Climate Crisis & Climate Impact Modeling Review for SERC, City of Salem May 2021

By

John Hayes, Ph.D.

Chair, SERC and

Professor of Geography and Sustainability, Salem State University

Climate Change Deep Dive Model, Alternative Analysis, and Targeted Outreach/Engagement

The City of Salem is applying for the FY22 Coastal Resilience Grant Program from the Massachusetts Office of Coastal Zone Management. Each year, Massachusetts coastal communities experience erosion, flooding, and coastal storm impacts to property, infrastructure, and natural resources. These impacts are getting worse as the climate changes. To help address these issues, this grant program provides financial and technical assistance to advance proactive, innovative and transferable local and regional (multi-community) efforts to increase climate resiliency.

The City of Salem has partnered with the City of Beverly to develop a Climate Action and Resilience Plan : Resilient Together. This plan furthers the many plans/assessments/reports that Salem has done over the past 10 years to advance climate resilience for our most vulnerable communities. With the development of the final plan approaching in July 2021, this project would be one of the first implemented from our over 70 actions to prepare for and reduce our impacts on future climate change projections.

PROJECT SUMMARY

This **Climate Change Deep Dive Model, Alternative Analysis, and Targeted Outreach & Engagement project** will be focused on one specific area: The Point/Palmer Cove neighborhood. Through several previous studies, reports, climate impact data, and community member surveys, the City has narrowed down the focus to The Point/Palmer Cove neighborhood because of its vulnerability to climate change impacts (such as sea level rise, storm surge, precipitation, and heat waves) combined with the vulnerability of its residents, workers, infrastructure, and development.

This area has the highest density of residents in the entire city, is an Environmental Justice Population, and home to many important assets such as the community health center, affordable and senior housing, large utility infrastructure, historic assets, Shetland Park office complex, 2 schools, and 3 parks. The neighborhood is at risk of severe flooding already which is projected to be even worse in the coming years. This area is a complicated area surrounded by ocean, a tidal river, and significant amounts of older and “hard” storm water infrastructure (seawalls, berms, etc.) and impervious surfaces. The City will use this opportunity to develop an approach to analyzing complicated climate change risks at a neighborhood level, developing alternatives that are supported by the community. By focusing on one area of the City vulnerable to flooding, we can then use this model and lessons learned, to implement similar processes in other specific vulnerable areas of the City.

CZM Grant application by the City for mathematical modeling of climate change and hydrologic impacts – for coastal resiliency planning, May 2021.

Climate Change Deep Dive Model, Alternative Analysis, and Targeted Outreach/Engagement

The goal of this project is to hire a consultant team to develop a deep dive model of the area's current and future climate risks, provide alternative analyses and solutions for the area to adapt and mitigate to these risks, and to conduct an intensive multi-lingual outreach, education, and engagement campaign in the community throughout the entire project timeline. The approach of this project will be collaborative: the city and the consultants, along with several community partners and newly hired ambassadors, will engage with the community to create technical and community-based solutions for current and future climate risks. Once the project is done and we have created a report with several solutions to take on, the city will seek additional funding from several sources to implement these solutions.

PROJECT BUDGET

The total budget for this project is $225,000. The City is applying to CZM for the amount of $168,750 and will contribute a cash & in-kind match of $56,250 (25% of the total project budget). The budget breakdown is as follows:

- $200,000: Consultant fees
    - Hydraulic and Hydrologic models of the area, with climate projections
    - Technical and community-based analysis of assets and vulnerabilities
    - Alternatives Analysis with cost and benefits, potential funding sources, and opportunities for partnerships or combining existing projects with needed climate change improvements (I.e., road improvements).
    - Community engagement team led by dual language staff.
- $20,000: Hire local ambassadors to engage the community on-the-ground, following CDC guidelines
- $5,000: Local community meetings (venue, food/drinks, childcare, print materials, etc.), following CDC guidelines

Letter of support from SERC for the City's CZM grant application, May 21, 2021.

Sustainability, Energy, and Resiliency Committee (SERC)

City of Salem, MA 01970

TO: Massachusetts Office of Coastal Zone Management, EOEEA CZM

FR: John Hayes, Ph.D., Chair of Sustainability, Energy, and Resiliency Committee, City of Salem, MA

RE: Letter in support of City of Salem's application for the FY22 Coastal Resilience Grant Program

DT: 21 May 2021

I am writing on behalf of the City of Salem's Sustainability, Energy, and Resiliency Committee (SERC). We have read and fully support the City's application titled "Climate Change Deep Dive Model, Alternatives Analysis, and Targeted Outreach/Engagement".

The IPCC's 1.5°C Special Report of a little over two years ago sounded the alarm on the climate crisis that we face and the urgency of confronting this crisis. I, along with several members of SERC, attended the public presentations last year of the modeling-based research done by Woods Hole for the town of Marblehead. Their alternatives analysis for various scenarios of SLR, storm surge, and coastal flooding was compelling and important to the Town's planning for the short, medium, and long-term. Our committee believes that the City's application to procure grant monies for similar climate change modeling targeted to The Point/Palmer Cove neighborhood is exactly what is needed for the City's protection of the vulnerable populations of the neighborhood, the historic and community assets including schools and parks, the commercial properties, and the existing infrastructure. Our Committee would welcome the opportunity to engage with the City as this project goes forward, and to help promote and educate the community about its importance and value for planning, especially in the medium to long-term.

The City's grant application has outlined how forward-thinking the City is in regards to its current climate action planning [Resilient Together] which is a joint effort with our neighbor, the city of Beverly. I was a member of the City's Advisory Working Group to develop a "Climate Change Vulnerability Assessment and Adaptation Plan" in 2014. The state-of-the-science has greatly improved over the past seven years in terms of neighborhood-scale computer simulation modeling of SLR and storm surge flooding risk.

Our Committee strongly supports this grant application and it is our hope that CZM will look favorably upon the application and will grant the requested monies to the City. We are a coastal community worried about sea level rise, coastal flooding, and storm surges. We believe that this project needs to go forward!

Sincerely,

Dr. John Hayes, Chair, City of Salem's Sustainability, Energy, and Resiliency Committee

email: jthayes1212@gmail.com

How 2016 Became Earth's Hottest Year on Record

By JUGAL K. PATEL JAN. 18, 2017

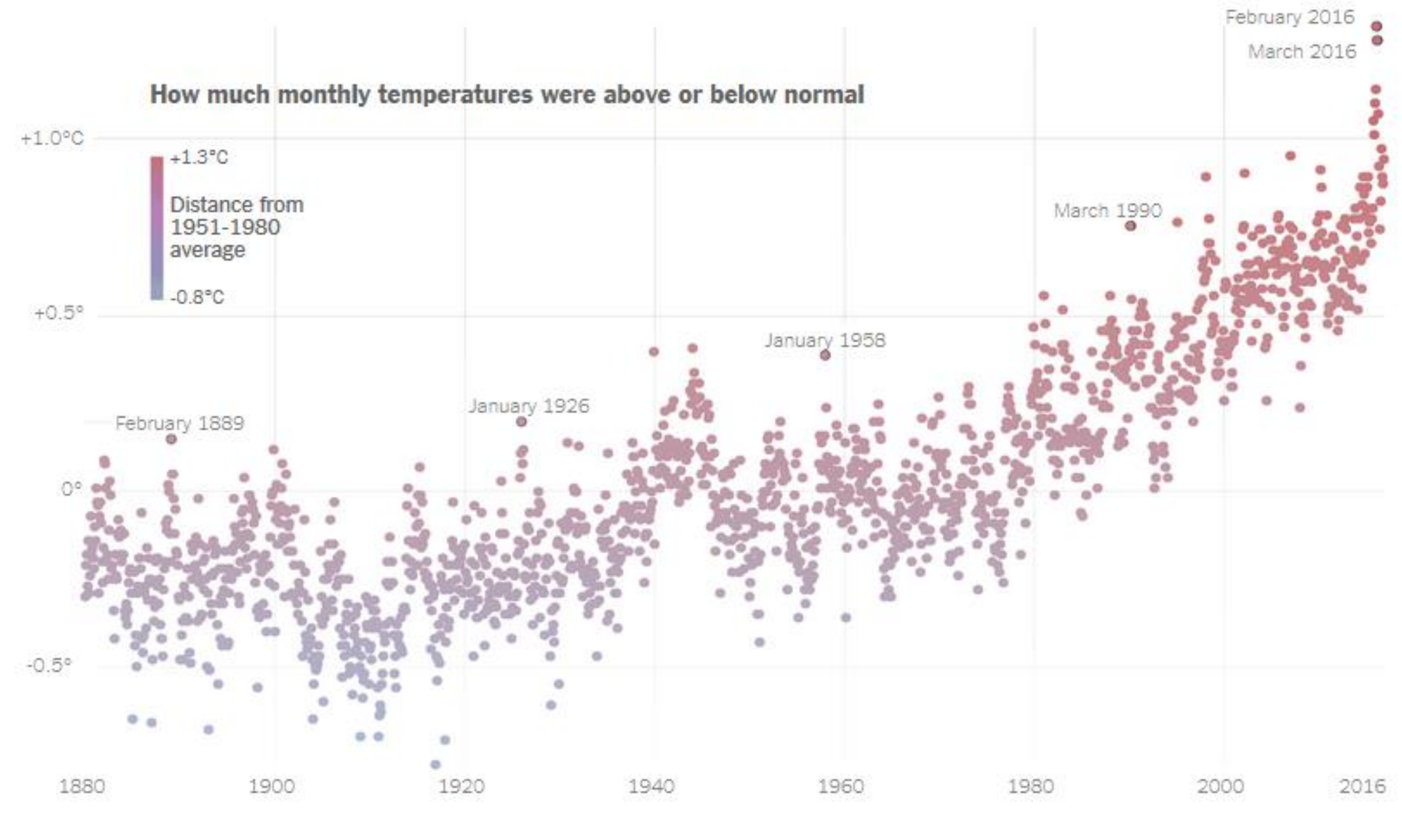
Global temperatures have continued to rise, making 2016 the hottest year on the historical record and the third consecutive record-breaking year, scientists say. Of the 17 hottest years ever recorded, 16 have now occurred since 2000.

The New York Times

Human-induced climate change has made it at least 160 times more likely that three consecutive years after 2000 would be record-setting, according to Michael E. Mann, a climate scientist at Pennsylvania State University.

His findings show that if human-induced climate change was not part of the equation, the amount of warming in 2016 would have less than one-in-a-million odds of occurring.

"One could argue that about 75 percent of the warmth was due to human impact," Dr. Mann said.



2017 Was One of the Hottest Years on Record. And That Was Without El Niño.

By HENRY FOUNTAIN, JUGAL K. PATEL and NADJA POPOVICH JAN. 18, 2018

The world in 2017 saw some of the highest average surface temperatures ever recorded, surprising scientists who had expected sharper retreat from recent record years.

National Oceanic and Atmospheric Administration
U.S. Department of Commerce

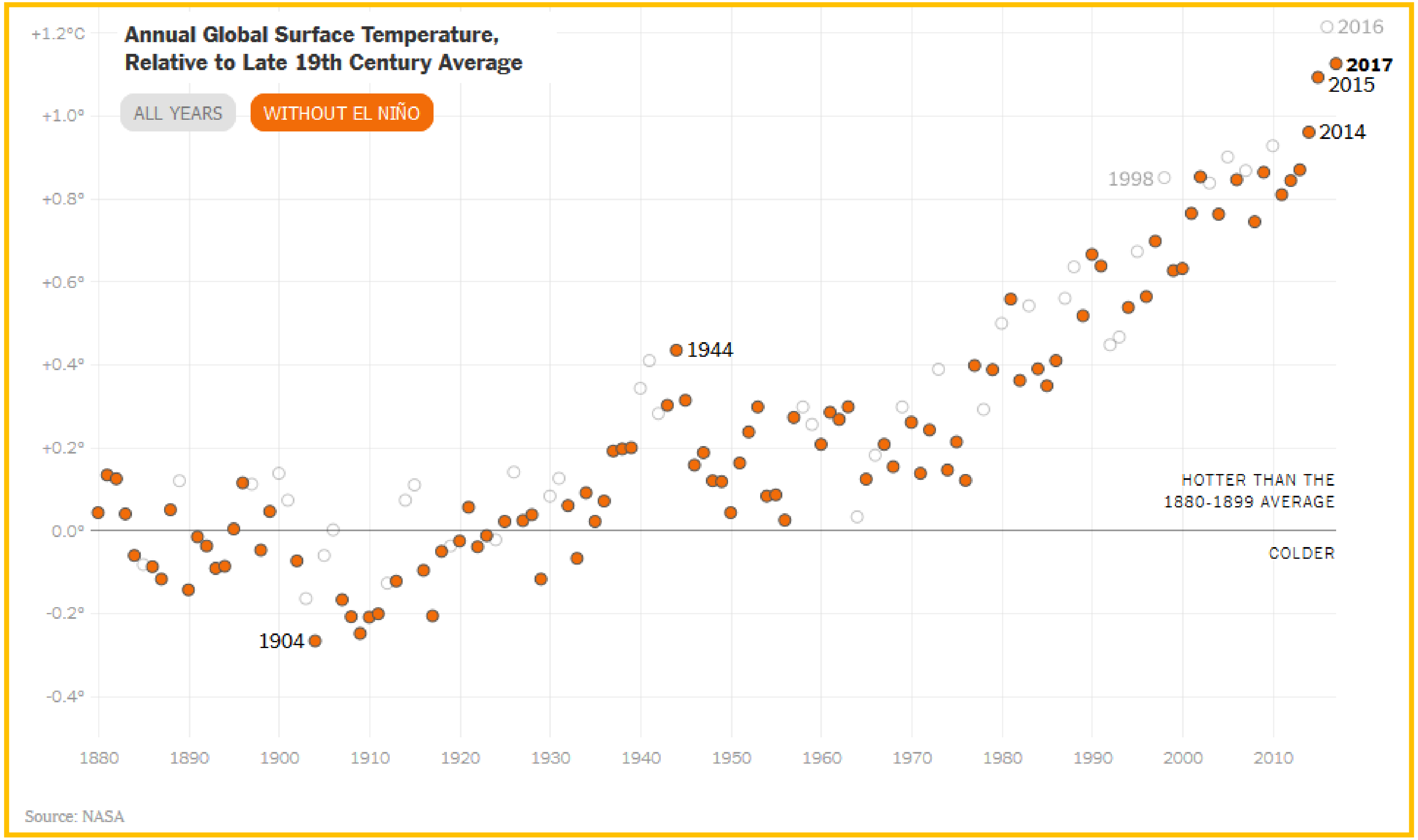
Search NOAA sites

Home / News & Features

2017 was one of three warmest years on record, international report confirms

2018 Is Shaping Up to Be the Fourth-Hottest Year. Yet We're Still Not Prepared for Global Warming.

It's hot. But it may not be the new normal yet. Temperatures are still rising.



This excellent graphic shows the years in this 136 year global average air temperature record that were not El Nino years (orange dots). El Nino (also called ENSO) is a part of Earth's climate variability when the eastern Pacific Ocean off the west coast of South America warms.

"This is the new normal," said Gavin A. Schmidt, director of the Goddard Institute for Space Studies, the NASA group that conducted the analysis. But, he said, "It's also changing. It's not that we've gotten to a new plateau — this isn't where we'll stay. In ten years we're going to say 'oh look, another record decade of warming temperatures.'"

National Oceanic and Atmospheric Administration
U.S. Department of Commerce

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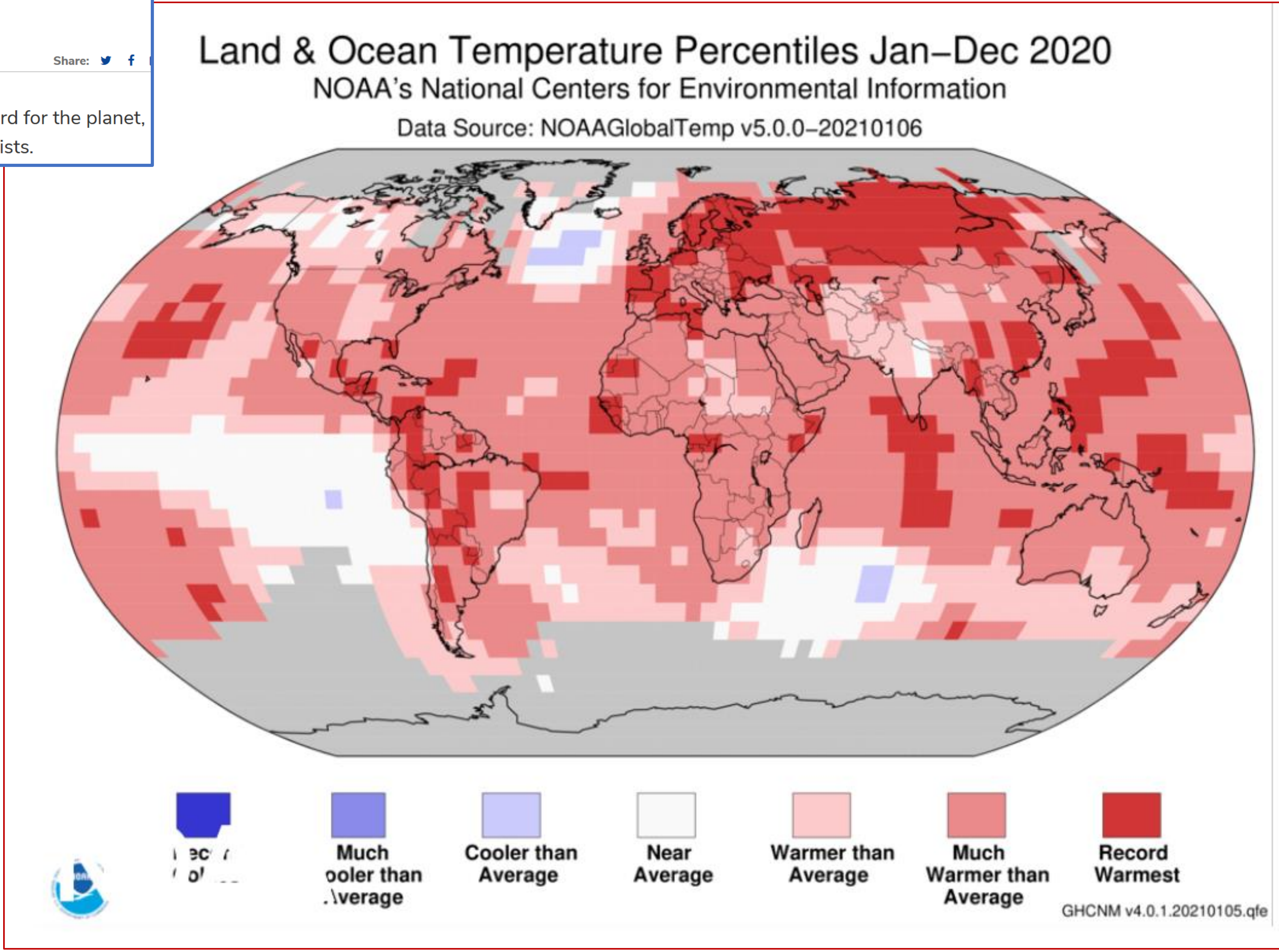
2020 was Earth’s 2nd-hottest year, just behind 2016

Focus areas: Climate, Satellites **Topics:** temperature rankings, global average temperatures, State of the Climate Share:

January 14, 2021 — It’s official: 2020 ranks as the second-hottest year on record for the planet, knocking 2019 down to third hottest, according to an analysis by NOAA scientists.



The world's seven-warmest years have all occurred since 2014, with 10 of the warmest years occurring since 2005.

It was also Earth's 44th consecutive year with global land and ocean temperatures, at least nominally, above the 20th-century average, according to scientists at NOAA's National Centers for Environmental Information.

2020 as ranked by other scientific organizations

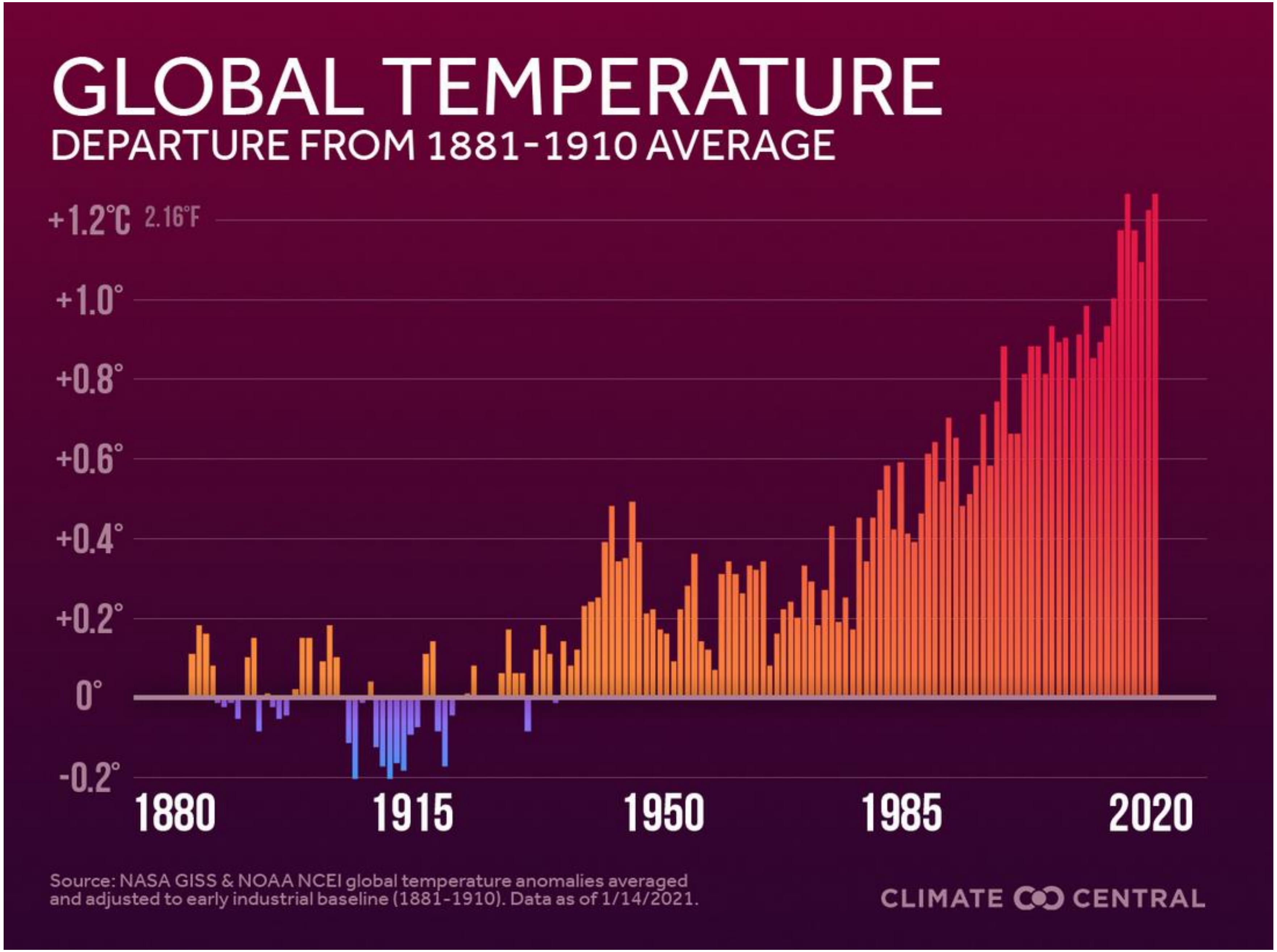
NASA scientists, who conducted a separate but similar analysis, have determined that 2020 ties 2016 as the warmest year on record, sharing the first-place spot.

Scientists from Copernicus also have 2020 tying with 2016 as the warmest year on record, while the United Kingdom Met Office ranked 2020 as the second-warmest year on record.

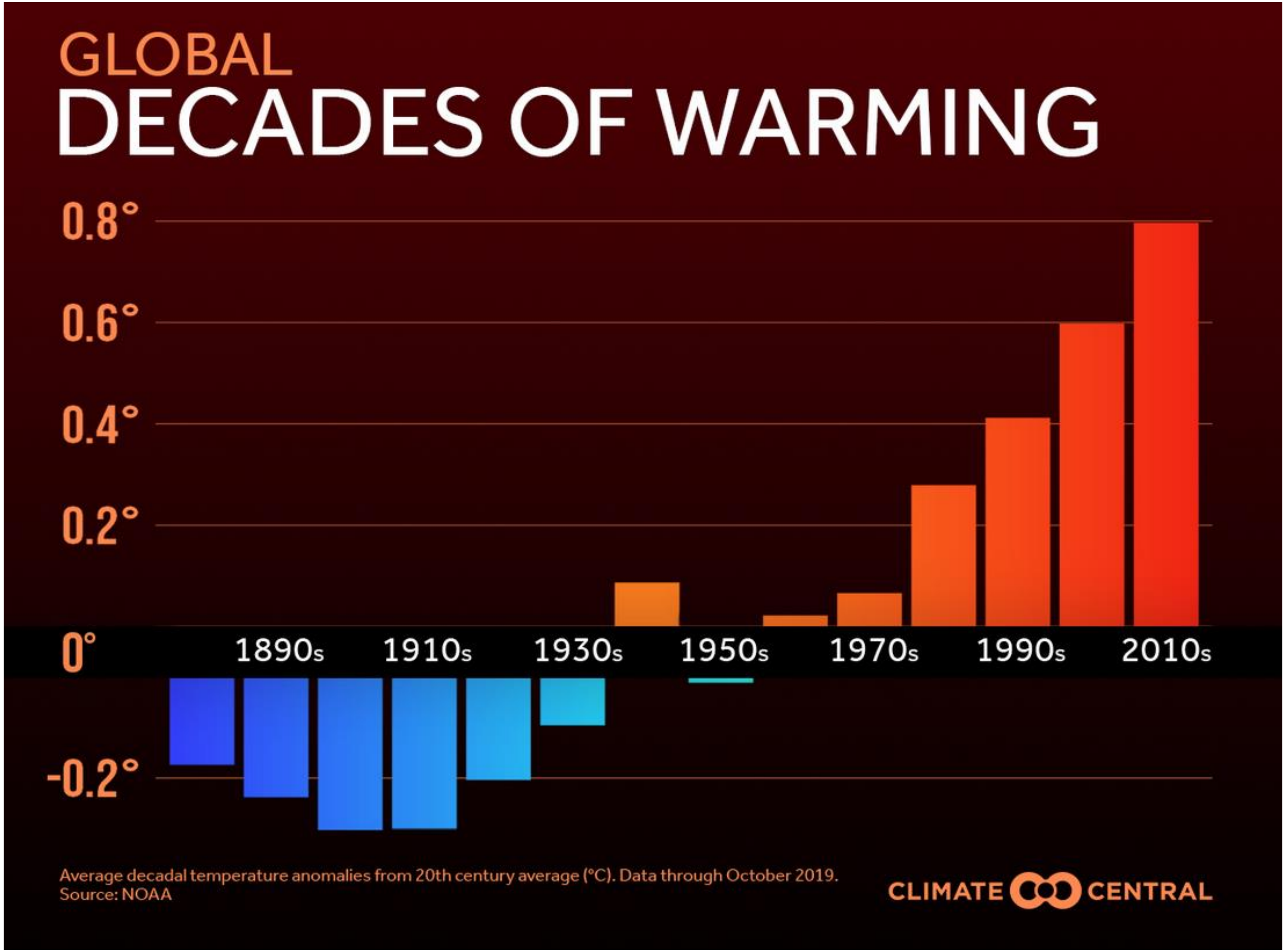
The state of sea ice

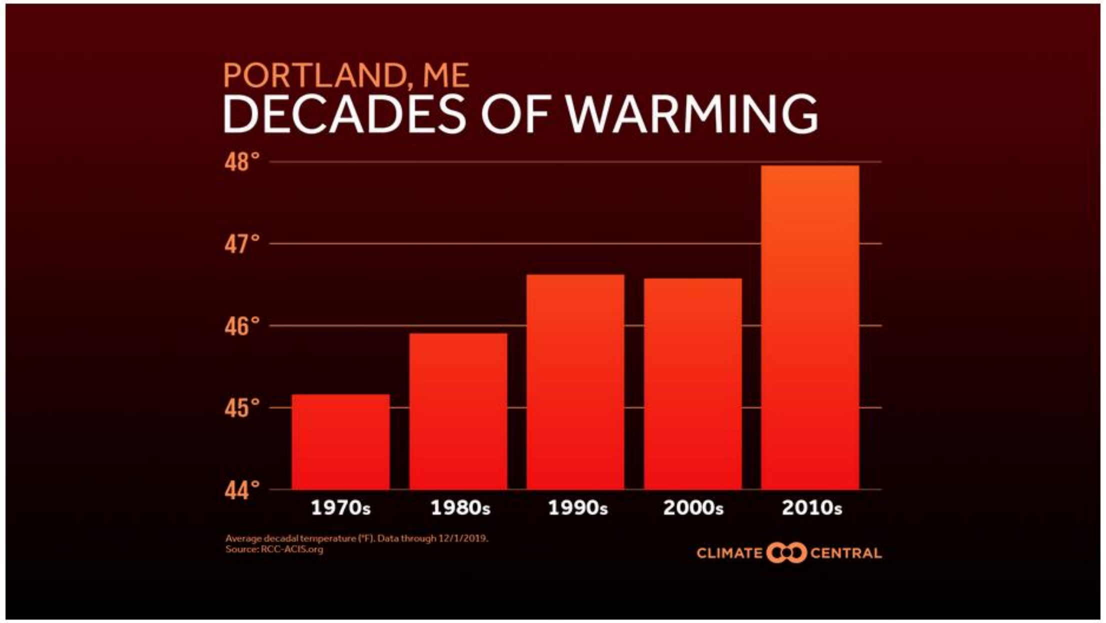
The 2020 average annual *Arctic sea ice* extent (coverage) was approximately 3.93 million square miles and ties 2016 for the smallest on record. The five smallest Arctic annual extents have occurred in the last five years (2016-20).

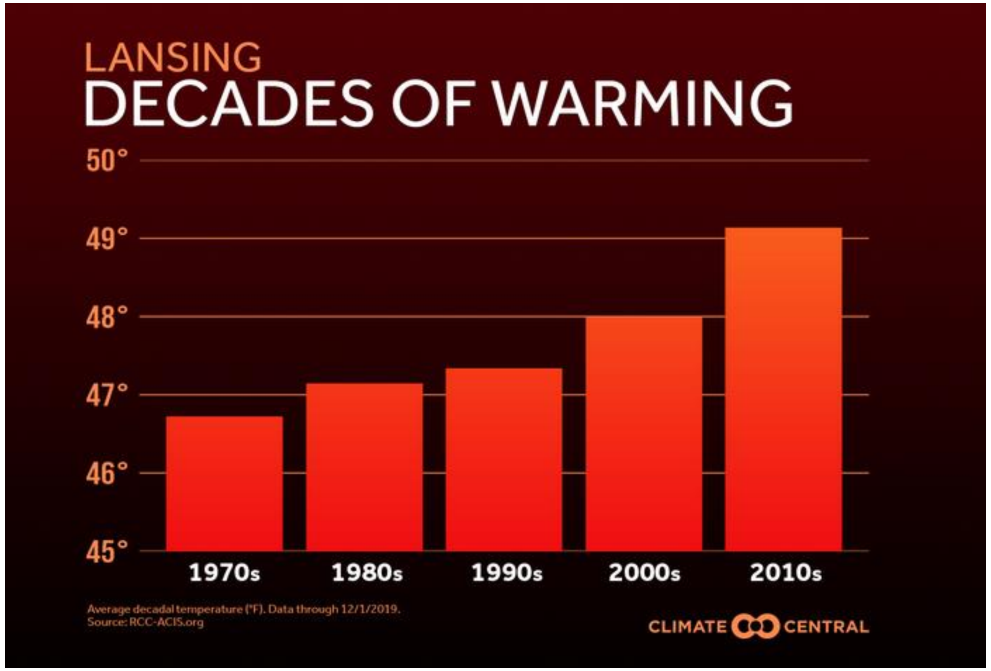
The annual *Antarctic sea ice* extent was near average at 4.44 million square miles.

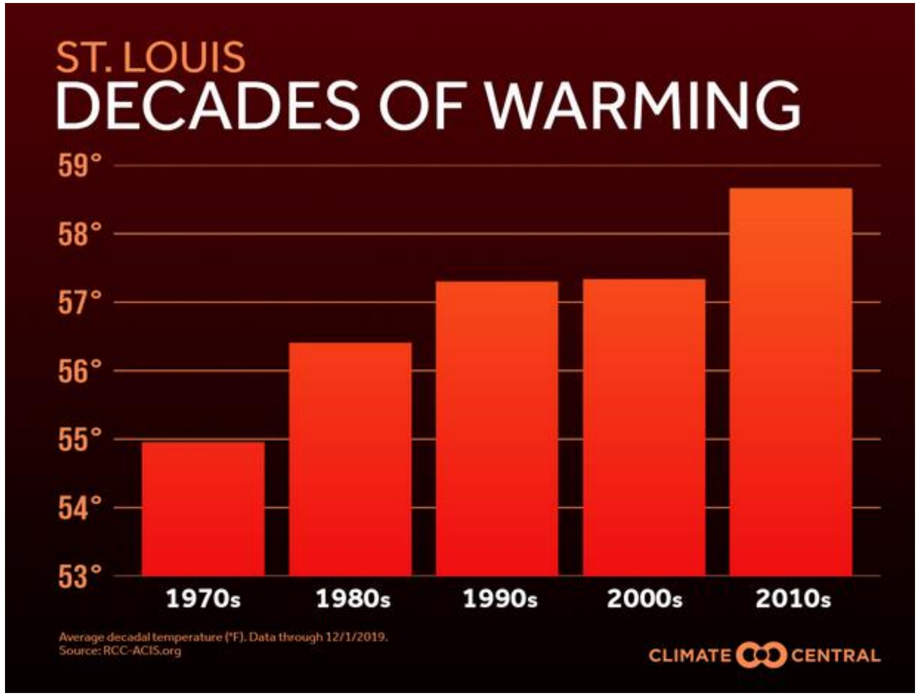

GLOBAL TEMPERATURE
DEPARTURE FROM 1881-1910 AVERAGE
+1.2°C 2.16°F
+1.0°
+0.8°
+0.6°
+0.4°
+0.2°
0°
-0.2°
1880
1915
1950
1985
2020
Source: NASA GISS & NOAA NCEI global temperature anomalies averaged and adjusted to early industrial baseline (1881-1910). Data as of 1/14/2021.
CLIMATE CENTRAL

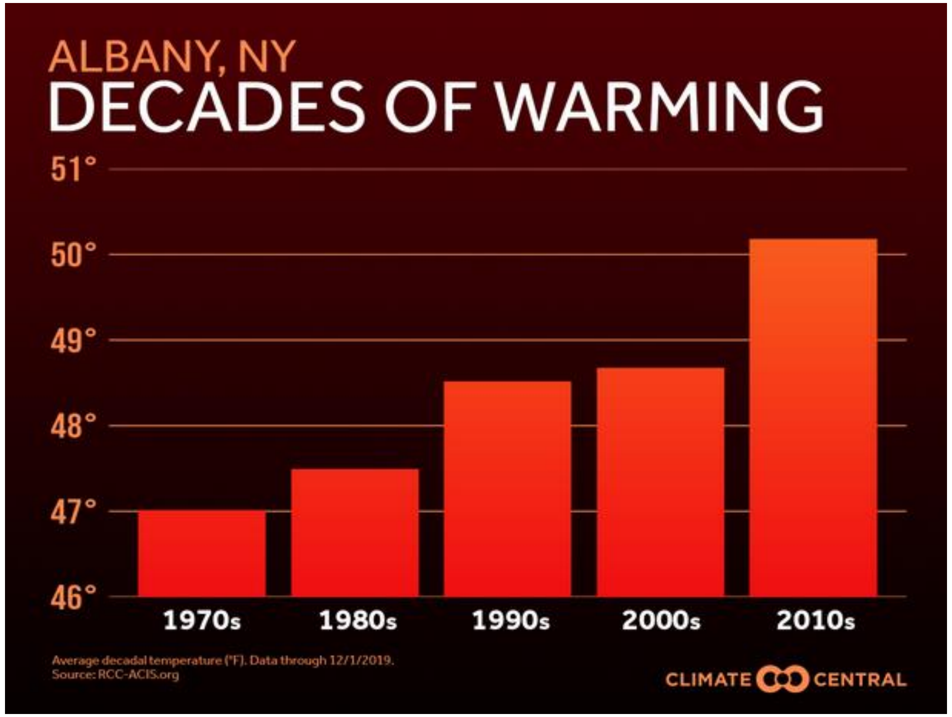
Looking at the global average air temperature data by decadal averages of the anomaly in comparison to the global 20th century average.

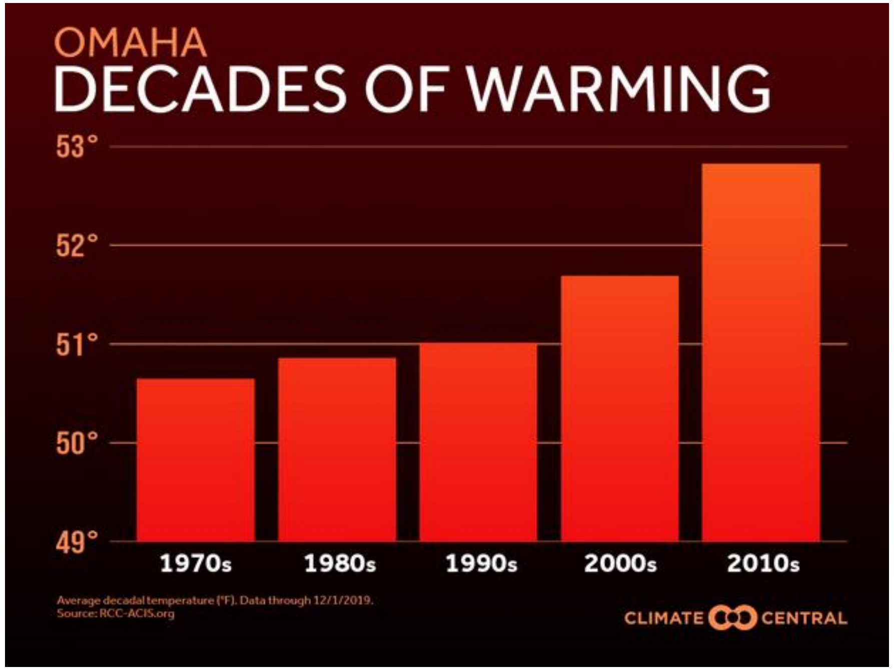


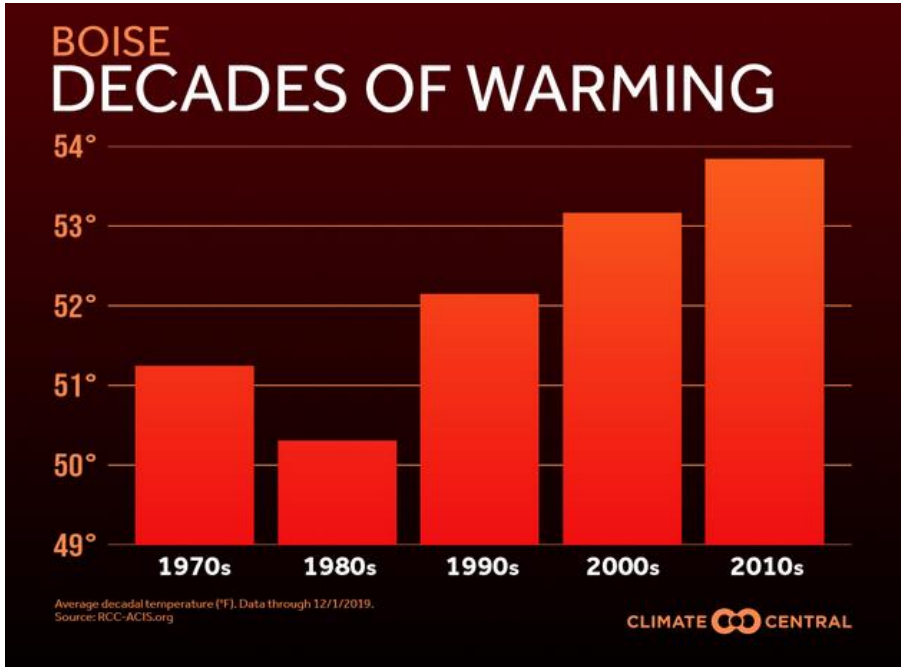

PORTLAND, ME
DECADES OF WARMING
48°
47°
46°
45°
44°
1970s
1980s
1990s
2000s
2010s
Average decadal temperature (°F). Data through 12/1/2019.
Source: RCC-ACIS.org
CLIMATE CENTRAL

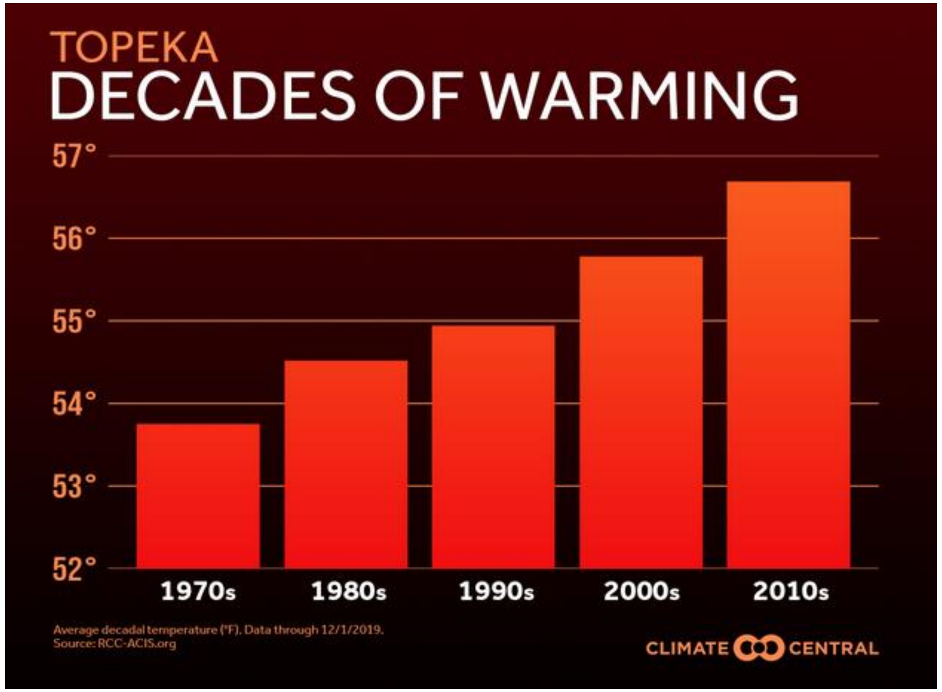

LANSING
DECADES OF WARMING
50°
49°
48°
47°
46°
45°
1970s
1980s
1990s
2000s
2010s
Average decadal temperature (°F). Data through 12/1/2019.
Source: RCC-ACIS.org
CLIMATE CENTRAL

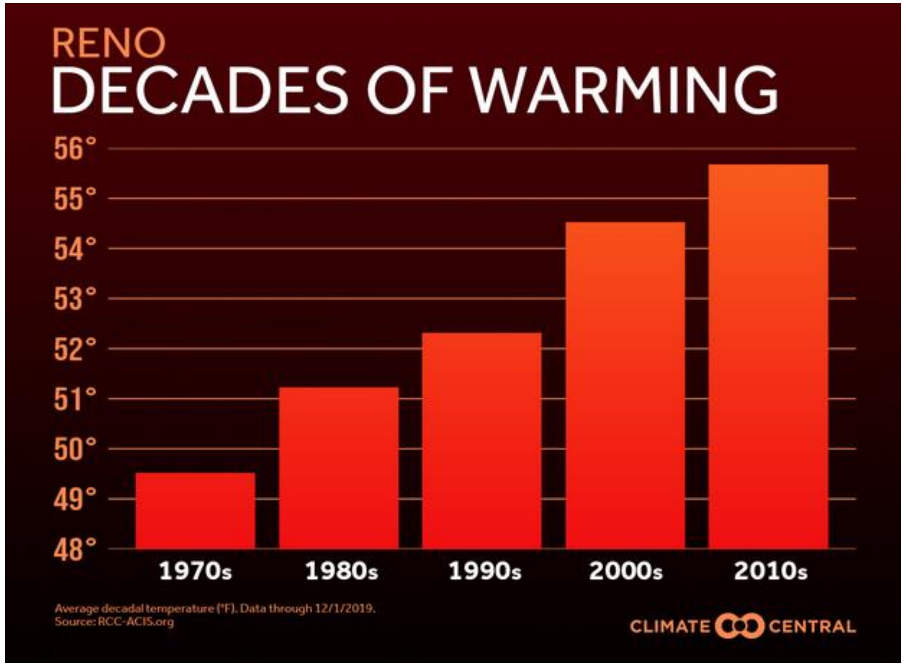

ST. LOUIS
DECADES OF WARMING
59°
58°
57°
56°
55°
54°
53°
1970s
1980s
1990s
2000s
2010s
Average decadal temperature (°F). Data through 12/1/2019.
Source: RCC-ACIS.org
CLIMATE CENTRAL


ALBANY, NY
DECADES OF WARMING
51°
50°
49°
48°
47°
46°
1970s
1980s
1990s
2000s
2010s
Average decadal temperature (°F). Data through 12/1/2019.
Source: RCC-ACIS.org
CLIMATE CENTRAL


OMAHA
DECADES OF WARMING
53°
52°
51°
50°
49°
1970s
1980s
1990s
2000s
2010s
Average decadal temperature (°F). Data through 12/1/2019.
Source: RCC-ACIS.org
CLIMATE CENTRAL


BOISE
DECADES OF WARMING
54°
53°
52°
51°
50°
49°
1970s
1980s
1990s
2000s
2010s
Average decadal temperature (°F). Data through 12/1/2019.
Source: RCC-ACIS.org
CLIMATE CENTRAL


TOPEKA
DECADES OF WARMING
57°
56°
55°
54°
53°
52°
1970s
1980s
1990s
2000s
2010s
Average decadal temperature (°F). Data through 12/1/2019.
Source: RCC-ACIS.org
CLIMATE CENTRAL


RENO
DECADES OF WARMING
56°
55°
54°
53°
52°
51°
50°
49°
48°
1970s
1980s
1990s
2000s
2010s
Average decadal temperature (°F). Data through 12/1/2019.
Source: RCC-ACIS.org
CLIMATE CENTRAL

The New York Times

There's a New Definition of 'Normal' for Weather

By Henry Fountain and Jason Kao May 12, 2021

The United States is getting redder.

No, not *that* kind of red. (We'll leave that to the political pundits.) We're talking about the thermometer kind.

The National Oceanic and Atmospheric Administration last week issued its latest "climate normals": baseline data of temperature, rain, snow and other weather variables collected over three decades at thousands of locations across the country.

"There's a huge difference in temperature over time, as we go from cooler climates in the early part of the 20th century to ubiquitously warmer climates," he said.

The change is especially drastic between the new normals and the previous ones, from 2010. "Almost every place in the U.S. has warmed," Dr. Palecki said.

The temperature results are in keeping with what we've long known: that the world has warmed by more than 1 degree Celsius (about 1.8 degrees Fahrenheit) since 1900, and that the pace of warming has accelerated in recent decades.

Capital Weather Gang

NOAA unveils new U.S. climate 'normals' that are warmer than ever

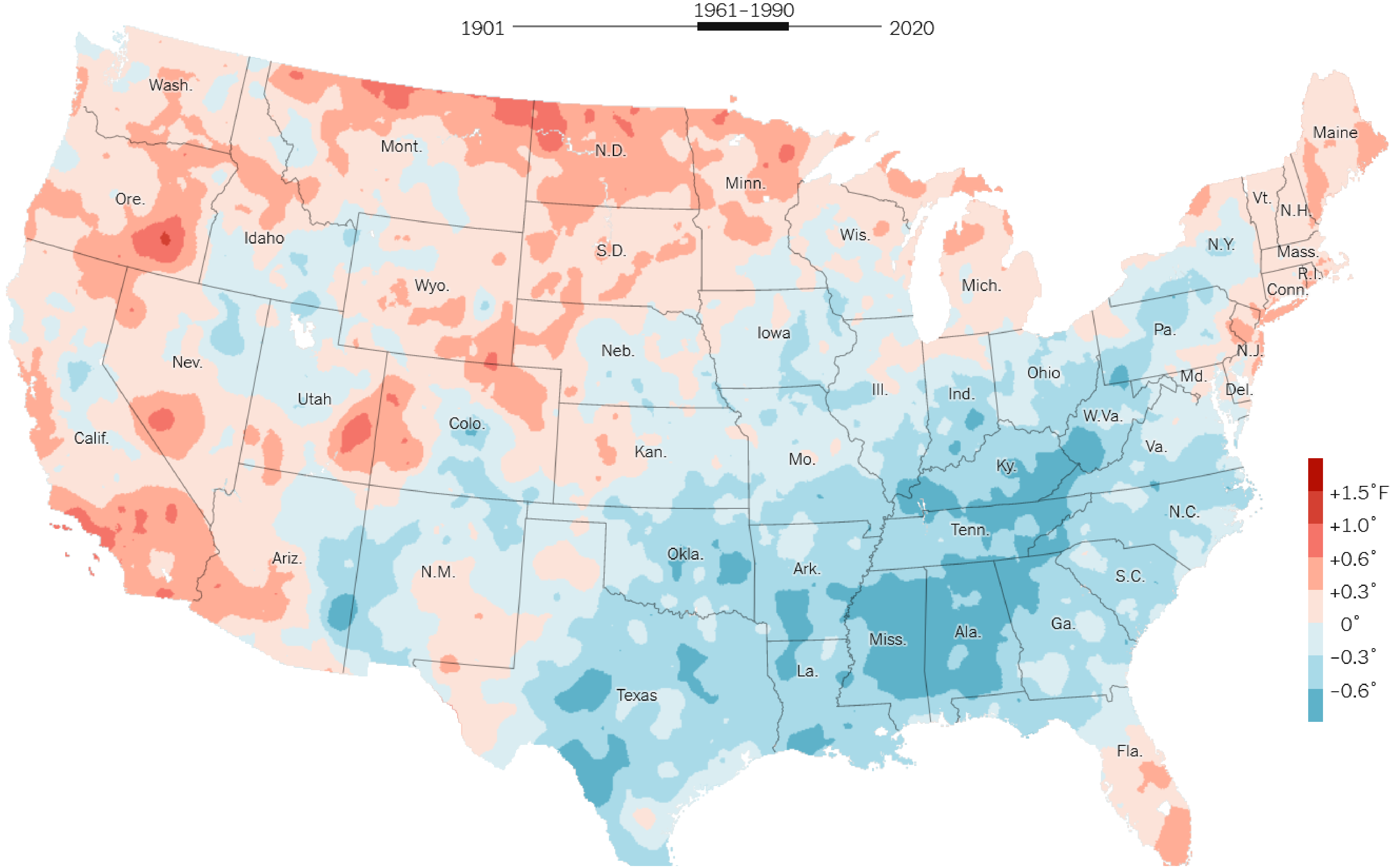
By Bob Henson and Jason Samenow

May 4, 2021 at 7:00 a.m. EDT

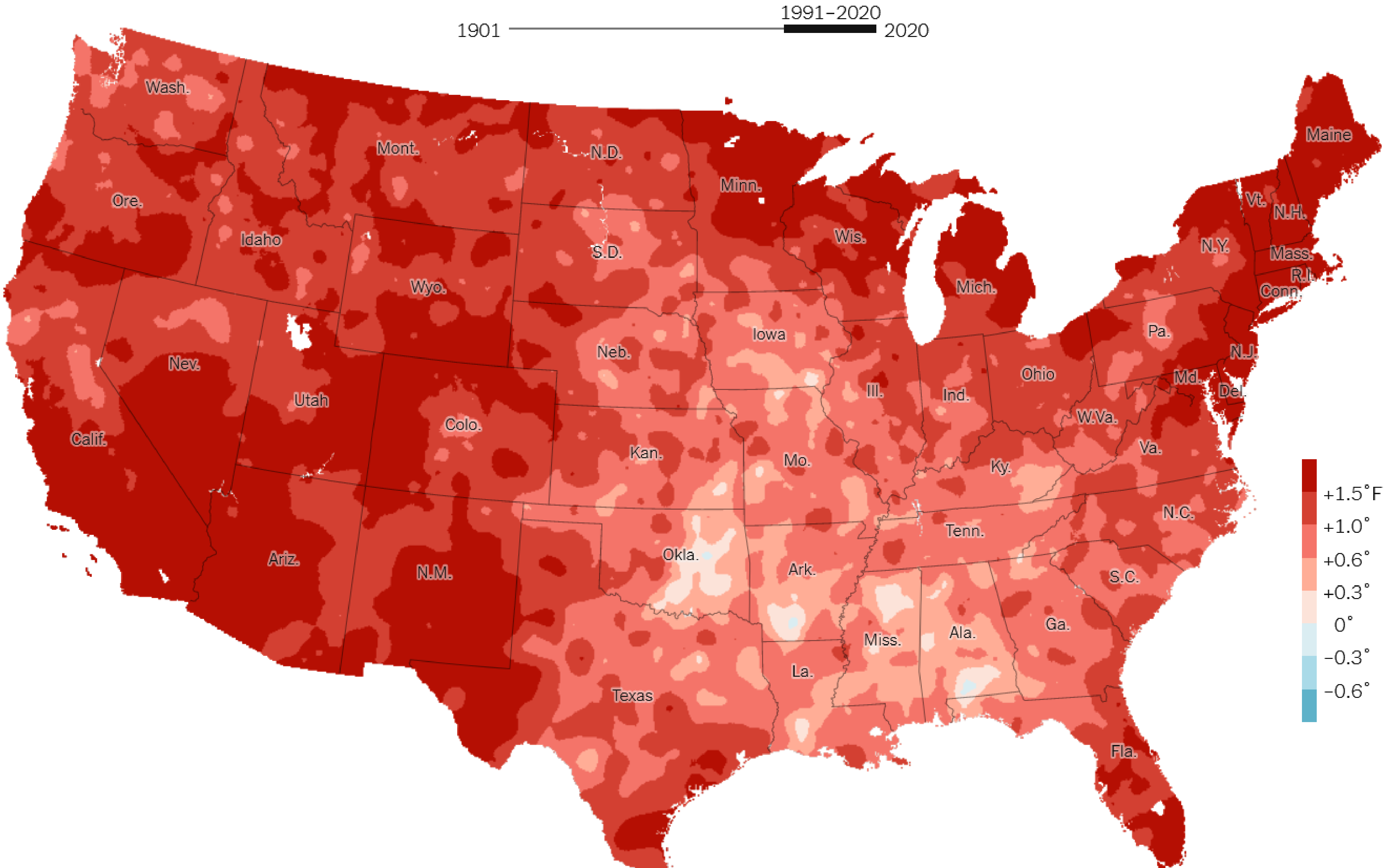
Drawing from the latest decade of weather data, the new normals are a reflection of climate change

The New York Times

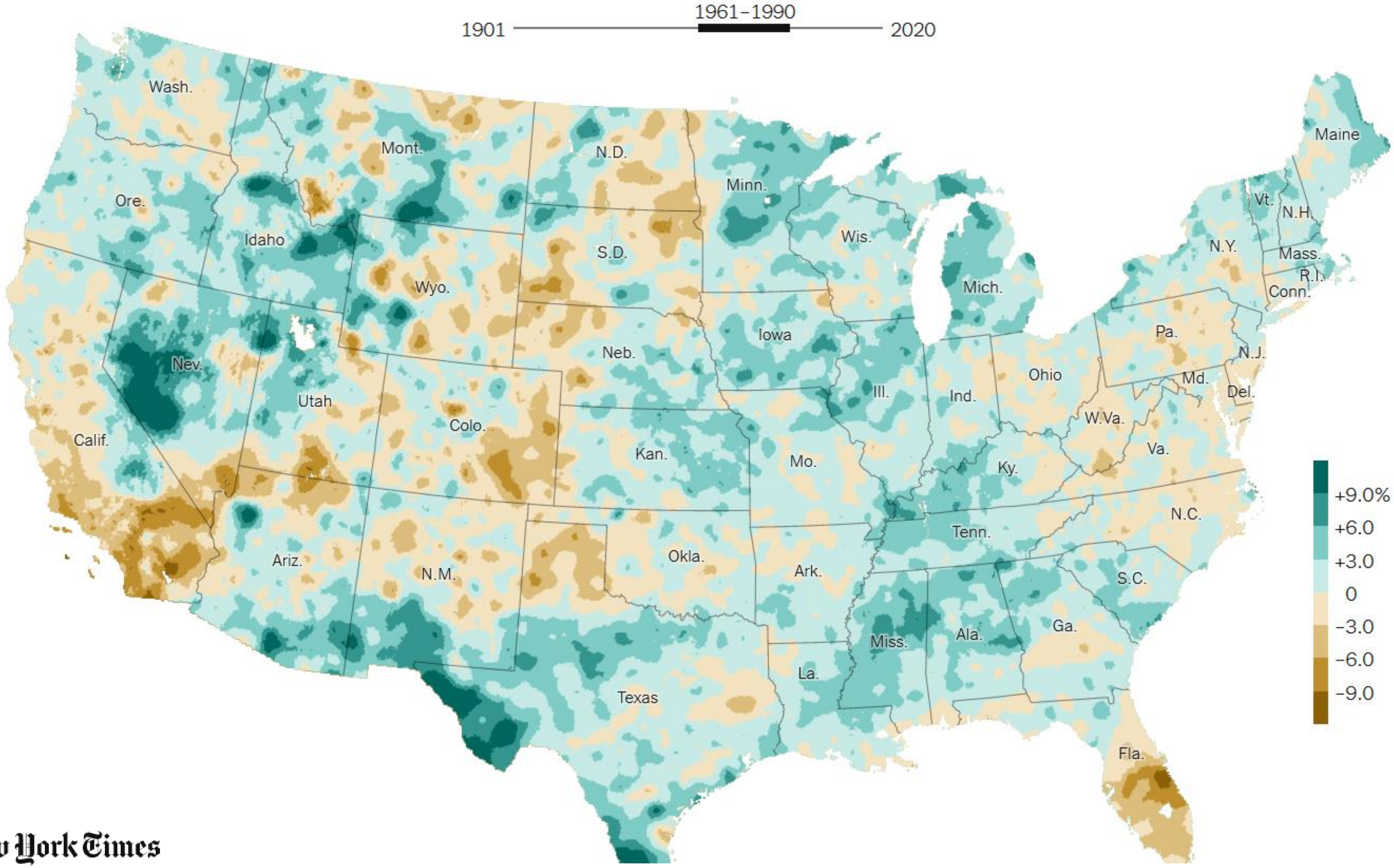
30-year temperatures compared with 20th century average



30-year temperatures compared with 20th century average

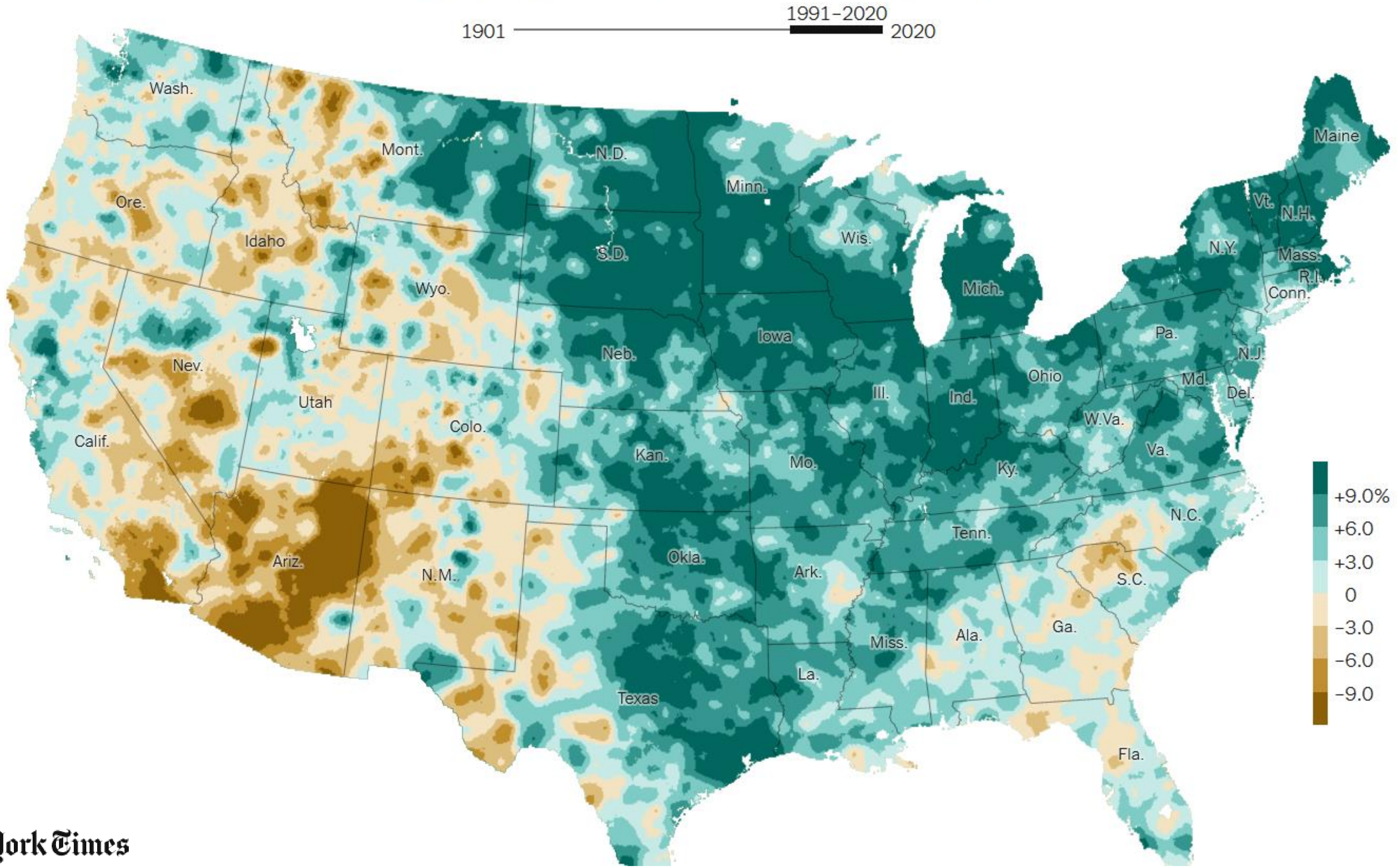


30-year precipitation compared with 20th century average



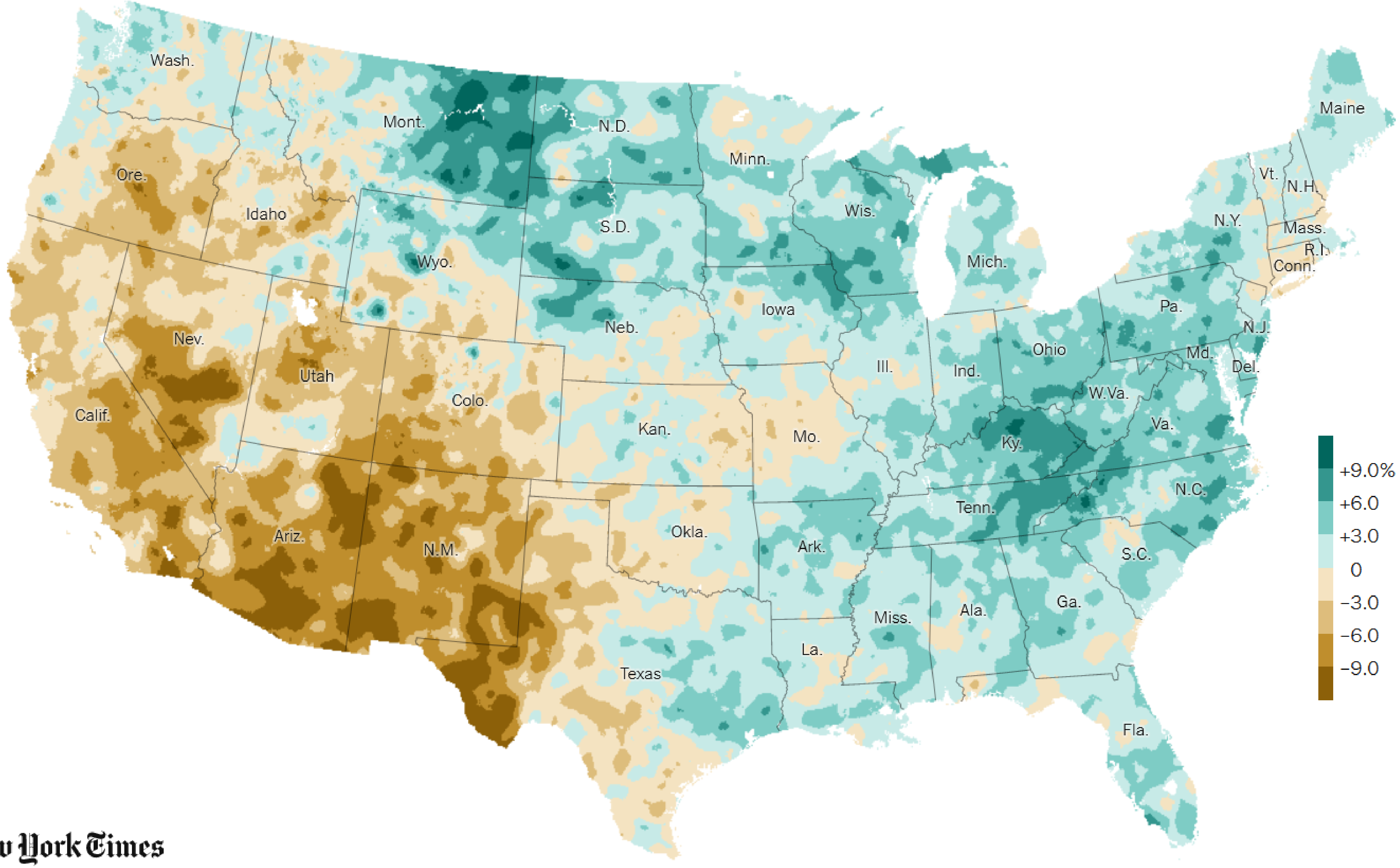
The New York Times

30-year precipitation compared with 20th century average



The New York Times

Change in average precipitation between 1981-2010 and 1991-2020



The New York Times

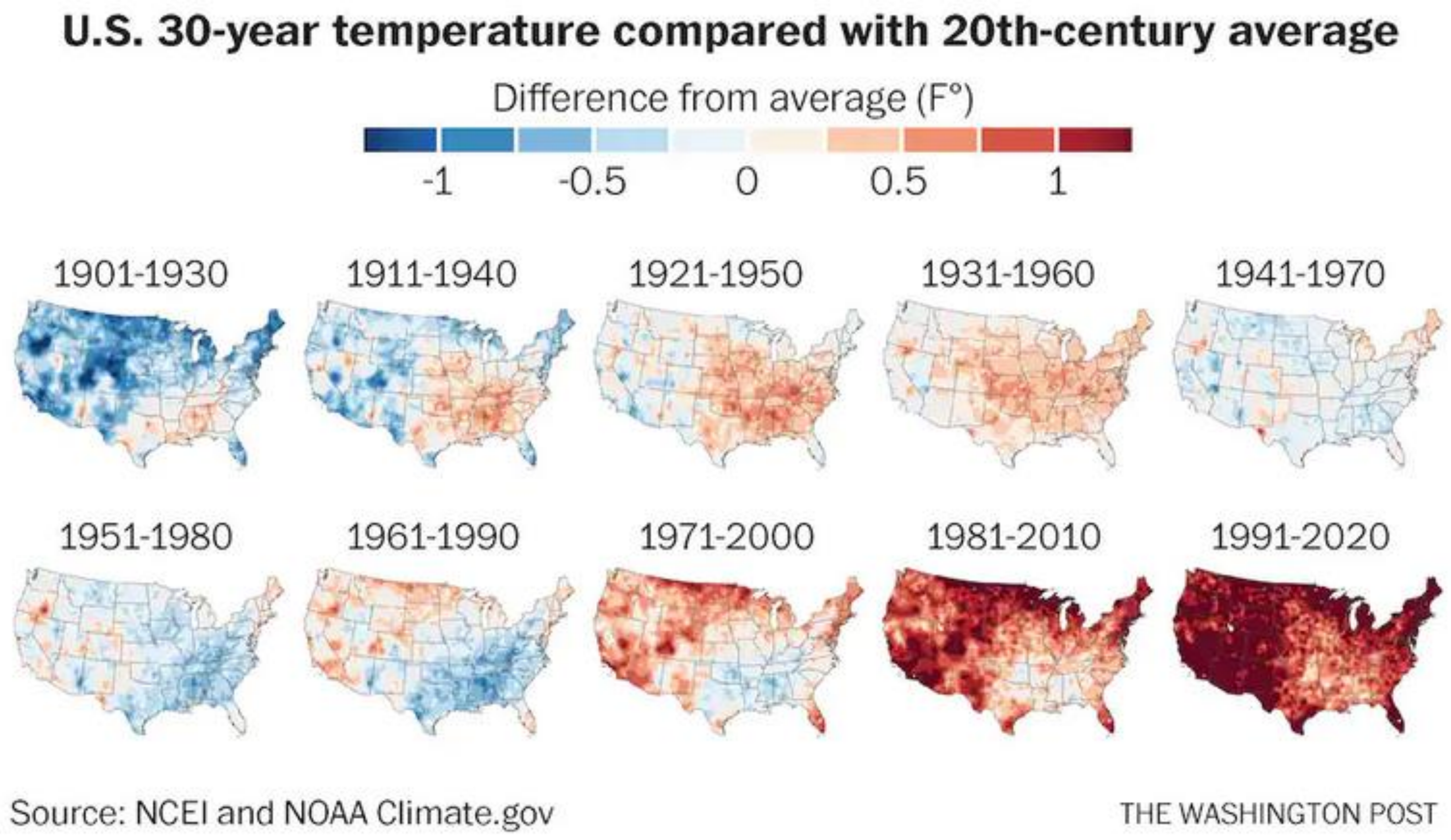
The precipitation results also track the understanding that warming increases evaporation, and warmer air holds more moisture, so generally precipitation is expected to increase as the world gets warmer. Heavy downpours have increased in the United States in recent decades, and the trend is expected to continue.

But climate change can also cause shifts in circulation in the atmosphere and oceans, which can in turn affect regional precipitation patterns. So as the maps show, precipitation changes over the decades are less uniform across the United States.

The normals use data gathered from about 15,000 weather stations around the country. About 900 of them, mostly at airports, are fully automated, providing measurements of temperature, precipitation, wind speed and other variables around the clock.

But more than 8,000 stations are operated by volunteer weather geeks, part of one of the largest — and, dating back to 1890, one of the oldest — citizen-science projects anywhere.

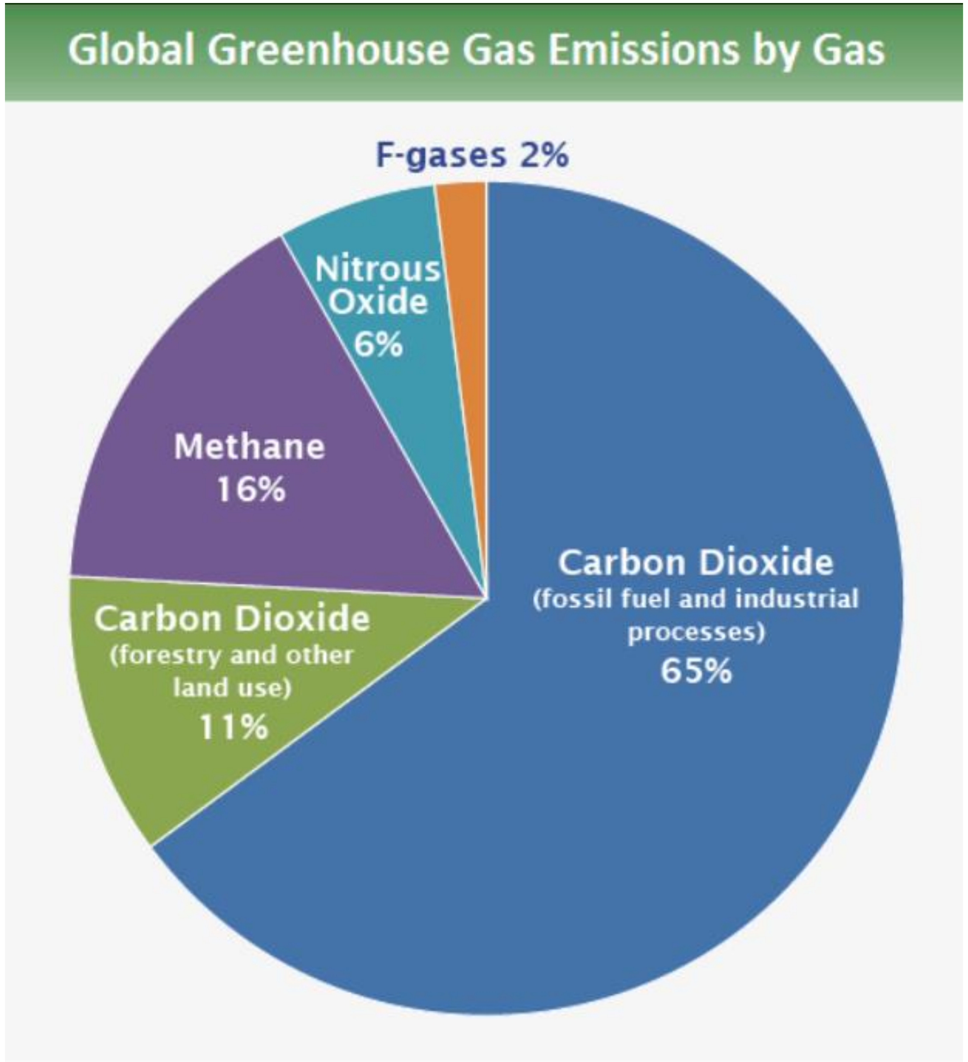
The normals are computed using 30 years of data and the newest ones include data from 1991 to 2020. But they are not simple averages. NOAA experts account for changes in monitoring instruments and other conditions that could create inconsistencies or gaps.



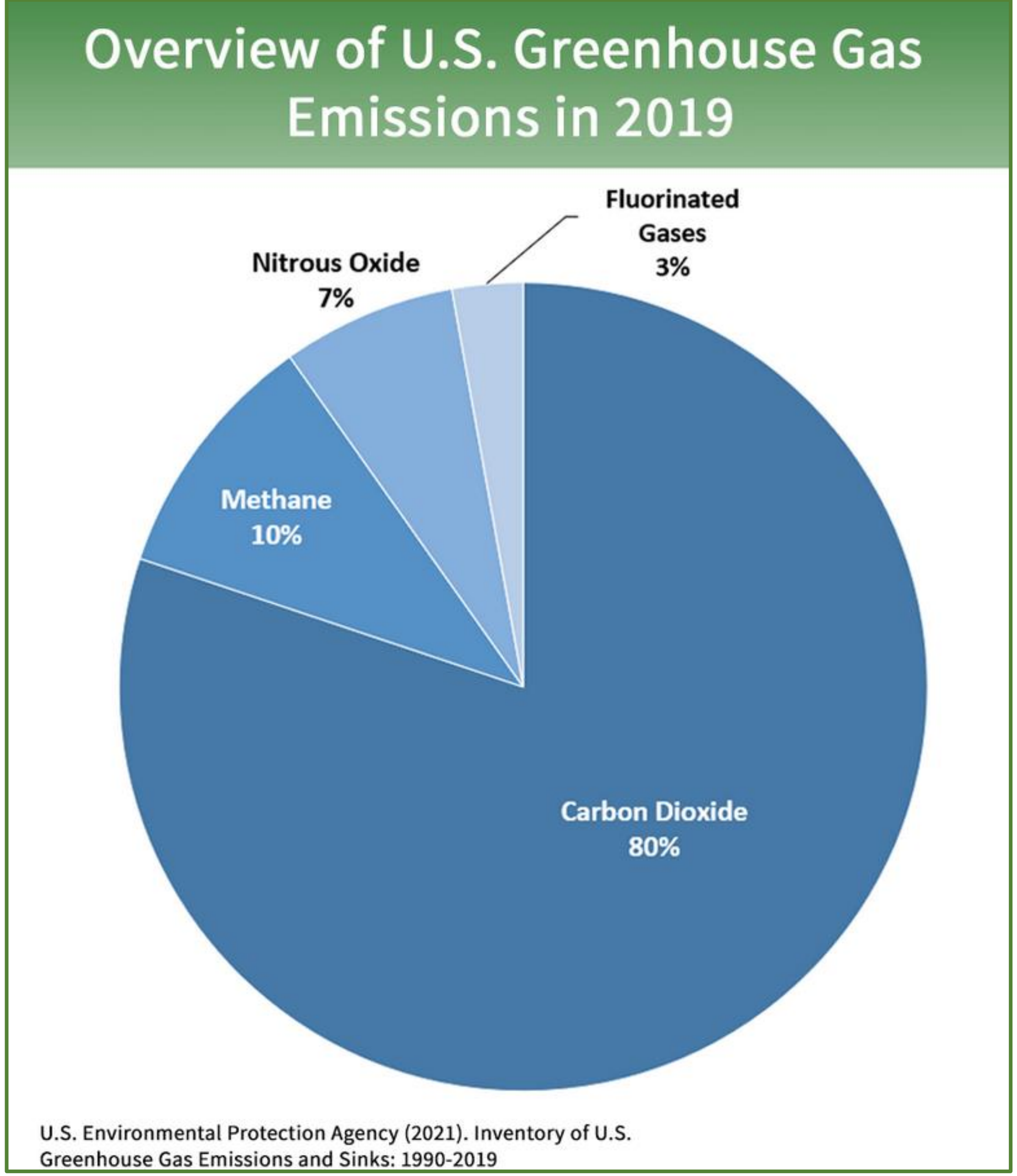
U.S. 30-year temperature compared with 20th-century average (The Washington Post)

This graphic from The Washington Post shows all ten of the 30—year average temperature maps by NOAA in comparison to the 20th century average temperature for the U.S.

United States Environmental Protection Agency



Source: IPCC (2014) EXIT based on global emissions from 2010. Details about the sources included in these estimates can be found in the *Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. EXIT



Total U.S. Emissions in 2019 = 6,558 Million Metric Tons of CO_2 equivalent (excludes land sector). Percentages may not add up to 100% due to independent rounding.

NOAA RESEARCH NEWS

Carbon dioxide peaks near 420 parts per million at Mauna Loa observatory

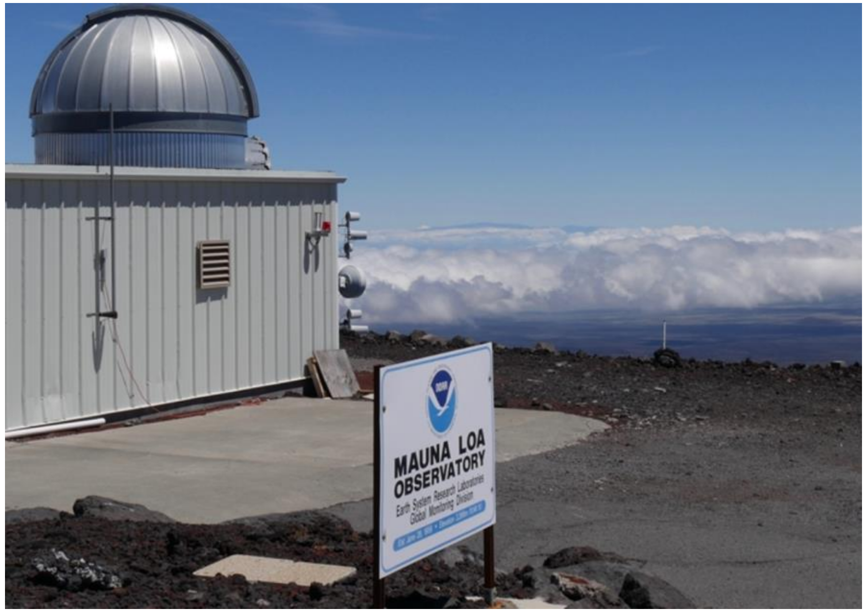
Atmospheric carbon dioxide measured at NOAA's Mauna Loa Atmospheric Baseline Observatory peaked for 2021 in May at a monthly average of 419 parts per million (ppm), the highest level since accurate measurements began 63 years ago, scientists from NOAA and Scripps Institution of Oceanography at the University of California San Diego announced today.

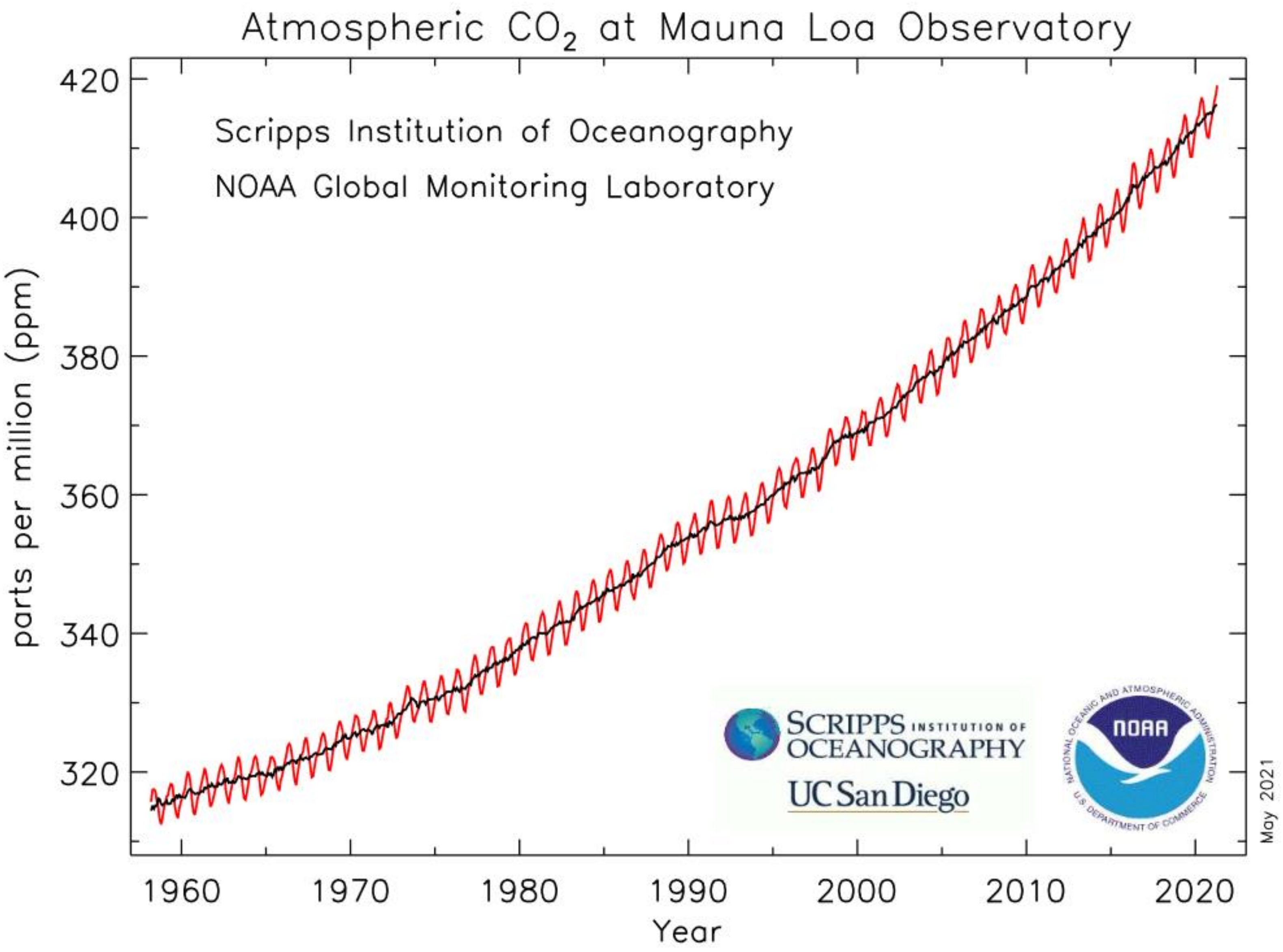
Scripps' scientist Charles David Keeling initiated on-site measurements of carbon dioxide, or CO_2, at NOAA's weather station on Mauna Loa in 1958. NOAA began measurements in 1974, and the two research institutions have made complementary, independent observations ever since.

In May, NOAA's measurements at the mountaintop observatory averaged 419.13 ppm. Scientists at Scripps calculated a monthly average of 418.92 ppm. The average in May 2020 was 417 ppm.

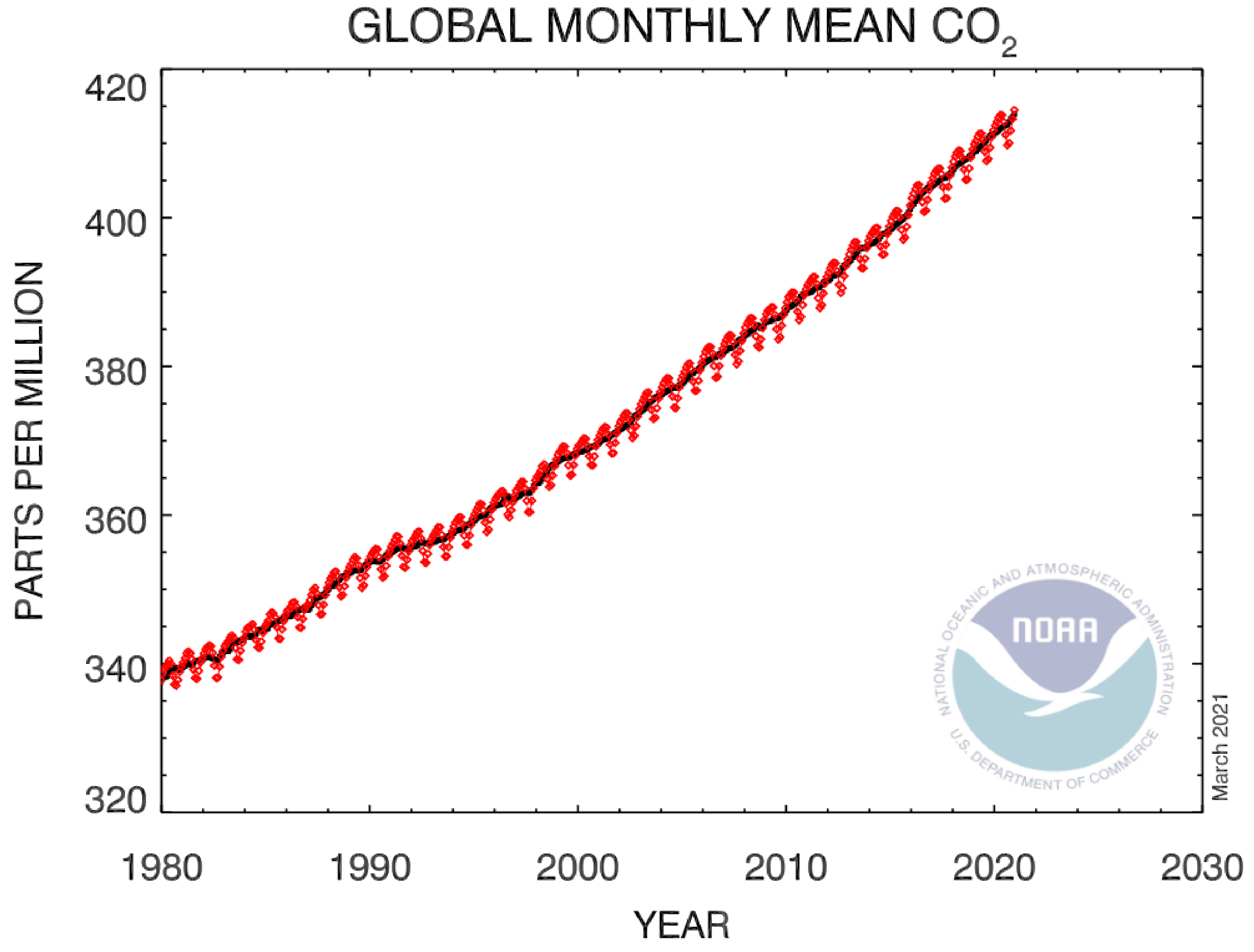
Pieter Tans, a senior scientist with NOAA's Global Monitoring Laboratory, noted that CO_2 is by far the most abundant human-caused greenhouse gas, and persists in the atmosphere and oceans for thousands of years after it is emitted.

"We are adding roughly 40 billion metric tons of CO_2 pollution to the atmosphere per year," said Tans. "That is a mountain of carbon that we dig up out of the Earth, burn, and release into the atmosphere as CO_2 - year after year. If we want to avoid





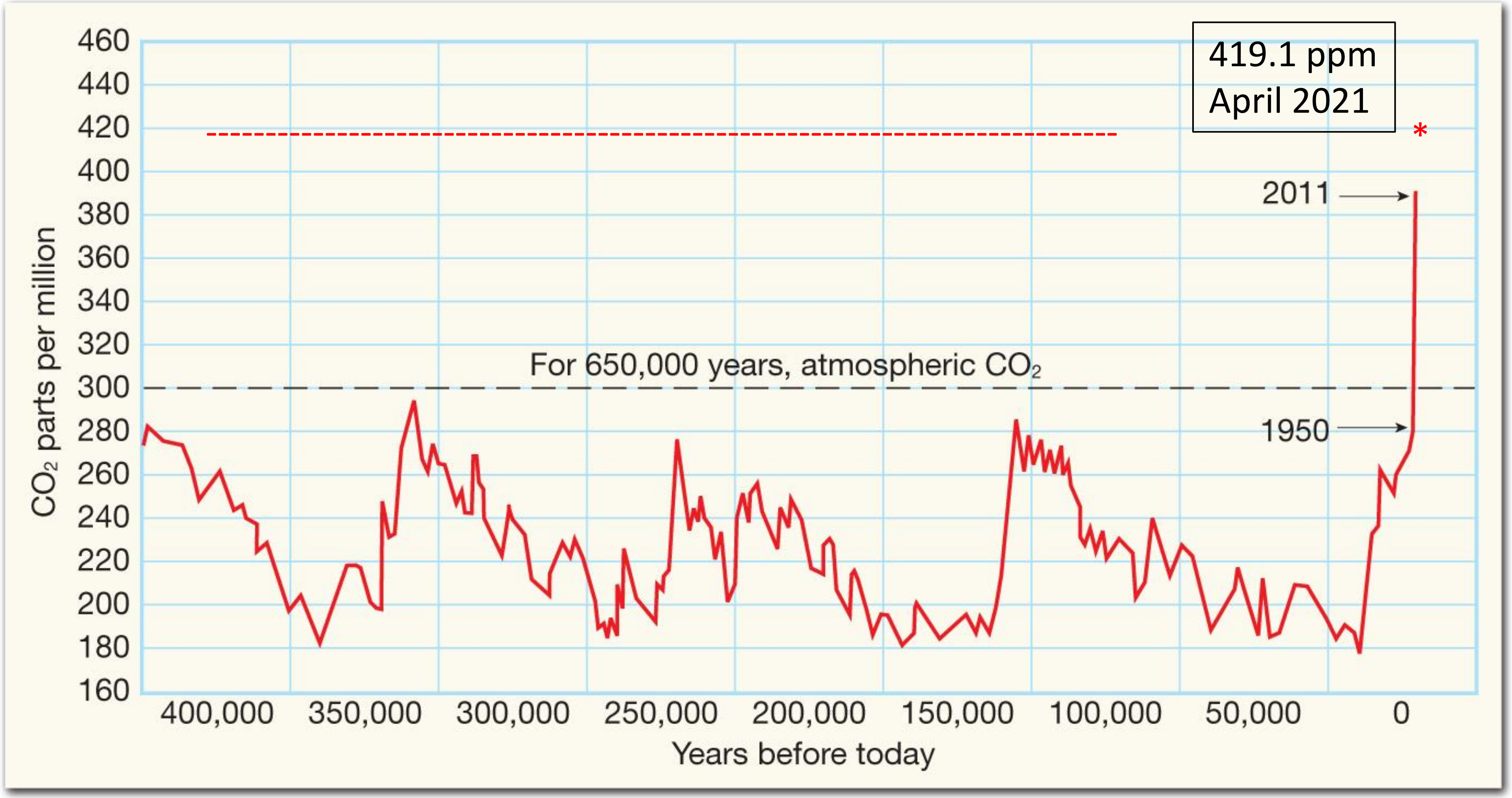
April 2021: 419.05 ppm
April 2020: 416.45 ppm
Last updated: May 5, 2021



December 2020: 414.49 ppm

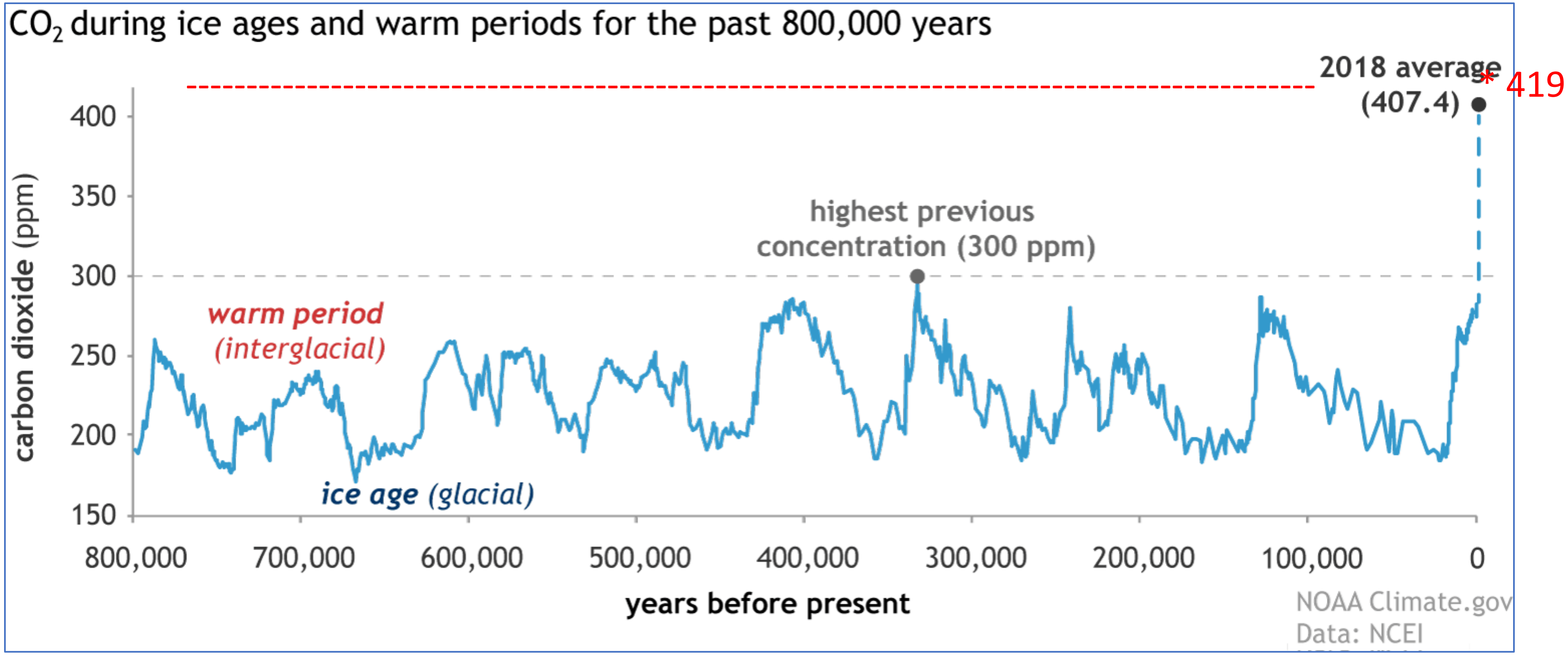
December 2019: 411.75 ppm

Last updated: March 5, 2021



It is important to understand the importance of the following ppm's:
180 ppm vs. 280 ppm vs. 419 ppm . See next slide.

April 2021: 419.05 ppm
April 2020: 416.45 ppm
Last updated: May 5, 2021



Global atmospheric carbon dioxide concentrations (CO_2) in parts per million (ppm) for the past 800,000 years. The peaks and valleys track ice ages (low CO_2) and warmer interglacials (higher CO_2). During these cycles, CO_2 was never higher than 300 ppm. In 2018, it reached 407.4 ppm. On the geologic time scale, the increase (blue dashed line) looks virtually instantaneous. NOAA Climate.gov, based on EPICA Dome C data (Lüthi, D., et al., 2008) provided by NOAA NCEI Paleoclimatology Program.

New Climate Maps Show a Transformed United States

by Al Shaw, Abrahm Lustgarten, ProPublica, and Jeremy W. Goldsmith, Special to ProPublica, September 15, 2020.

According to new data from the Rhodium Group analyzed by ProPublica and The New York Times Magazine, warming temperatures and changing rainfall will drive agriculture and temperate climates northward, while sea level rise will consume coastlines and dangerous levels of humidity will swamp the Mississippi River valley.

see next slide→

Taken with other recent research showing that the most habitable climate in North America will shift northward and the incidence of large fires will increase across the country, this suggests that the climate crisis will profoundly interrupt the way we live and farm in the United States. See how the North American places where humans have lived for thousands of years will shift and what changes are in store for your county.

projects.propublica.org/climate-migration/

Future of the human climate niche

Chi Xu (徐驰)[a,1], Timothy A. Kohler[b,c,d,e], Timothy M. Lenton[f], Jens-Christian Svenning[g], and Marten Scheffer[c,h,i,1]

[a]School of Life Sciences, Nanjing University, Nanjing 210023, China; [b]Department of Anthropology, Washington State University, Pullman, WA 99164; [c]Santa Fe Institute, Santa Fe, NM 87501; [d]Crow Canyon Archaeological Center, Cortez, CO 81321; [e]Research Institute for Humanity and Nature, Kyoto 603-8047, Japan; [f]Global Systems Institute, University of Exeter, Exeter, EX4 4QE, United Kingdom; [g]Center for Biodiversity Dynamics in a Changing World, Department of Bioscience, Aarhus University, DK-8000 Aarhus C, Denmark; [h]Wageningen University, NL-6700 AA, Wageningen, The Netherlands; and [i]SARAS (South American Institute for Resilience and Sustainability Studies), 10302 Bella Vista, Maldonado, Uruguay

Contributed by Marten Scheffer, October 27, 2019 (sent for review June 12, 2019; reviewed by Victor Galaz and Luke Kemp)

All species have an environmental niche, and despite technological advances, humans are unlikely to be an exception. Here, we demonstrate that for millennia, human populations have resided in the same narrow part of the climatic envelope available on the globe, characterized by a major mode around ~11 °C to 15 °C mean annual temperature (MAT). Supporting the fundamental nature of this temperature niche, current production of crops and livestock is largely limited to the same conditions, and the same optimum has been found for agricultural and nonagricultural economic output of countries through analyses of year-to-year variation. We show that in a business-as-usual climate change scenario, the geographical position of this temperature niche is projected to shift more over the coming 50 y than it has moved since 6000 BP. Populations will not simply track the shifting climate, as adaptation in situ may address some of the challenges, and many other factors affect decisions to migrate. Nevertheless, in the absence of migration, one third of the global population is projected to experience a MAT >29 °C currently found in only 0.8% of the Earth's land surface, mostly concentrated in the Sahara. As the potentially most affected regions are among the poorest in the world, where adaptive capacity is low, enhancing human development in those areas should be a priority alongside climate mitigation.

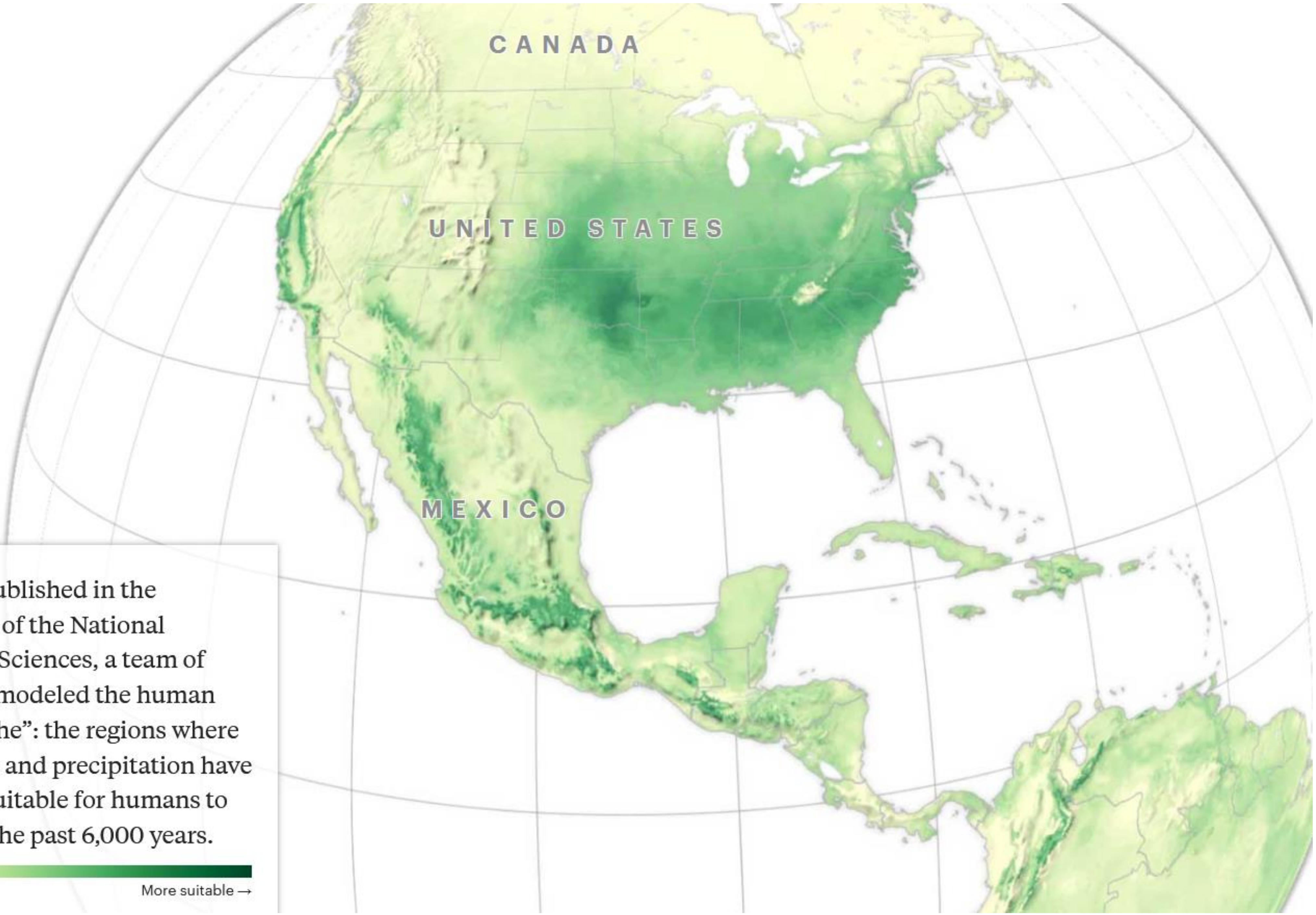
Significance

We show that for thousands of years, humans have concentrated in a surprisingly narrow subset of Earth's available climates, characterized by mean annual temperatures around ~13 °C. This distribution likely reflects a human temperature niche related to fundamental constraints. We demonstrate that depending on scenarios of population growth and warming, over the coming 50 y, 1 to 3 billion people are projected to be left outside the climate conditions that have served humanity well over the past 6,000 y. Absent climate mitigation or migration, a substantial part of humanity will be exposed to mean annual temperatures warmer than nearly anywhere today.

Peer-reviewed research utilized by the Rhodium Group.

11350–11355 | PNAS | May 26, 2020 | vol. 117 | no. 21

www.pnas.org/cgi/doi/10.1073/pnas.1910114117



In a paper published in the Proceedings of the National Academy of Sciences, a team of researchers modeled the human climate "niche": the regions where temperature and precipitation have been most suitable for humans to live in over the past 6,000 years.

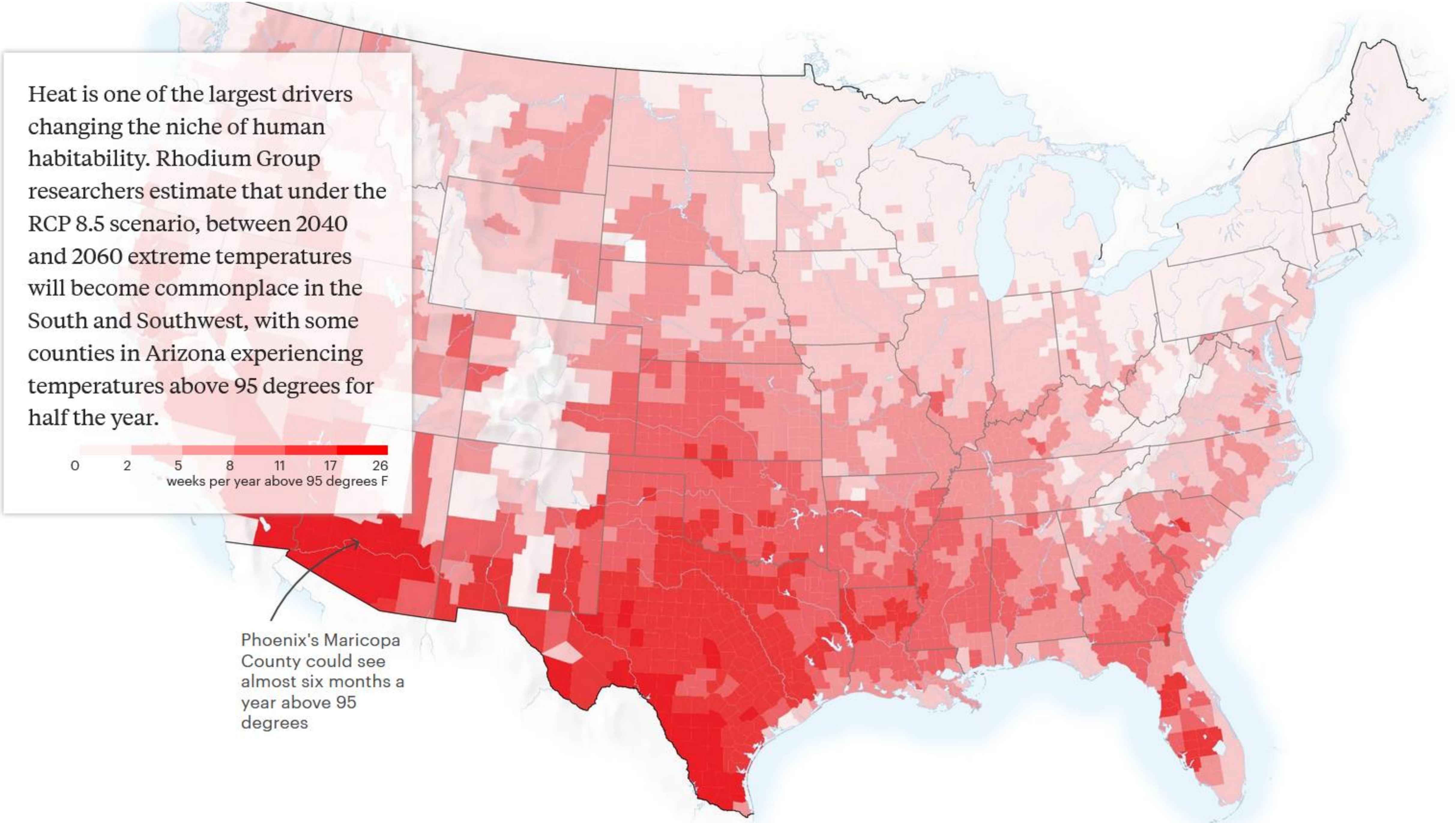
More suitable →

In the United States, that niche today blankets the heart of the country, from the Atlantic seaboard through northern Texas and Nebraska, and the California coast.

But as the climate warms, the niche could shift drastically northward. Under even a moderate carbon emissions scenario (known as RCP 4.5), by 2070 much of the Southeast becomes less suitable and the niche shifts toward the Midwest.

In the case of extreme warming (represented as RCP 8.5), the niche moves sharply toward Canada, leaving much of the lower half of the U.S. too hot or dry for the type of climate humans historically have lived in. Both scenarios suggest massive upheavals in where Americans currently live and grow food.

Heat is one of the largest drivers changing the niche of human habitability. Rhodium Group researchers estimate that under the RCP 8.5 scenario, between 2040 and 2060 extreme temperatures will become commonplace in the South and Southwest, with some counties in Arizona experiencing temperatures above 95 degrees for half the year.



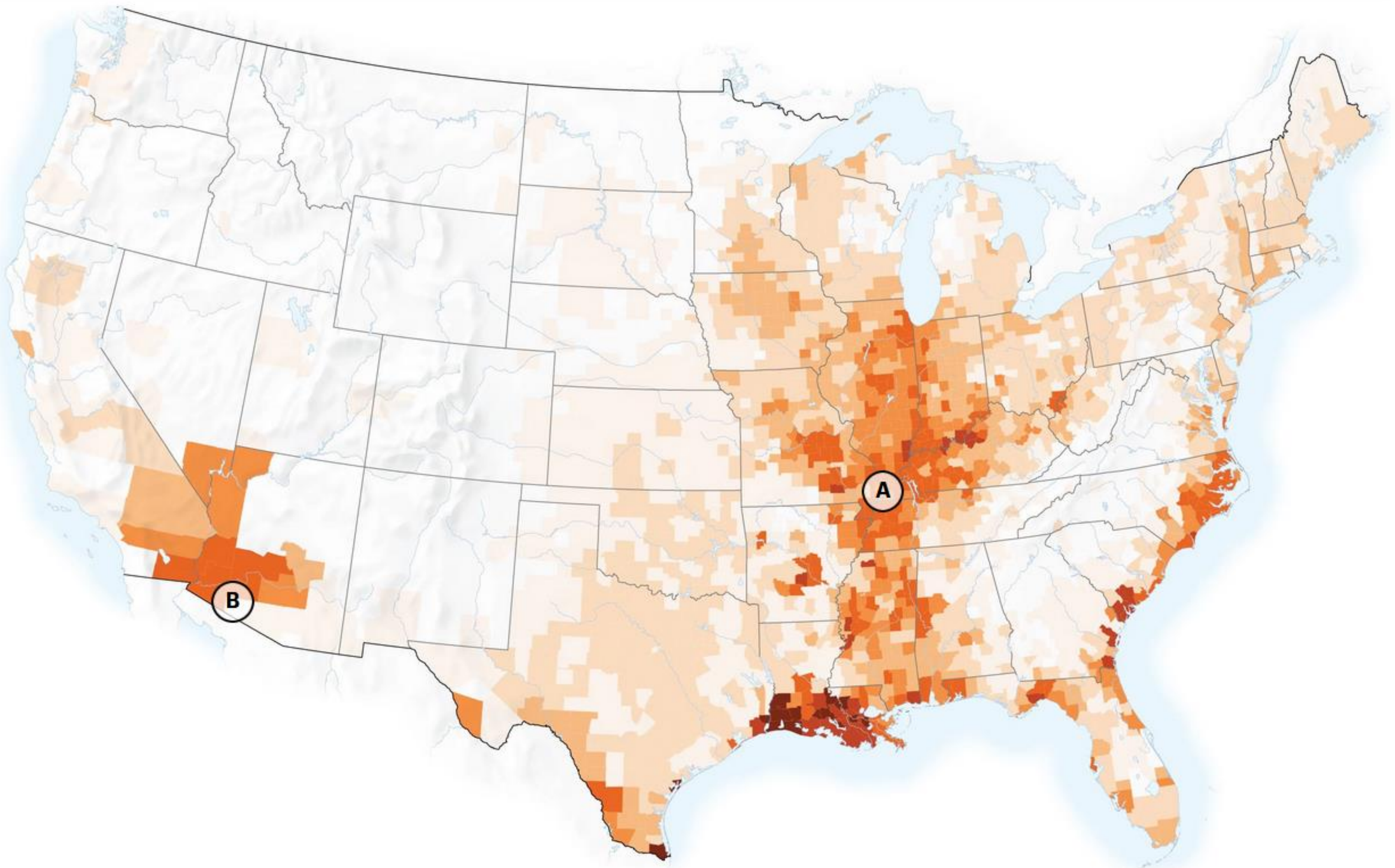
Extreme Heat and Humidity: 2040-2060

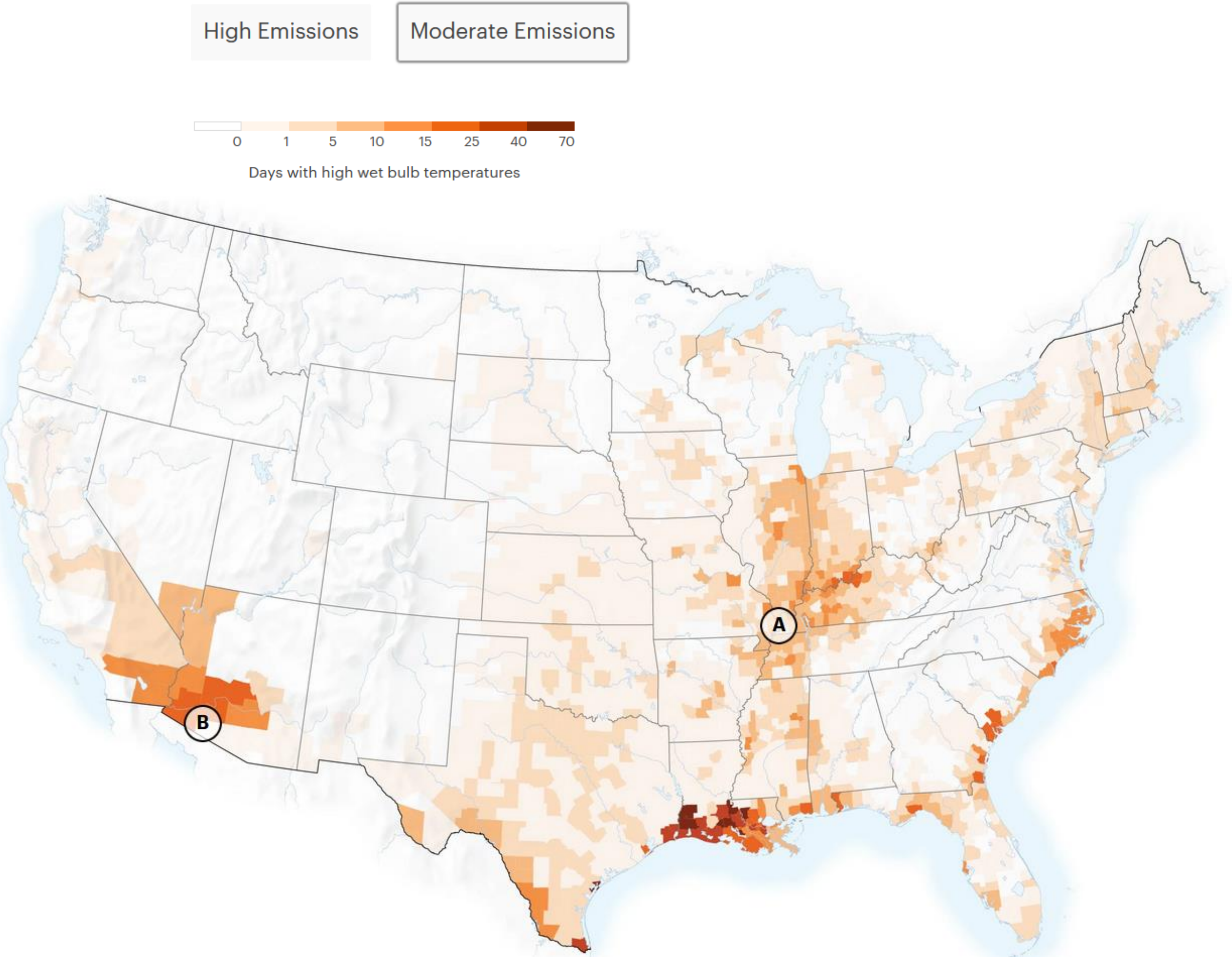
When heat meets excessive humidity, the body can no longer cool itself by sweating. That combination creates wet bulb temperatures, where 82 degrees can feel like southern Alabama on its hottest day, making it dangerous to work outdoors and for children to play school sports. As wet bulb temperatures increase even higher, so will the risk of heat stroke — and even death.

High Emissions | Moderate Emissions

0 | 1 | 5 | 10 | 15 | 25 | 40 | 70

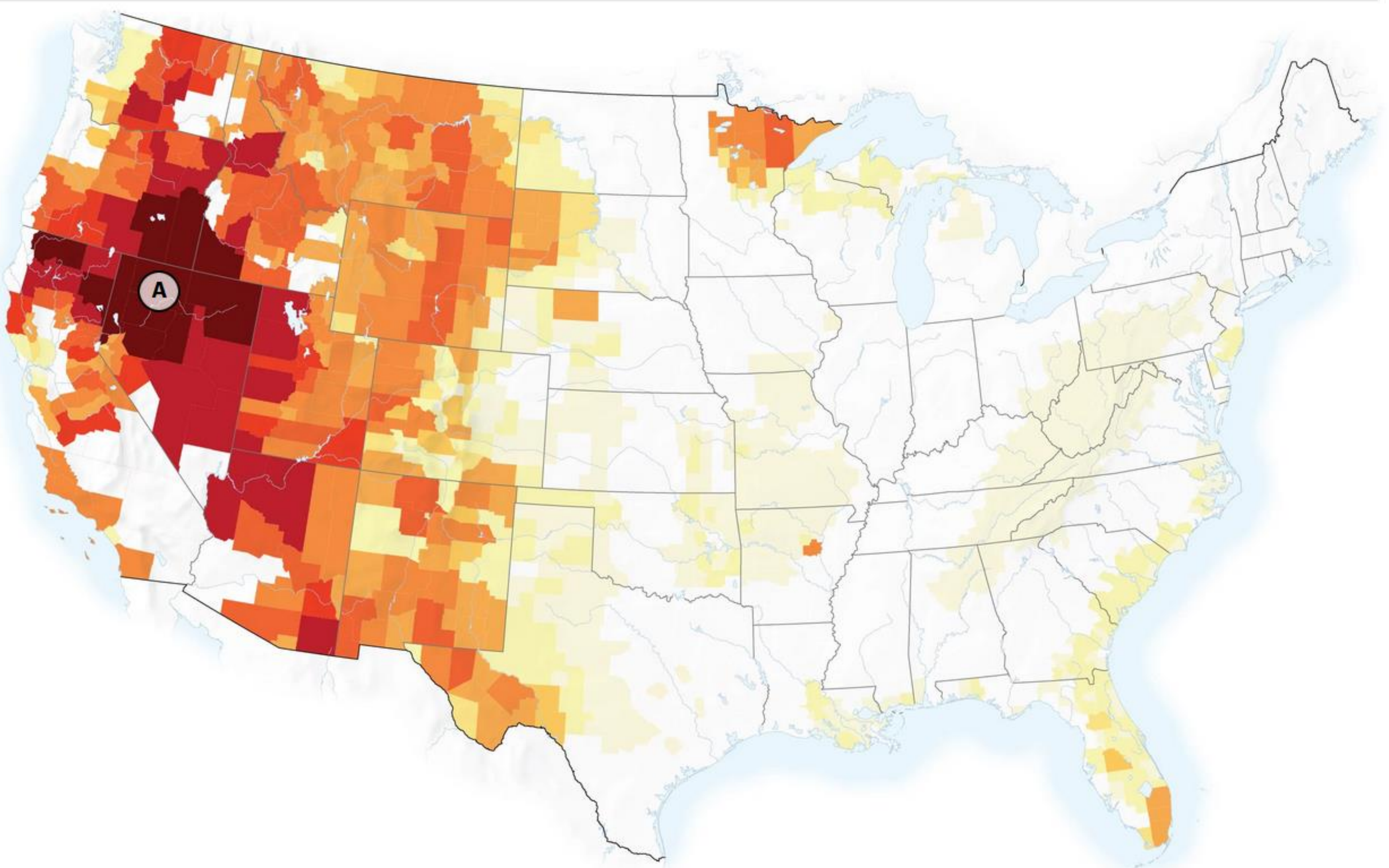
Days with high wet bulb temperatures




High Emissions
Moderate Emissions
0
1
5
10
15
25
40
70
Days with high wet bulb temperatures
A
B

Large Wildfires: 2040-2071

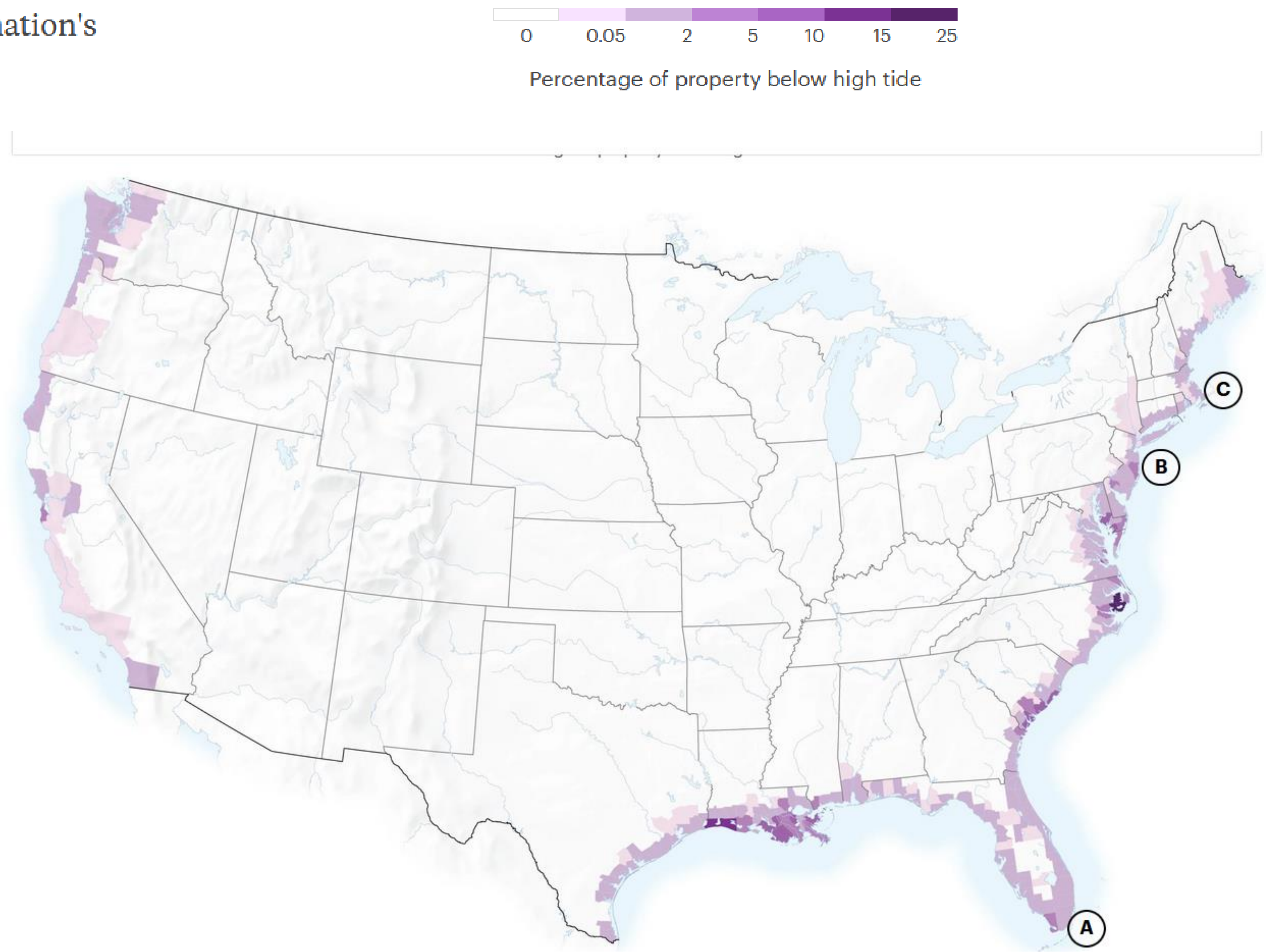
With heat and evermore prevalent drought, the likelihood that very large wildfires (ones that burn over 12,000 acres) will affect U.S. regions increases substantially, particularly in the West, Northwest and the Rocky Mountains, but also in Florida, Georgia and the Southeast, according to peer-reviewed research published in the International Journal of Wildland Fire.



Sea Level Rise: 2040-2060

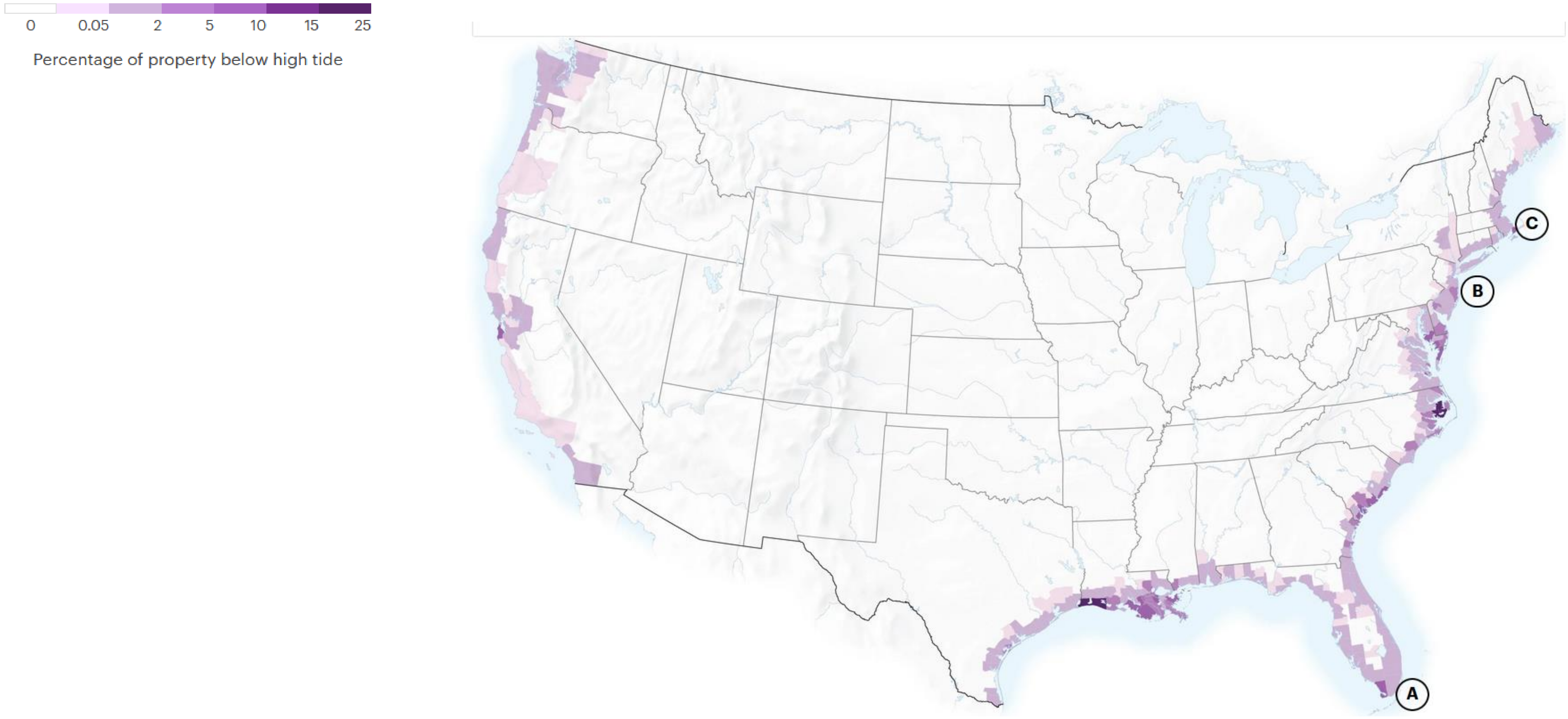
High Emissions | Moderate Emissions

As sea levels rise, the share of property submerged by high tides increases dramatically, affecting a small sliver of the nation's land but a disproportionate share of its population.



High Emissions

Moderate Emissions



Economic Damages From Climate: 2040-2060

Rising energy costs, lower labor productivity, poor crop yields and increasing crime are among the climate-driven elements that will increasingly drag on the U.S. economy, eventually taking a financial toll that exceeds that from the COVID-19 pandemic in some regions. Rhodium measured how much damage — or how much of a benefit — those counties might see, as a share of their GDP.

Farm Crop Yields: 2040-2060

With rising temperatures, it will become more difficult to grow food. Corn and soy are the most prevalent crops in the U.S. and the basis for livestock feed and other staple foods, and they have critical economic significance. Because of their broad regional spread, they offer the best proxy for predicting how farming will be affected by rising temperatures and changing water supplies.

The Greatest Climate Risk? Compounding Calamities.

Taken together, some parts of the U.S. will see a number of issues stack on top of one another — heat and humidity may make it harder to work outside, while the ocean continues to claim more coastal land. The table below ranks the most at-risk counties in the U.S. if all of the perils were combined. You can also sort by individual climate risk to see how each one stacks up, with higher numbers being worse in all categories. The projections are for 2040-2060 under RCP 8.5.

Note: Wet bulb, sea level rise, crop yield and economic damage data represent ranges of median probabilities for each county modeled by the Rhodium Group for each climate scenario between 2040 and 2060. Sources: Chi Xu, School of Life Sciences, Nanjing University (global human climate niche), Rhodium Group/Climate Impact Lab (wet bulb, heat, crop yields and economic damages), John Abatzoglou, University of California, Merced (very large fires). Noun Project icons by Adrien Coquet, Laymik and ProSymbols

projects.propublica.org/climate-migration/

County	Heat	Wet Bulb	Farm Crop Yields	Sea Level Rise	Very Large Fires	Economic Damages
Beaufort County, SC	6	9	8	7	3	9
Pinal County, AZ	10	6	8	1	6	7
St. Martin Parish, LA	7	10	8	4	3	7
Colleton County, SC	6	9	8	6	3	8
Wakulla County, FL	7	9	8	4	1	9
Assumption Parish, LA	6	9	7	7	2	9
Jefferson Davis Parish, LA	7	10	8	4	1	8
Livingston Parish, LA	7	9	8	6	1	8
St. John the Baptist Parish, LA	6	9	8	6	2	8
Jackson County, MS	6	9	8	4	3	8
Hyde County, NC	4	7	7	10	2	9
Jasper County, SC	6	9	8	4	3	8
Graham County, AZ	10	2	8	1	8	6
Camden County, GA	6	9	[illegible]	[illegible]	2	8
Calcasieu Parish, LA	6	10	[illegible]	[illegible]	1	8

See all counties

County-level analysis of compounding hazards due to climate change.

Climate Impact Lab

Rh Rhodium Group | What We Do | Research | Data | People

Climate Risk Service

Rh Rhodium Group | What We Do | Research | Data | People

Rhodium Group is an independent research provider combining economic data and policy insight to analyze global trends

WHAT WE DO →

IMPACT

Climate Impact Lab: How Much Hotter Is Your Hometown Than When You Were Born?

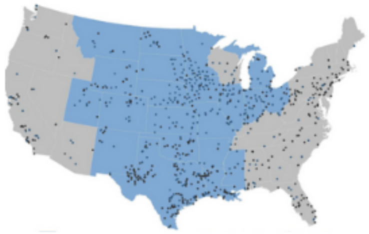
Our state-of-the-art analysis of historical climate data and localized climate projections powers a New York Times interactive that helps localize global warming.

REPORT — Apr 20, 2021

The Economic Benefits of Carbon Capture: Investment and Employment Estimates for the Contiguous United States

This report is a state-by-state analysis exploring the economic benefits associated with carbon capture retrofit opportunities at existing industrial and electric power facilities, including private...

John Larsen, Whitney Herndon, Galen Hiltbrand, and Ben King



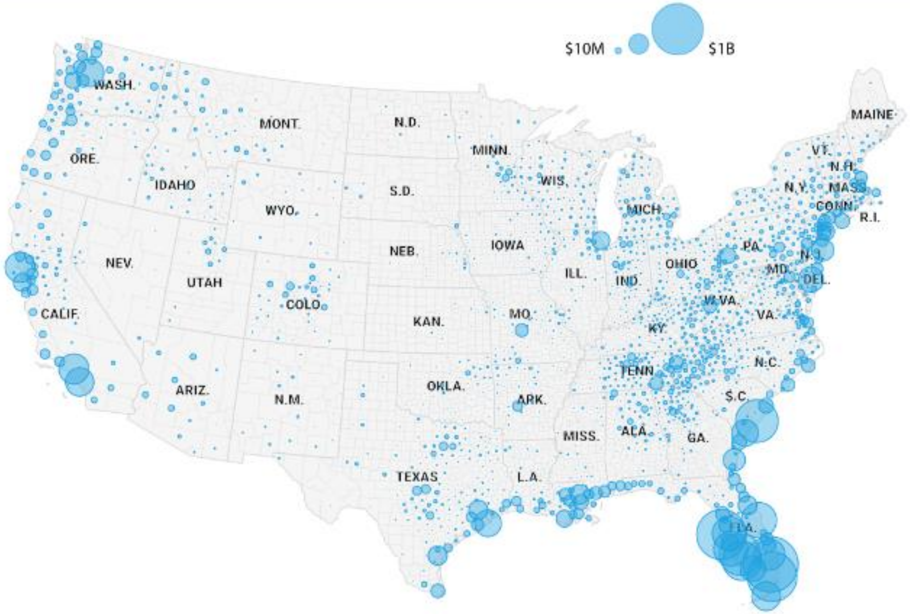
BOOK — Dec 10, 2020

Climate Convexity: The Inequality of a Warming World

If carbon emissions and associated damages are left unaddressed, the climate crisis will not only become more costly to global health and the global economy,...

Trevor Houser

LATEST FROM FIRST STREET FOUNDATION



ARTICLE

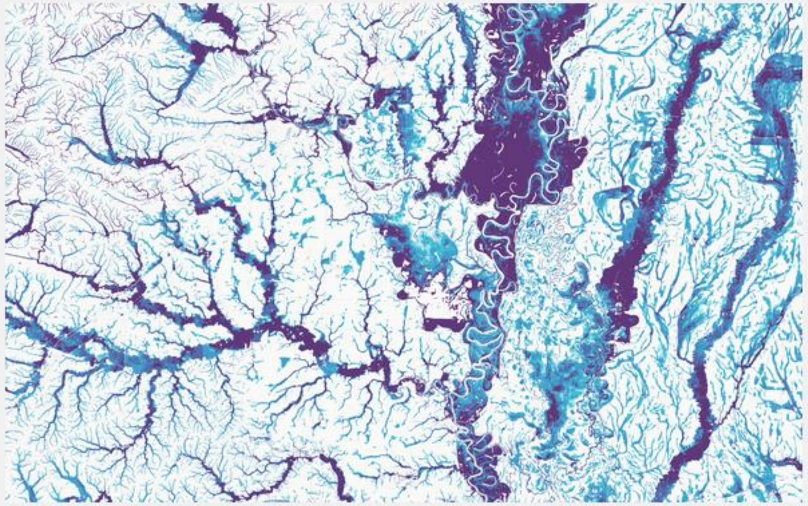
Highlights From "The Cost of Climate: America's Growing Flood Risk"

A new national report from the First Street Foundation provides a comprehensive national analysis of the state of flood risk in the continental U.S.

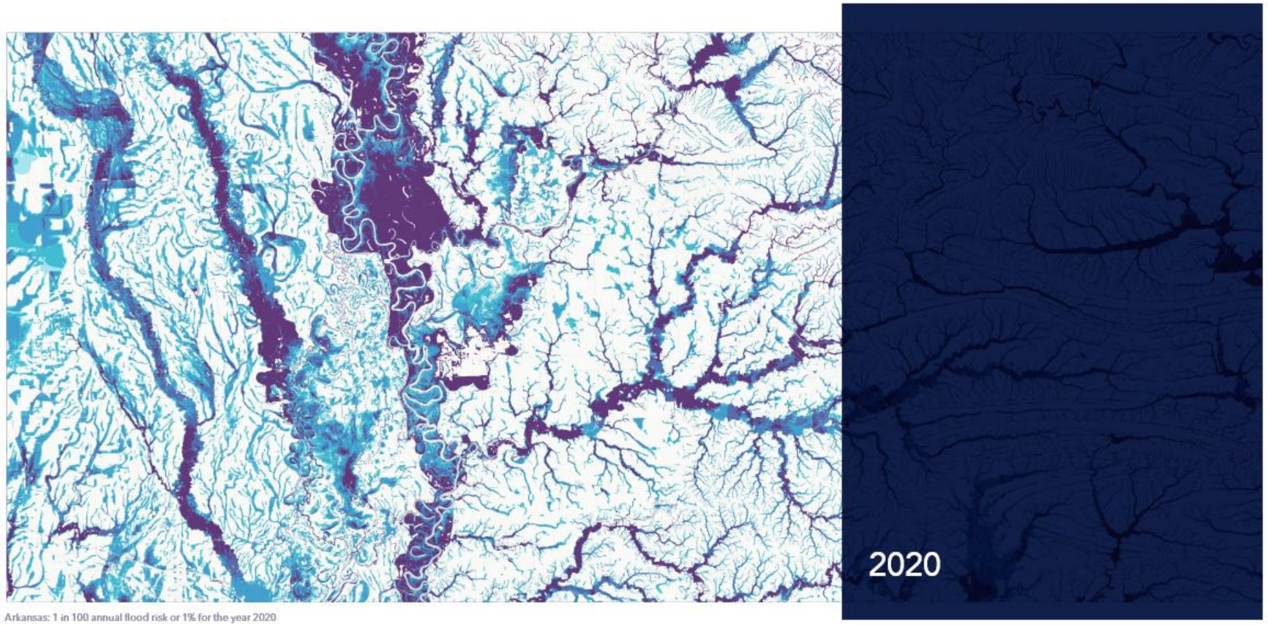
READ ARTICLE →

METHODOLOGY

First Street Foundation Flood Model 2020 Methodology Overview



FIRST STREET FOUNDATION



Arkansas: 1 in 100 annual flood risk or 1% for the year 2020

The First National Flood Risk Assessment

Defining America's Growing Risk

Introduction

The goal of the First Street Flood Model is to make flood risk transparent, easy to understand, informative, and available to everyone.

The nonprofit research and technology group First Street Foundation has publicly released flood risk data for more than 142 million homes and properties across the country. The data, based on decades of peer-reviewed research, assigns every property in the contiguous United States a "Flood Factor™," or score from 1 to 10, based on its cumulative risk of flooding over a thirty year mortgage. People can get more information about a property's past, present, and future flood risk by connecting to FloodFactor.com, the Foundation's online visualization tool.

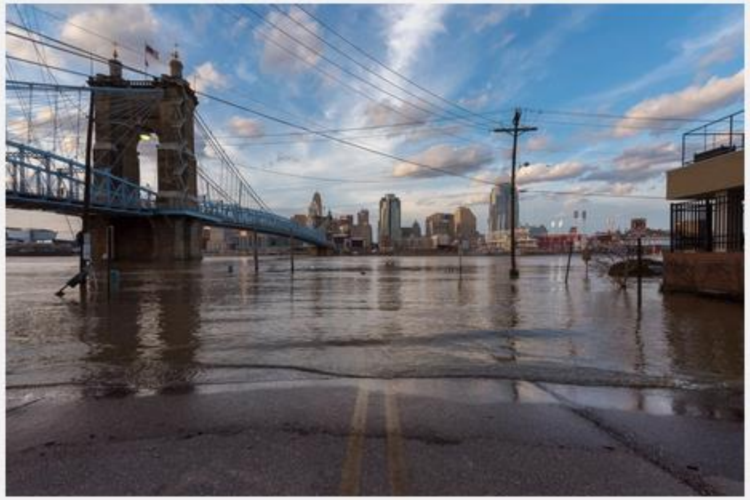
While FEMA classifies 8.7 million properties as having substantial risk, or within Special Flood Hazard Areas (SFHAs), the First Street Foundation Flood Model identifies nearly 70% more, or 14.6 million properties with the same level of risk. This means nearly 6 million households and property owners have underestimated or been unaware of their current risk. This discrepancy exists because the Foundation uses current climate data, maps precipitation as a stand-alone risk, and includes areas that FEMA has not mapped.

Defining Flood Risk **National Overview**

First Street definitions of risk that are used in this report.
Substantial risk **is analogous to the FEMA SFHA designation.**

First Street Risk Description	Return Period	Annual Probability flooding at least 1cm	Cumulative Probability flooding at least once over 30 years	Properties at risk in 2020 48 U.S. States + D.C.	Percent of all properties
Almost Certain Risk	5 Year (1 in 5)	20.0%	>99%	**3.6 million**	**2.6%**
Substantial Risk	100 Year (1 in 100)	1.0%	>26%	**14.6 million**	**10.3%**
Any Risk	500 Year (1 in 500)	0.2%	>0%	**21.8 million**	**15.4%**

The three types of flooding that are modeled in the First Street Flood Model projections.



Fluvial (riverine flooding in Cincinnati, OH)

Pluvial (precipitation flooding in Houston, TX)

Surge (hurricane storm surge flooding in Wilmington, NC)

Abstract

The First Street Foundation Flood Model represents the culmination of decades of research and development made possible by building upon existing knowledge and frameworks regularly referenced in the identification of flood risk.

The outcome of this work is the development of a high precision, climate adjusted flood model that can be understood by individual property owners today and into the future. The high-level results indicate significantly more flood risk across the U.S. when compared to standard flood risk tools, nationally across the contiguous United States. These results are being made publicly available through a new tool, Flood Factor™, and represent the first free source of high-quality probabilistic flood risk information available to the public. This report provides a high-level national summary and a series of state reports with a focus on summarizing and providing insight into new findings around flood risk, adaptation, and changing environmental factors as they relate to flood risk.

The nonprofit research and technology group First Street Foundation has publicly released flood risk data for more than 142 million homes and properties across the country. The data, based on decades of peer-reviewed research, assigns every property in the contiguous United States a "Flood Factor™," or score from 1 to 10, based on its cumulative risk of flooding over a thirty year mortgage. People can get more information about a property's past, present, and future flood risk by connecting to FloodFactor.com, the Foundation's online visualization tool.

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When adjusting for future environmental factors like changing sea levels, warming sea surface and atmospheric temperatures, and changing precipitation patterns, the Foundation's model finds the number of properties with substantial risk grows to 16.2 million by the year 2050. A report highlighting significant national, state, and city findings of the First Street Foundation Model, titled The First National Flood Risk Assessment: Defining America's Growing Risk can be found here.

The model was developed by more than 80 of the world's leading hydrologists, researchers, and data scientists, including from Rhodium Group and the Climate Impact Lab. Rhodium Group and its Climate Impact Lab (CIL) partners provided sea-level rise projections and hurricane storm surge

FloodFactor

Find your home's Flood Factor

Past floods, current risks, and future projections based on peer-reviewed research from the world's leading flood modelers.

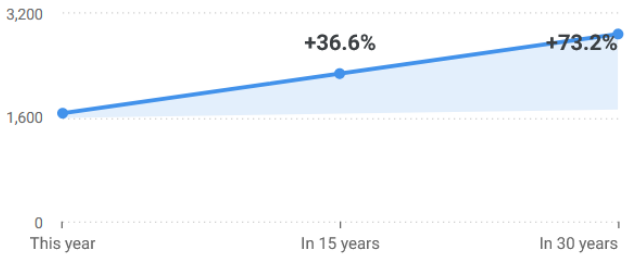
Salem, MA ✕

Intended for non-commercial, informational purposes only. See terms of use. For commercial use click here. The Flood Factor model is designed to approximate flood risk and not intended to include all possible risks or mitigations of flood.

Flood risk is increasing for Salem.

As sea levels rise and and weather patterns change, flood risks will increase. Approximately 1,666 properties are already at risk in Salem, and within 30 years, about 2,885 will be at risk.

Change in number of properties at risk



Total annual flood damages in Salem

$1.6M
This year

$3M +89%
In 30 years

▼ Damage breakdown by Flood Factor

	This year ($)	In 30y ($)	Change
Minor (2)	0	8,300	–
Moderate (3-4)	13.4K	195.7K	+1,360%
Major (5-6)	108.4K	480.6K	+343%
Severe (7-8)	180.1K	541.7K	+201%
Extreme (9-10)	1.3M	1.8M	+37%

SCORE MAP

Flood Factors across Salem.

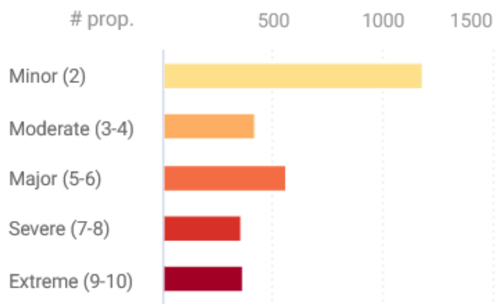
A property's Flood Factor is an indicator of its comprehensive flood risk, ranging from 1 (minimal) to 10 (extreme). Properties with higher Flood Factors are more likely to flood.

Learn more about the Flood Factor methodology.

Filter by Flood Factor:

- [ ] All
- [ ] Minimal (1)
- [x] Minor (2)
- [x] Moderate (3-4)
- [x] Major (5-6)
- [x] Severe (7-8)
- [x] Extreme (9-10)

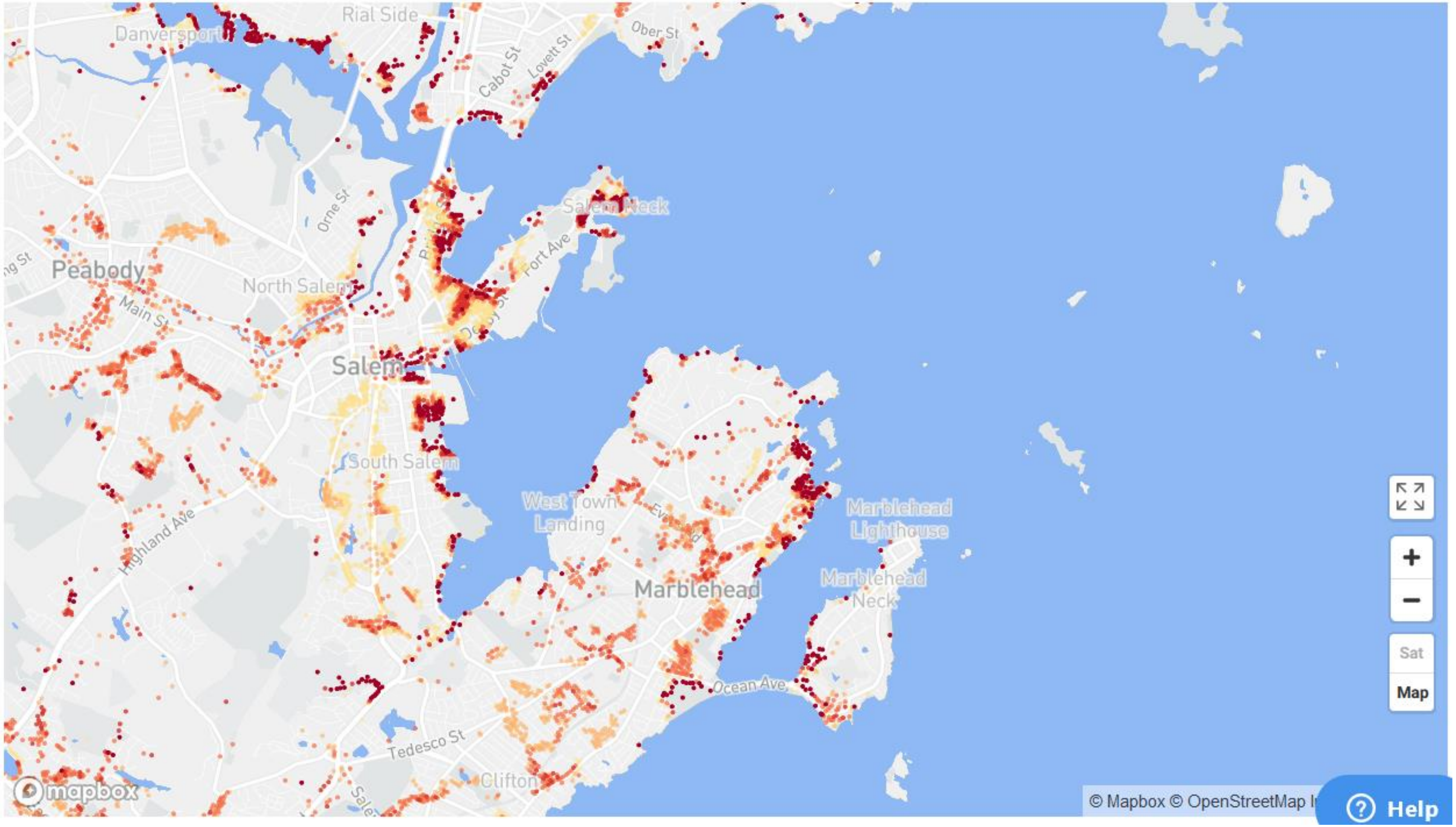
Number of properties at risk by Flood Factor

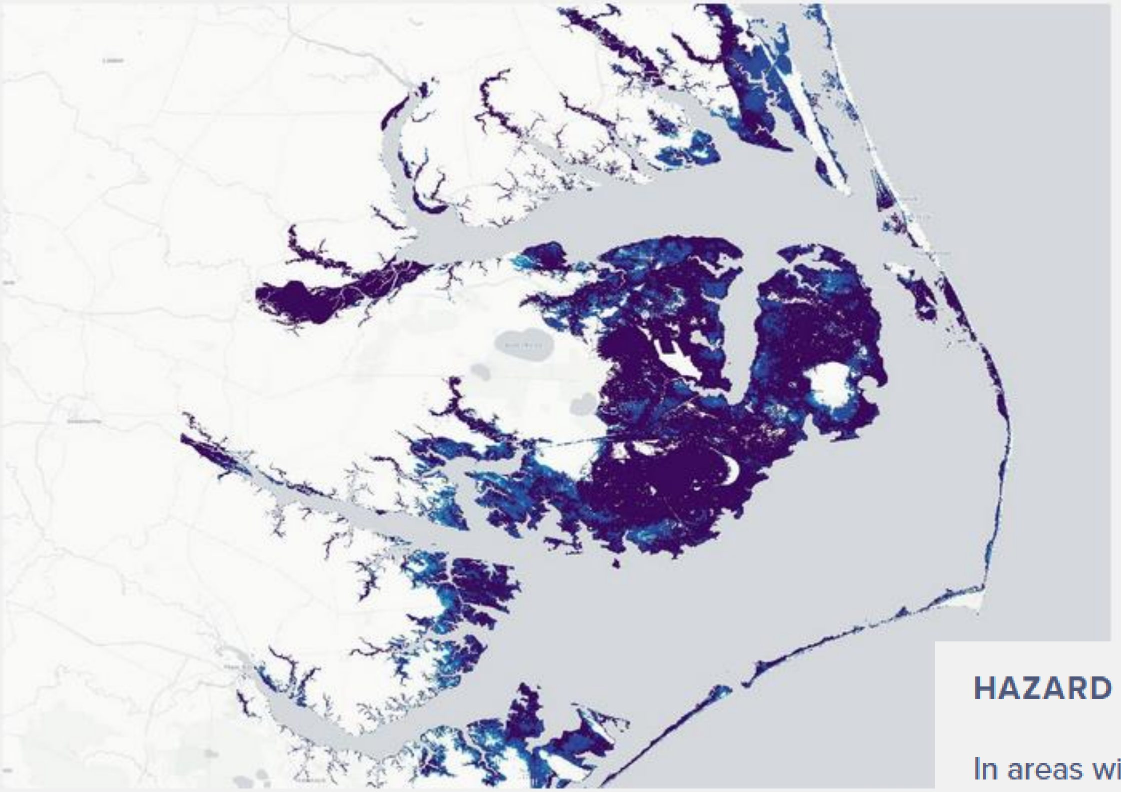


Legend for map on next slide →

Salem Massachusetts

- Summary
- Score Map
- Historic Flooding
- Flood Risk Explorer
- Environmental Changes
- Community Solutions





Hurricane Irene simulation in North Carolina

HAZARD COUPLING

In areas with no surge or tidal hazard, the fluvial and pluvial hazard layers for any given return period are combined by selecting the maximum value of the two layers. The interaction of these hazards is not explicitly accounted for because in inland areas, flooding is typically dominated by one source or the other. Because they are largely independent, a simple approach was selected to represent risk.

In areas of coastal hazards, the First Street Foundation Flood Model presents a hazard layer agnostic to the source of flooding. Surge, fluvial, and pluvial hazards were modeled separately, and then modeled together in several different combinations of return periods by source. These were dynamic hydraulic simulations intended to capture the joint effects on flooding based on the varying co-occurrence of different flood hazards. Statistical analysis of the historical records of both tide and stream gauges in each catchment yielded co-occurrence of the different flood hazards, which gives an indication of how likely different surge levels are to occur at the same time as elevated river levels. These rates of co-occurrence then informed the combination of these hazards into an overall joint distribution at each location, generating new inundation depths per return period.

Portland Press Herald

BUSINESS > Posted May 4 | Updated May 5

Maine fishing interests seek total ban on offshore wind energy

A Republican-backed bill to prohibit all future offshore wind development in the state faces an uphill battle, with Democrats in control.

Important for SERC and SAFE to know if we have interest in regional offshore wind projects.

BY TUX TURKEL STAFF WRITER

More than 60 commercial fishermen and their supporters testified Tuesday in favor of a bill that would block any attempt to develop offshore wind projects anywhere along the Maine coast.

The bill would prohibit any state agency from permitting or approving any offshore wind energy project regardless of its location. It was introduced by Rep. Billy Bob Faulkingham, R-Winter Harbor, a commercial fisherman, and co-sponsored by eight other Republican lawmakers.

The testimony on L.D. 101 from lobstermen, their families and town officials from fishing communities drew a clear line in the sand: Any offshore wind development, they told told lawmakers on the Energy, Utilities and Technology Committee, would threaten the very survival of their iconic industry and way of life.

This sort of testimony overshadowed the comparatively few comments relating to a bill introduced by Gov. Janet Mills and sponsored by Sen. Mark Lawrence, D-York.

That proposed law, L.D. 1619, would establish a 10-year ban on wind energy development in state waters, which extend 3 miles from the mainland. The bill was meant to appease the state's lobster industry, which harvests an estimated three-quarters of its catch in state waters.

But Mills' proposal, first launched last winter, sank fast and deep with lobstermen. Except for a demonstration project for a single floating turbine expected to be built next year near Monhegan Island, Maine's near-shore waters aren't a prime target for wind development, although one developer was reportedly exploring a venture last winter. The offshore wind industry here is expected to take shape in deeper, federally controlled waters, where the Mills administration wants to locate a relatively small wind farm dedicated to research.

scientific reports

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Article | Open Access | Published: 02 March 2020

Sea-Level Rise Induced Multi-Mechanism Flooding and Contribution to Urban Infrastructure Failure

Shellie Habel, Charles H. Fletcher, Tiffany R. Anderson & Philip R. Thompson

Scientific Reports **10**, Article number: 3796 (2020) | Cite this article

Journal of Water Resources Planning and Management / Volume 141 Issue 4 - April 2015

Adapting Urban Infrastructure to Climate Change: A Drainage Case Study

Paul Kirshen, M.ASCE; Lauren Caputo, A.M.ASCE; Richard M. Vogel, M.ASCE; Paul Mathisen, M.ASCE; Ana Rosner; and Tom Renaud, A.M.ASCE Show less

ELSEVIER

Ocean & Coastal Management

Volume 95, July 2014, Pages 176-188

Assessing the vulnerability of coastal infrastructure to sea level rise using multi-criteria analysis in Scarborough, Maine (USA)

A. Johnston [a], P. Slovinsky [b], K.L. Yates [a, c, d]

[a] Environmental Science Research Institute, University of Ulster, Cromore Road, Coleraine BT52 1SA, UK

[b] Maine Geological Survey, Department of Agriculture, Conservation and Forestry, Augusta, ME 04333, USA

[c] ARC Centre of Excellence for Environmental Decisions, School of Biological Sciences, University of Queensland, Brisbane, QLD 4072, Australia

[d] School of the Environment, Flinders University, South Australia 5042, Australia

Highlights

- GIS mapping is used to identify Infrastructure vulnerability to sea level rise.
- A multi-criteria analysis methodology is used to prioritize impacted areas.
- A broad range of consequences is considered in ranking vulnerabilities.
- The most critical locations identified are major roads and evacuation routes.
- Solution options are developed to address the most critical vulnerabilities.

Rising Groundwater Is A Problem In Coastal Lowlands

This sea-level rise will also cause coastal groundwater to rise (Befus et al. 2020). This is a problem in coastal lowlands, where groundwater is already close to the land surface. Underground infrastructure, coastal roads, stormwater drains, historic structures, coastal ecosystem resilience, and water quality all may be adversely affected when groundwater rises. In addition, sea walls or other structures designed to keep surface water back will not stop rising groundwater from inundating the land surface behind the barrier.

Sea- level-rise-induced groundwater effects

These sea-level-rise-induced groundwater effects have been projected to occur 3 to 4 times farther inland than tidal surface-water inundation (Knott, Jacobs, et al., 2018). In California, rising groundwater is projected to flood land area 50 to 130 meters (160 to 430 feet) inland in low-lying communities such as those around San Francisco Bay (Befus et al., 2020). Coastal cities such as Boston, which was originally built on top of filled wetlands, are particularly vulnerable to rising groundwater.

A study in Honolulu has shown that urban areas along the coast are subject to flooding from three mechanisms (Habel et al., 2020):

1. direct marine flooding
2. storm-drain backflow,
3. groundwater inundation

Adaptation plans addressing coastal flooding from sea-level rise

To be successful, adaptation plans addressing coastal flooding from sea-level rise and coastal storms must also consider rising groundwater.

Looking at recent research about coastal flooding from SLR, rising groundwater levels along coasts due to SLR, and storm-drain backflow.

SCIENTIFIC REPORTS
natureresearch

OPEN

Sea-Level Rise Induced Multi-Mechanism Flooding and Contribution to Urban Infrastructure Failure

Shellie Habel[1*], Charles H. Fletcher[1], Tiffany R. Anderson[1] & Philip R. Thompson[2]

Sea-level rise (SLR) induced flooding is often envisioned as solely originating from a direct marine source. This results in alternate sources such as groundwater inundation and storm-drain backflow being overlooked in studies that inform planning. Here a method is developed that identifies flooding extents and infrastructure vulnerabilities that are likely to result from alternate flood sources over coming decades. The method includes simulation of flood scenarios consisting of high-resolution raster datasets featuring flood-water depth generated by three mechanisms: (1) direct marine flooding, (2) storm-drain backflow, and (3) groundwater inundation. We apply the method to Honolulu's primary urban center based on its high density of vulnerable assets and present-day tidal flooding issues. Annual exceedance frequencies of simulated flood thresholds are established using a statistical model that considers predicted tide and projections of SLR. Through assessment of multi-mechanism flooding, we find that approaching decades will likely feature large and increasing percentages of flooded area impacted simultaneously by the three flood mechanisms, in which groundwater inundation and direct marine flooding represent the most and least substantial single-mechanism flood source, respectively. These results illustrate the need to reevaluate main sources of SLR induced flooding to promote the development of effective flood management strategies.

[1]University of Hawai'i at Mānoa, School of Ocean and Earth Science and Technology, Department of Earth Sciences, POST Building, Suite 701, 1680 East-West Road, Honolulu, HI, 96822, USA. [2]University of Hawai'i at Mānoa, Sea Level Center, 1000 Pope Road, MSB 317, Honolulu, HI, 96822, USA. *email: skey@hawaii.edu

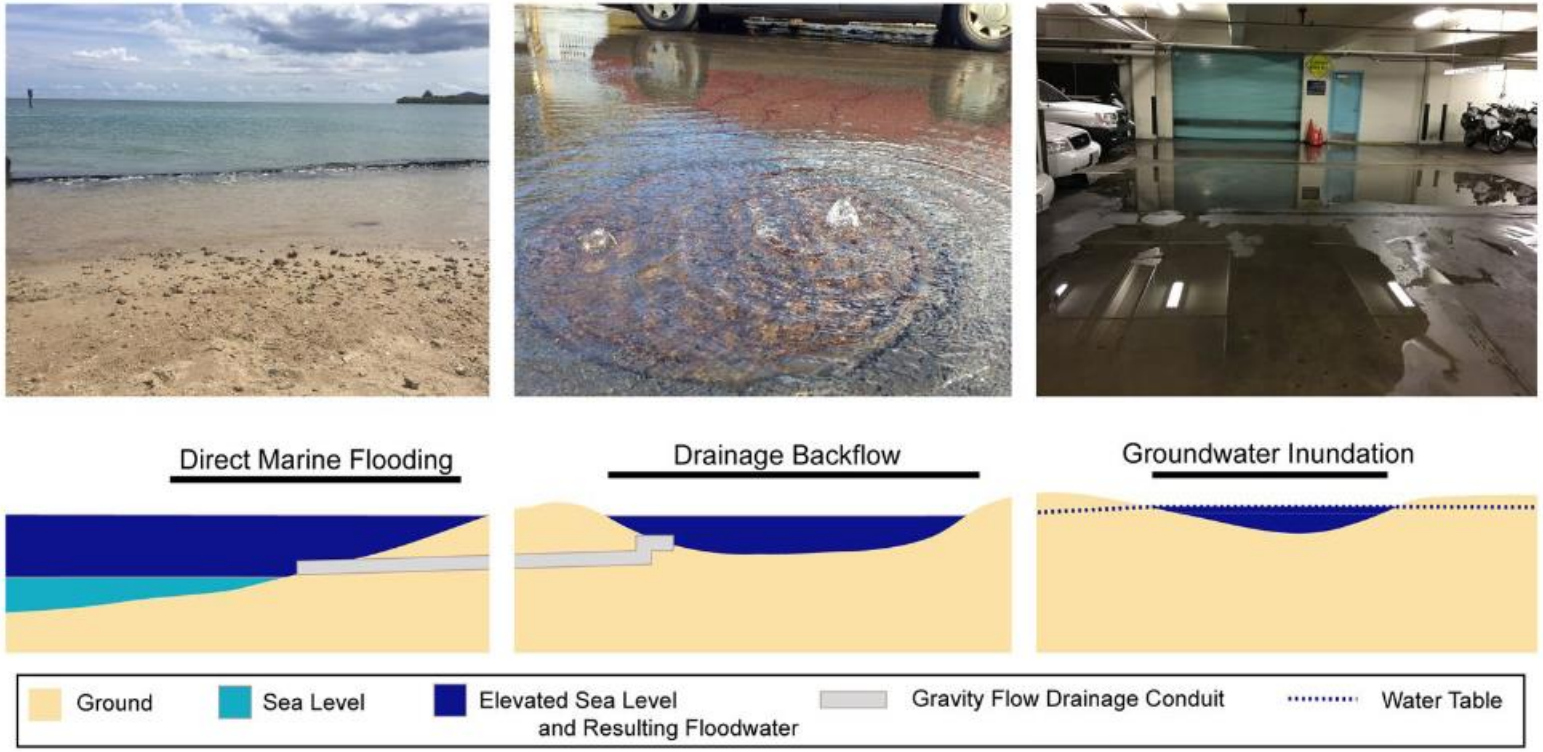

Figure 1. Observations and illustrations of direct marine flooding, storm-drain backflow, and groundwater inundation within Honolulu. Each mechanism of flooding has already been observed during periods of extreme tide in various locations within the study area. Photo Credit, Hawai'i and Pacific Islands King Tide Project[17].

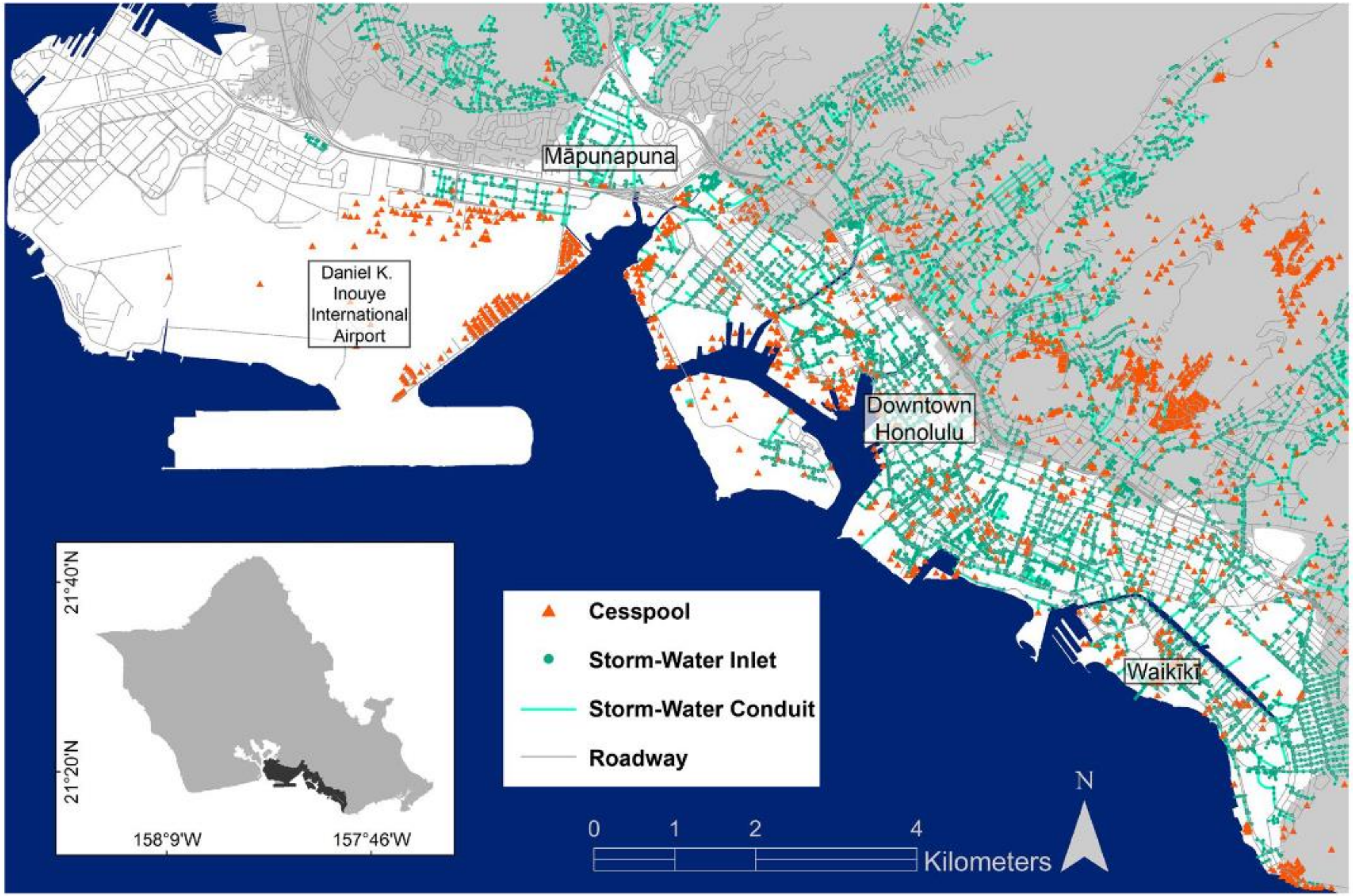

Figure 2. Honolulu's Cesspool, Storm-Water Drainage, and Roadway Infrastructure. Study area extent shown in white. Infrastructure locations including cesspools, storm-water drainage conduits and inlets, and roadways are shown.

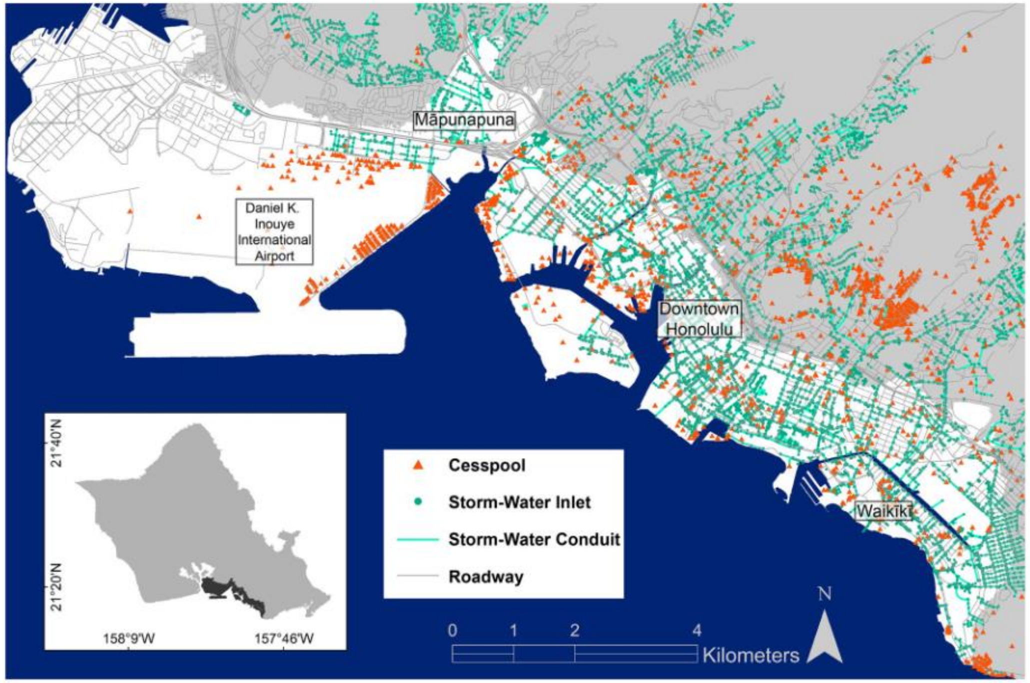

Figure 2. Honolulu's Cesspool, Storm-Water Drainage, and Roadway Infrastructure. Study area extent shown in white. Infrastructure locations including cesspools, storm-water drainage conduits and inlets, and roadways are shown.

	GWI Only		MI Only		DBF Only		Double Mechanism GWI and MI		Double Mechanism GWI and DBF		Double Mechanism MI and DBF		Triple Mechanism GWI, MI, DBF		
Flood Type	Area Inundated (km^2)	% of Total	Area Inundated (km^2)	% of Total	Area Inundated (km^2)	% of Total	Area Inundated (km^2)	% of Total	Area Inundated (km^2)	% of Total	Area Inundated (km^2)	% of Total	Area Inundated (km^2)	% of Total	Total Area Inundated (km^2)
KT2017	0.19	26.33	0.02	2.39	0.00	0.40	0.31	41.98	0.07	10.10	0.00	0.65	0.13	18.15	0.73
Minor	0.24	23.32	0.03	2.66	0.01	0.84	0.38	36.65	0.17	16.14	0.01	0.95	0.20	19.43	1.04
Moderate	0.63	24.74	0.06	2.31	0.10	3.74	0.50	19.56	0.19	7.52	0.08	3.17	0.99	38.95	2.54
Major	1.19	15.19	0.28	3.61	0.04	0.55	1.37	17.55	0.18	2.35	0.47	6.05	4.27	54.71	7.81

Table 1. Multi-Mechanism Flooding Extent. Areas of single and multi-mechanism flooding within the study area encompassing Honolulu's primary urban center consisting of direct marine inundation (MI), storm-drain backflow (DBF), and groundwater inundation (GWI) at four flood thresholds: KT2017, minor, moderate, and major flood thresholds[5].

Modeling Groundwater Rise Caused by Sea-Level Rise in Coastal New Hampshire

Jayne F. Knott, Jennifer M. Jacobs, Jo S. Daniel, Paul Kirshen

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Journal of Coastal Research
Vol. 35 • No. 1
January 2019

Abstract

Knott, J.F.; Jacobs, J.M.; Daniel, J.S., and Kirshen, P., 2019. Modeling groundwater rise caused by sea-level rise in coastal New Hampshire. *Journal of Coastal Research,* 35(1), 143–157. Coconut Creek (Florida), ISSN 0749-0208.

Coastal communities with low topography are vulnerable from sea-level rise (SLR) caused by climate change and glacial isostasy. Coastal groundwater will rise with sea level, affecting water quality, the structural integrity of infrastructure, and natural ecosystem health. SLR-induced groundwater rise has been studied in coastal areas of high aquifer transmissivity. In this regional study, SLR-induced groundwater rise is investigated in a coastal area characterized by shallow unconsolidated deposits overlying fractured bedrock, typical of the glaciated NE. A numerical groundwater-flow model is used with groundwater observations and withdrawals, LIDAR topography, and surface-water hydrology to investigate SLR-induced changes in groundwater levels in New Hampshire's coastal region. The SLR groundwater signal is detected more than three times farther inland than projected tidal flooding from SLR. The projected mean groundwater rise relative to SLR is 66% between 0 and 1 km, 34% between 1 and 2 km, 18% between 2 and 3 km, 7% between 3 and 4 km, and 3% between 4 and 5 km of the coastline, with large variability around the mean. The largest magnitude of SLR-induced groundwater rise occurs in the marine and estuarine deposits and peninsulas with tidal water bodies on three sides. Groundwater rise is dampened near streams. Groundwater inundation is projected to contribute 48% of the total inundated area from both SLR-induced groundwater rise and marine tidal flooding in the city of Portsmouth, with consequences for built and natural resources. Freshwater wetlands are projected to expand 3% by the year 2030, increasing to 25% by the end of the century, coupled with water-depth increases.

Journal of Water Resources Planning and Management / Volume 141 Issue 4 - April 2015

Adapting Urban Infrastructure to Climate Change: A Drainage Case Study

Paul Kirshen, M.ASCE; Lauren Caputo, A.M.ASCE; Richard M. Vogel, M.ASCE; Paul Mathisen, M.ASCE; Ana Rosner; and Tom Renaud, A.M.ASCE

Show less

Abstract

Attributes of an effective infrastructure adaptation planning process as well as methods for choosing among adaptation strategies are described. The major attributes include: (1) a vulnerability assessment, (2) proactive adaptation strategies that are implemented over time and space, (3) climate change scenario analysis including climate surprises to handle the uncertainty of the future climate, (4) actions that are robust and/or flexible and adjustable, (5) a planned, progressive approach that ties implementation to critical thresholds of actual climate changes and preserves options for future actions, (6) evaluation with multiple social, economic and environmental criteria, and (7) integration of local stakeholders into the planning process. Multiple methods can be used to generate and evaluate adaptation strategies. A subset of the key attributes is then used in a case study of urban drainage management, which was designed and implemented to illustrate these attributes. It is shown that multicriteria scenario analysis can be effectively used to generate and evaluate alternative adaptation strategies. The identification of when critical thresholds are reached under conditions of climate variability and change is a major research need.

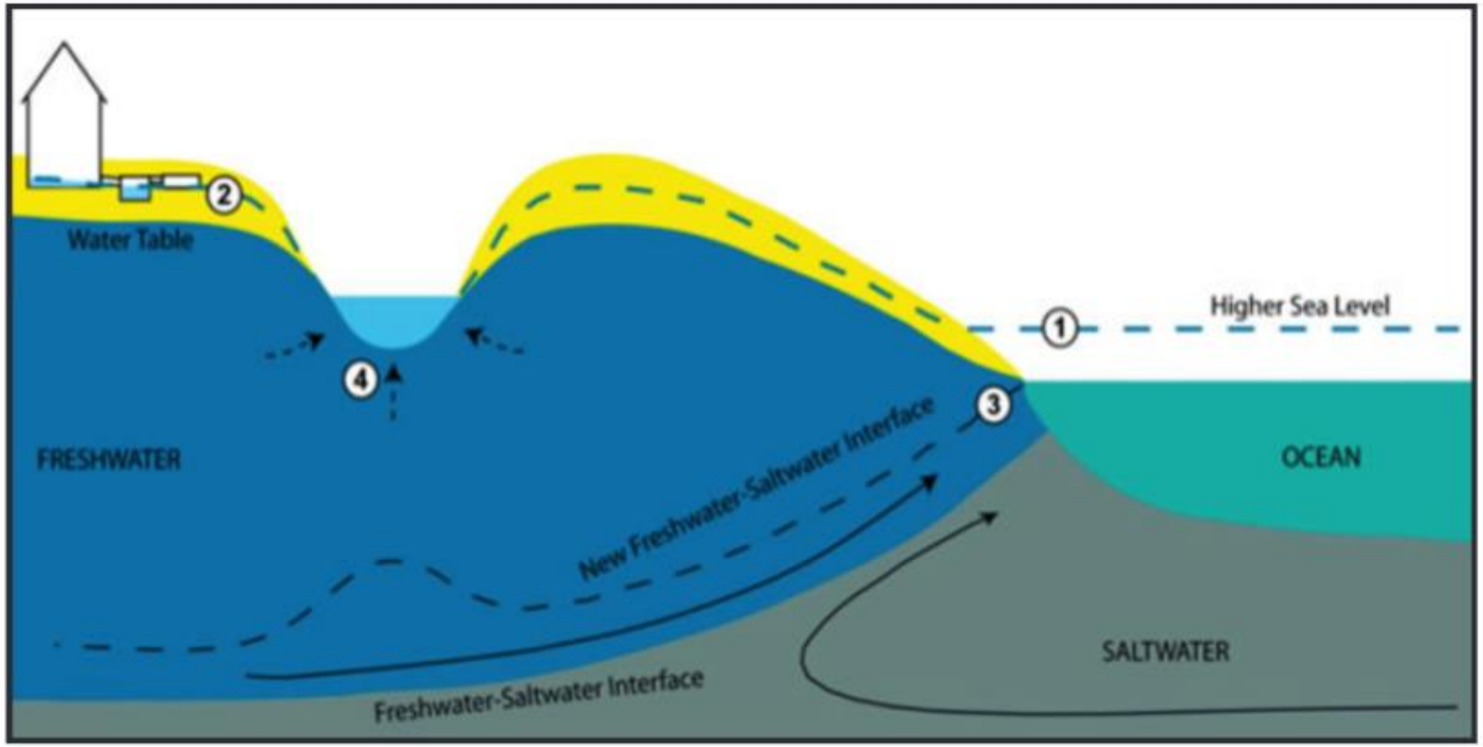
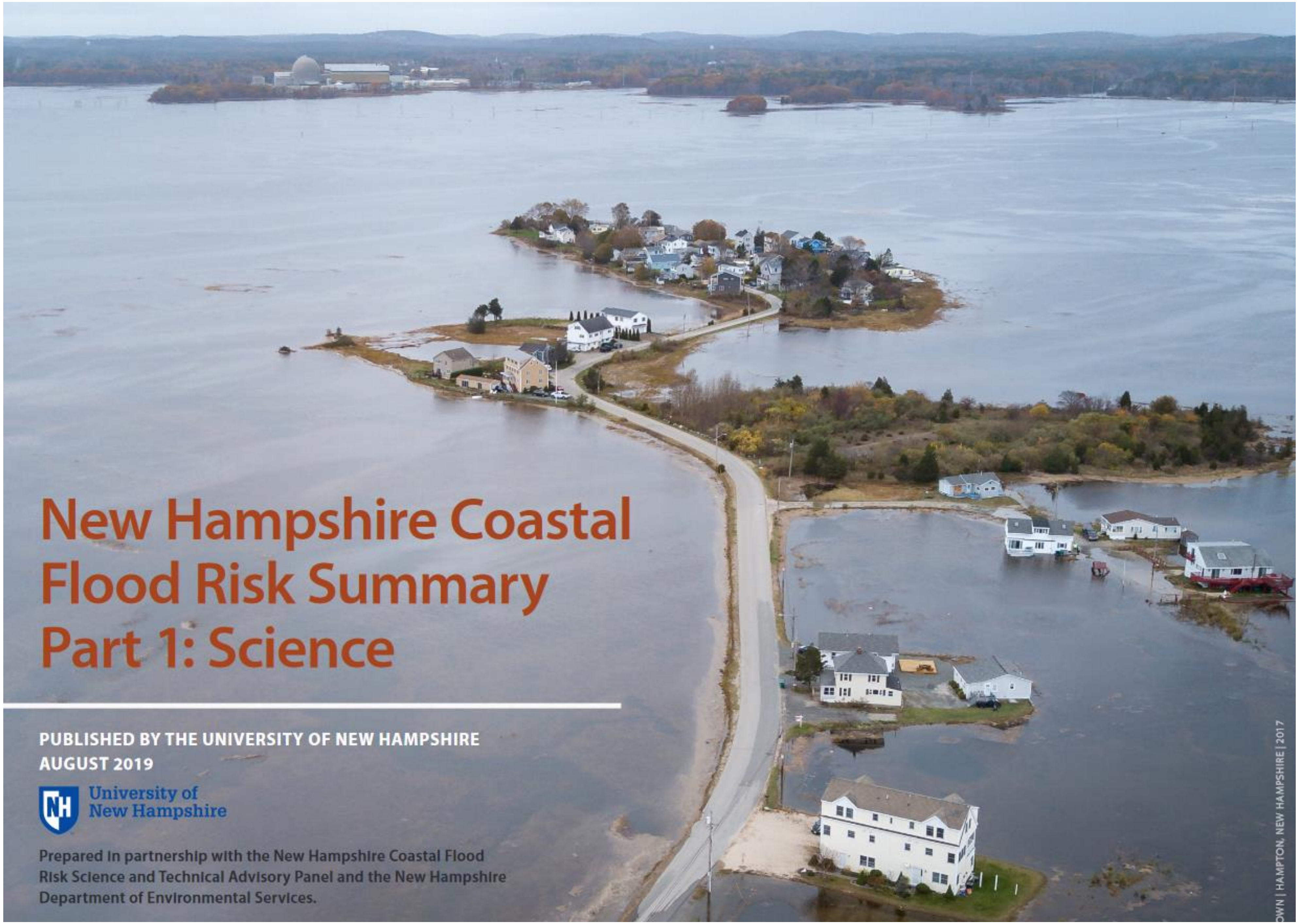


Figure 6.1. Schematic drawing showing the interconnected system of groundwater (fresh and saline) and surface water. Some consequences of rising groundwater are indicated: (1) SLR-induced groundwater rise, (2) septic system failure and basement flooding, (3) landward movement of the freshwater/saltwater interface, and (4) increased groundwater discharge to streams. **Source: U.S. Geological Survey; not to scale, vertically greatly exaggerated.**



New Hampshire Coastal Flood Risk Summary Part 1: Science

PUBLISHED BY THE UNIVERSITY OF NEW HAMPSHIRE
AUGUST 2019

University of New Hampshire

Prepared in partnership with the New Hampshire Coastal Flood Risk Science and Technical Advisory Panel and the New Hampshire Department of Environmental Services.

8-2019

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Recommended Citation
Wake, C., Knott, J., Lippmann, T., Stampone, M., Ballestero, T., Bjerklie, D., Burakowski, E., Glidden, S., Hosseini-Shakib, I., Jacobs, J. (2019). New Hampshire Coastal Flood Risk Summary – Part I: Science. Prepared for the New Hampshire Coastal Flood Risk Science and Technical Advisory Panel. Report published by the University of New Hampshire, Durham, NH.

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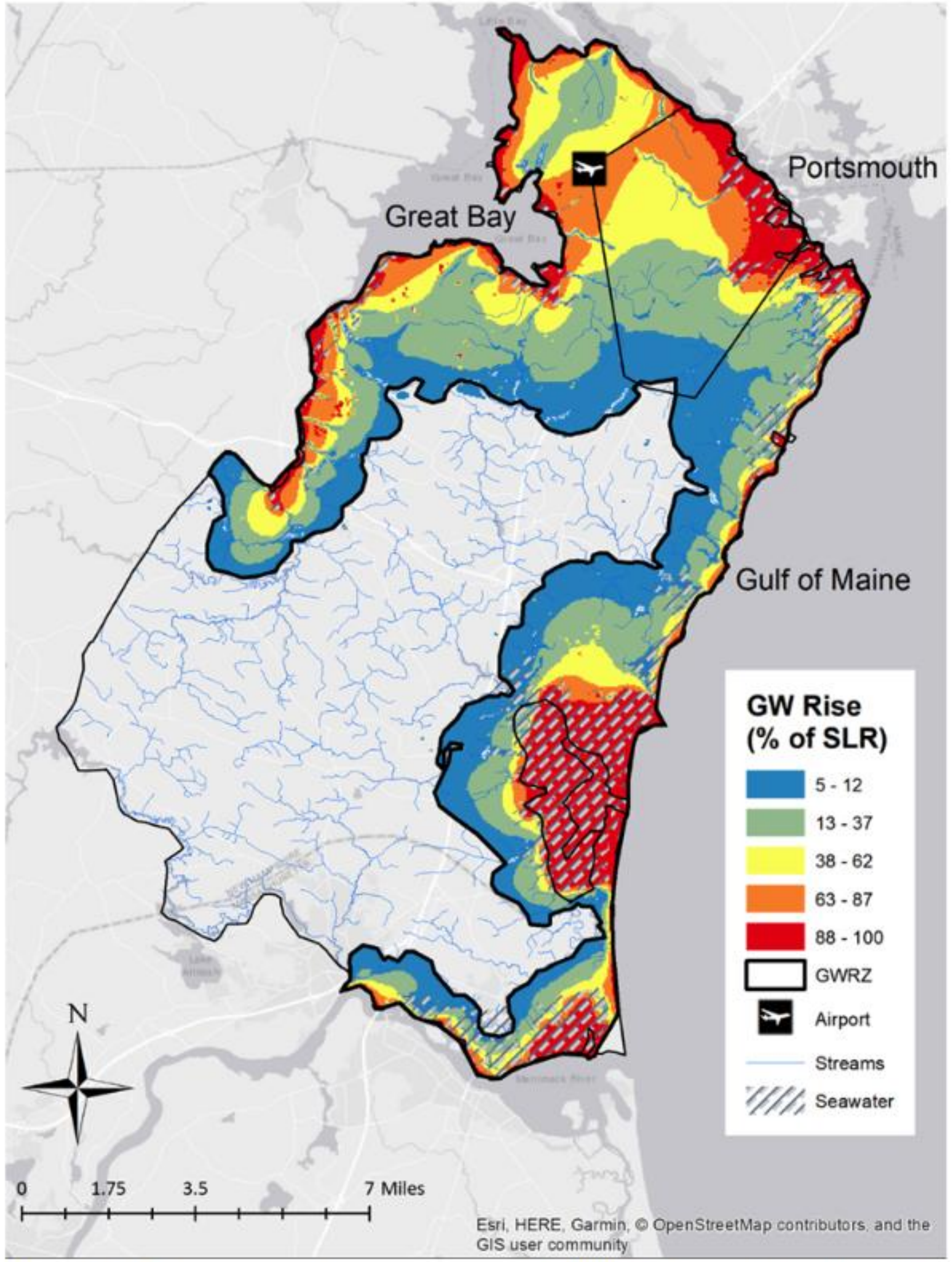

Figure 6.5. Projected groundwater rise as a percent of RSLR in the coastal New Hampshire study area. **Source: Modified from Knott et al. (2018a).**

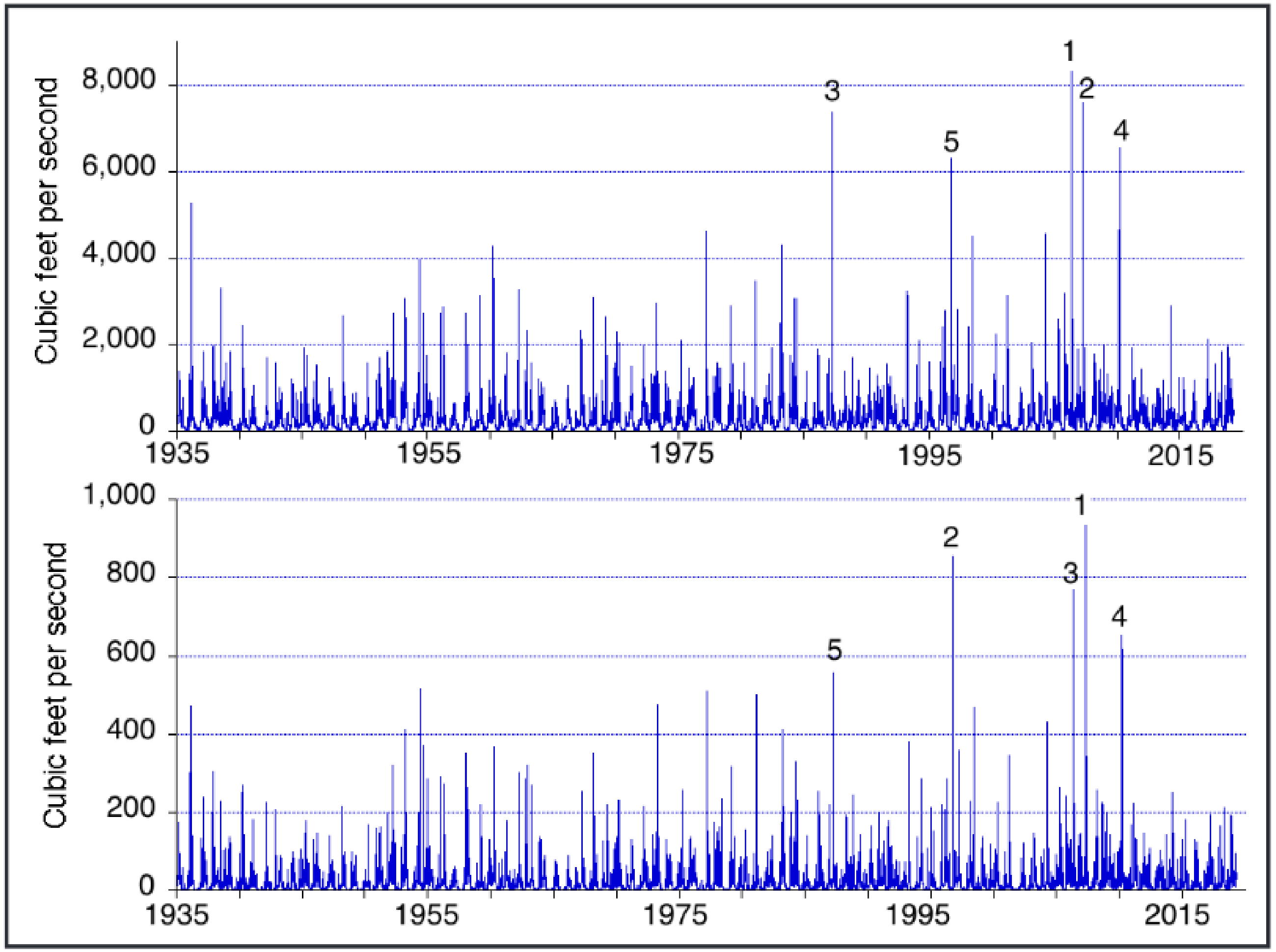

Figure 8.3. Daily peak discharge for the Lamprey River at USGS gage 01073500 (top) and the Oyster River USGS gage 01073000 (bottom) from 1934 through April 2019 (USGS, 2019). Note the largest five floods (ranked one through five for each record) on both rivers have occurred since 1986 (flood dates listed in Table 8.1).

Transportation Research Record: Journal of the Transportation Research Board
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Adaptation Planning to Mitigate Coastal-Road Pavement Damage from Groundwater Rise Caused by Sea-Level Rise

Jayne F. Knott, Jo Sias Daniel, Jennifer M. Jacobs, Paul Kirshen

First Published April 11, 2018 | Research Article | Check for updates
https://doi.org/10.1177/0361198118757441

Article Information
Volume: 2672 issue: 2, page(s): 11-22
Article first published online: April 11, 2018; Issue published: December 1, 2018

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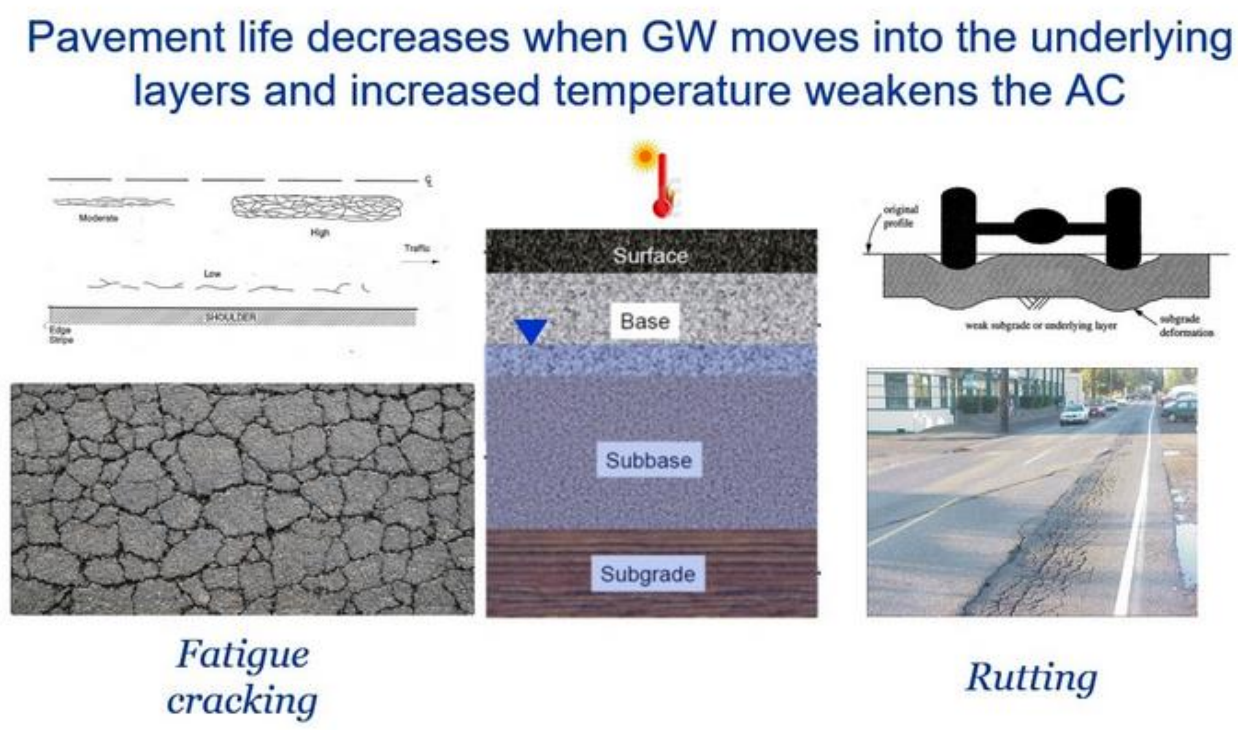
Abstract

Sea level in coastal New England is projected to rise 3.9–6.6 ft (1.2–2.0 m) by the year 2100. Many climate-change vulnerability and adaptation studies have investigated surface-water flooding from sea-level rise (SLR) on coastal-road infrastructure, but few have focused on rising groundwater. Groundwater modeling in New Hampshire's Seacoast Region has shown that SLR-induced groundwater rise will occur three to four times farther inland than surface-water flooding, potentially impacting 23% of the region's roads. Pavement service-life has been shown to decrease when the unbound layers become saturated. In areas where groundwater is projected to rise with SLR, pavements with groundwater 5.0 ft (1.5 m) deep or less are at risk of premature failure as groundwater moves into the pavement's underlying unbound layers. In this study, groundwater hydrology and multi-layer elastic pavement analysis were used to identify two case-study sites in coastal New Hampshire that are predicted to experience pavement service-life reduction caused by SLR-induced groundwater rise. Various pavement structures were evaluated to determine adaptation feasibility and costs to maintain the designed service-life in the face of rising groundwater. This investigation shows that relatively simple pavement structural modifications to the base and asphalt concrete (AC) layers of a regional corridor can eliminate the 80% to 90% service-life reduction projected with 1.0 ft SLR (year 2030) and will delay pavement inundation by 20 years. Pavements with adequate base-layer materials and thickness require only AC thickness modification to avoid premature pavement failure from SLR-induced groundwater rise.



Impacts from rising groundwater will occur across sectors.

In the transportation sector, rising groundwater will weaken the underlying base layers of roads resulting in premature pavement failure (Knott, Daniel, et al., 2018). In the water resources and drinking water sectors, rising groundwater has the potential to increase saltwater intrusion into coastal aquifers and impact groundwater quality. As groundwater rises, the separation distance between leach fields and the water table decreases, reducing contaminant removal effectiveness. In low-lying areas, septic systems may completely fail.

Regulations controlling the cleanup of hazardous waste disposal sites typically define a specific water-table depth deemed safe to prevent groundwater contamination. With rising groundwater, these requirements may no longer be satisfied, resulting in groundwater and surface-water quality degradation. Ecosystems will also be affected as rising groundwater will cause freshwater wetlands to expand and/or transition with changing water depths and salinities. Wetlands legislation will have to change to protect these important resources to maintain their important flood control and fisheries functions. (Wake et al., 2019)

HydroPredictions

WHAT DO RISING GROUNDWATER & SEA-LEVEL RISE HAVE IN COMMON?

What Do Sea Level and Rising Groundwater Have in Common?

The levels of both will rise with climate change, and this rise is expected to accelerate. Sea levels are projected to rise 5.3 feet under the middle emissions scenario and 6.5 feet under the high emissions scenario in the northeastern part of the United States by the end of the century (1% probability) (Wake et al., 2019).