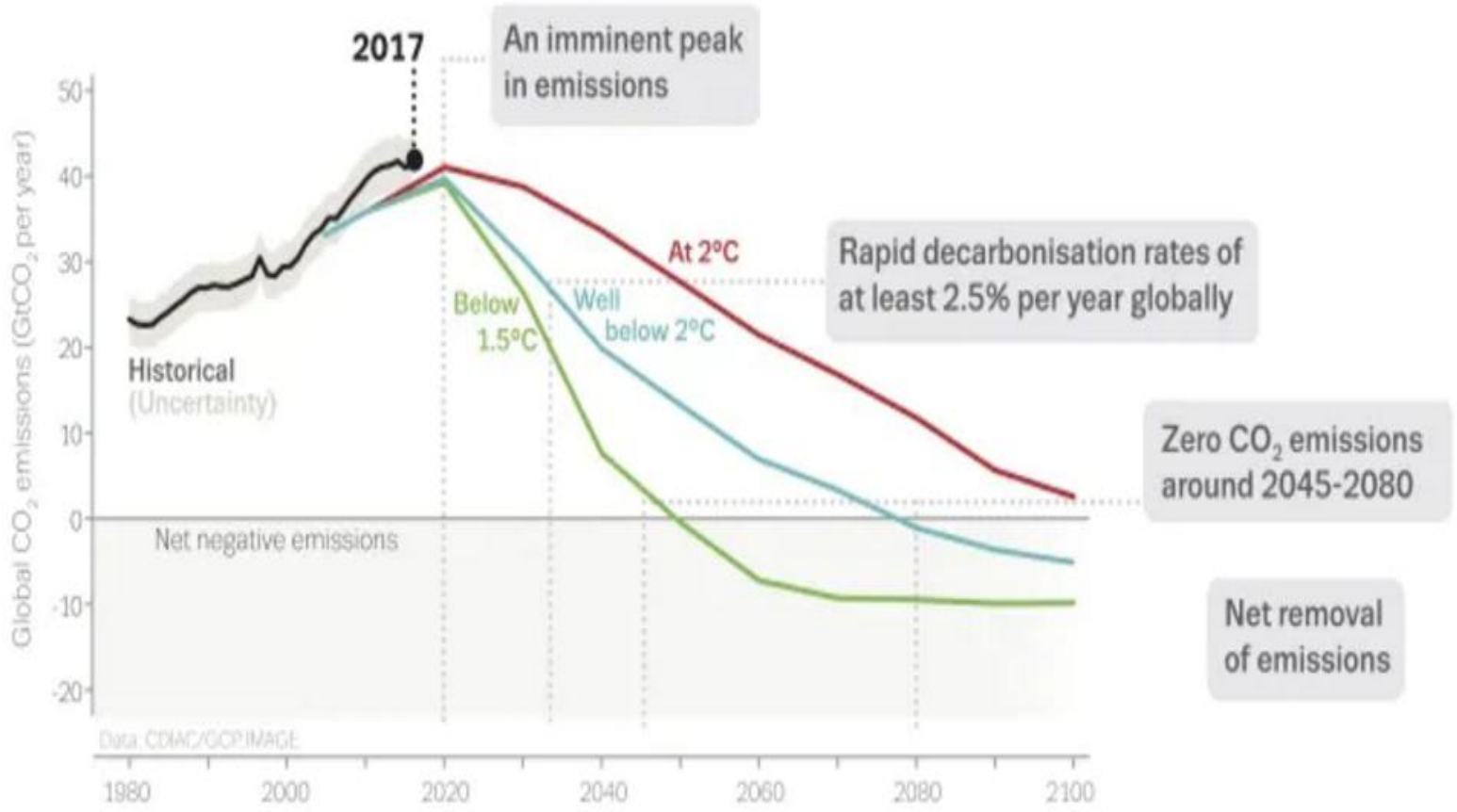
Some regions will become not just ‘ ‘uncomfortable’, but actually ‘**uninhabitable**’. Where will all these tens (hundreds?) of millions of desperate climate refugees go…? What wall will keep them out?



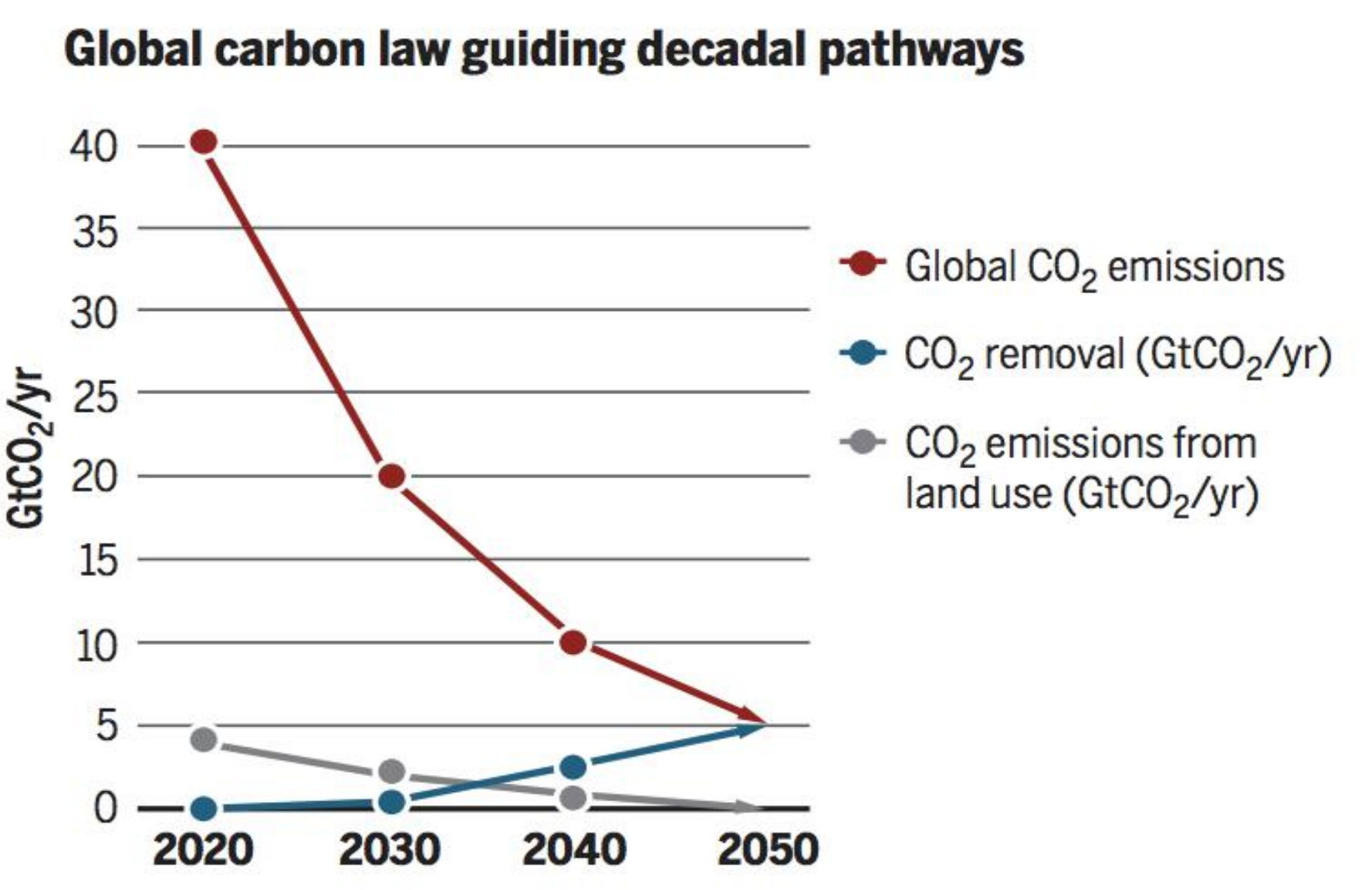
Note: cumulative emissions per person, USA is by far the most responsible for global warming



Future projected global CO_2 emissions that meet the Paris Agreement temperature goals have these characteristics...

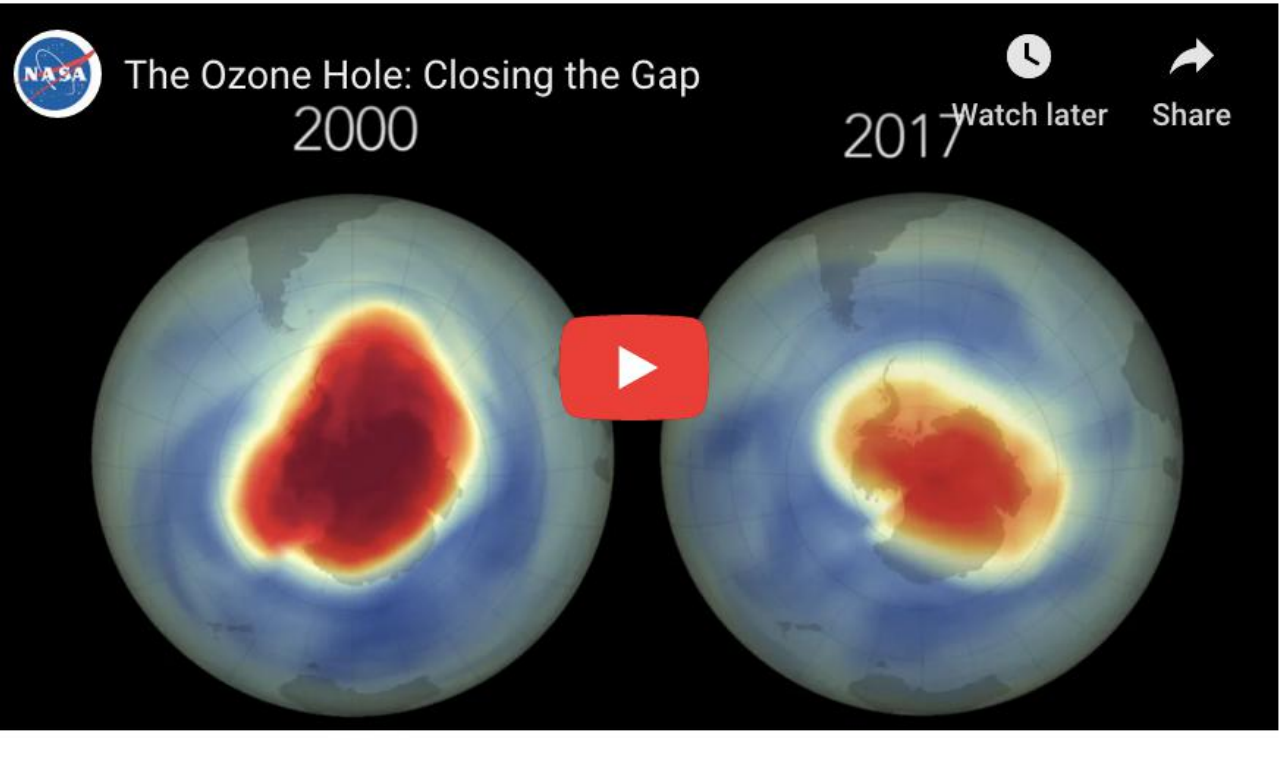


Getting to ‘carbon neutral’ by 2050? Can we ??... Will we ??



This means: cut ghg in half by 2030, then cut that in half again by 2040, then cut that in half by 2050 !! (plus neg emissions reforestation, CCS)

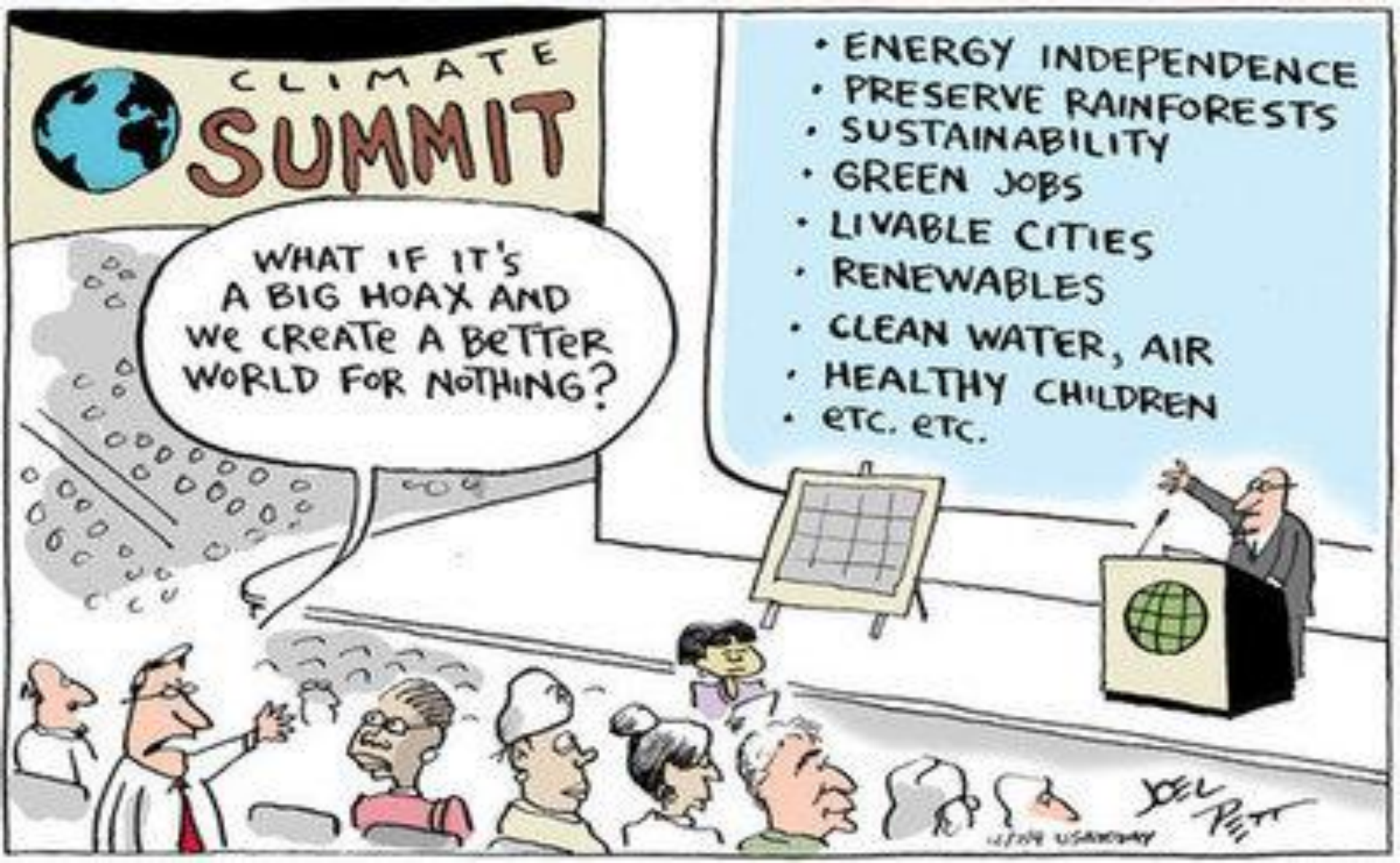
Some good news:
The Montreal Protocol is working!



The Ozone Hole: Closing the Gap

After thinning at alarming rates in the 1980s and 90s, the ozone layer over Antarctica is starting to recover. Watch how ozone concentrations in the stratosphere have changed from 1979 through 2018.

The stratospheric ozone hole has begun to heal (2050?)



"Let the people know the facts, and the country will be safe."
Abraham Lincoln

Stopping Climate Change is Hopeless. Let's Do it!

"…perhaps the rewards of solving climate change are so compelling, so nurturing, and so natural a piece of the human soul that we can't help but do it".

(NYT Sunday, October 7, 2018)

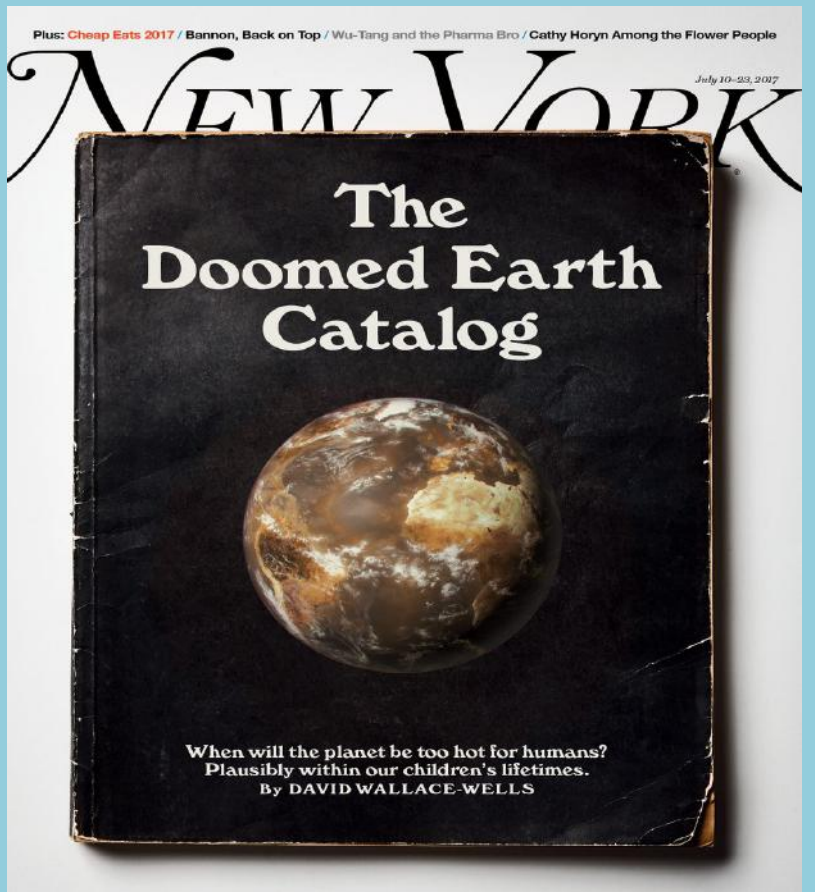
"I'm urging elders all over the world get the hell off the golf course,, get off the couch… This is the most important time in your life., Damn it all, get out there and speak and tell the truth!"

David Suzuki


IT'S TOO SOON TO ACT ON CLIMATE. IT'S JUST A THEORY.
Fossil fuel
STILL TOO SOON. NO HARD EVIDENCE OF ANY WARMING.
STILL TOO SOON. YES, THERE'S WARMING, BUT THE CAUSE IS UNCLEAR.
NOW'S NOT THE TIME. WE NEED TO PONDER COSTS AND BENEFITS.
TOLES
©2019 THE WASHINGTON POST
STILL TOO SOON. THERE'S NO 100% CONSENSUS TO ACT.
OKAY, FINALLY IT'S NOT TOO SOON. NOW IT'S TOO LATE.
AND I'LL BE THE FIRST TO ADMIT IT.

Greta Thunberg (Davos (1/19)

"I don't want your hope. I don't want you to be hopeful. I want you to panic. I want you to feel the fear I feel every day, to act as you would in a crisis… I want you to act as if the house was on fire. Because it is."



“How, then, shall we live?” KD Moore

“This changes everything” Naomi Klein

“It’s getting late a lot earlier now” Yogi Berra

“After the final ‘no’ there comes a ‘yes’, and on this yes the future world depends”

Wallace Stevens

“Whether we and our politicians know it or not, Nature is party to all our deals and decisions, and she has more votes, a longer memory, and a sterner sense of justice than we do.”

Wendell Berry

What can *I* do?

Determine (Carbon Calculator), and then reduce, your personal carbon footprint: greater efficiency, conservation, recycle, compost, eat less beef, waste less food, grow some food, no plastic bags, drive the speed limit, use public transit, divest ff, invest in renewables, buy green power (home solar panels), buy carbon offsets for your travel emissions (driving, especially air travel), make your next car an electric one. TAMING BIGFOOT WHIDBEY 2019 !

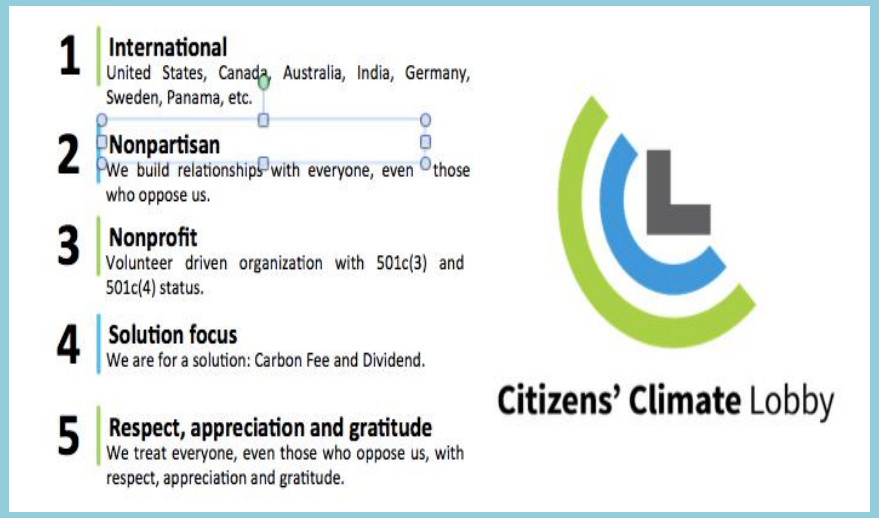
Study climate science/policy, explain it to others; become pro-active in your community, support climate-wise elected officials, candidates, initiatives in local to national elections, activists/ demonstrations (350.org, Climate Solutions, The Alliance for Jobs and Clean Energy, Citizens Climate Lobby …) get involved ! join forces!

Support policies to price fossil fuels correctly (c tax/fee, cap-n-trade, EPA policies on emissions (e.g. restricting coal burning, Clean Power Plan), low carbon energy (solar, wind, geothermal, nuclear(?)), research (biofuels, solar, batteries, CCS….)

Increase your charitable giving for international family planning programs, NGO programs to assist people in developing countries who are ALREADY suffering climate change related impacts (storms, droughts, floods, hunger, diseases…) we have caused (e.g.(El Porvenir), protect wild places, endangered/threatened species.

Support efforts to strengthen the US national commitment reduce emissions within the Paris Accord

Support local, state efforts to reduce greenhouse gas emissions, promote renewable energy.



Local PNW issues of fossil fuel transport, refining, export, exploration