Our Presenters – Climate Change and the Weather

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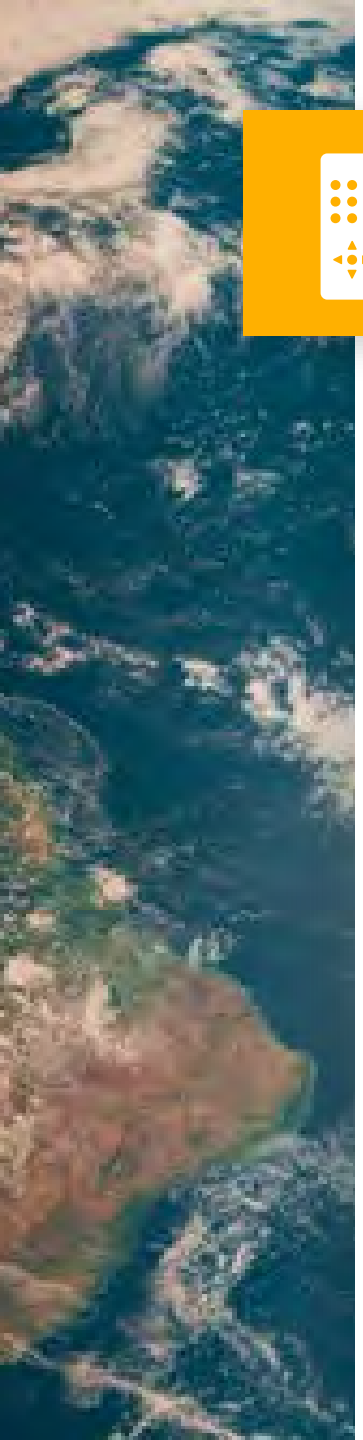
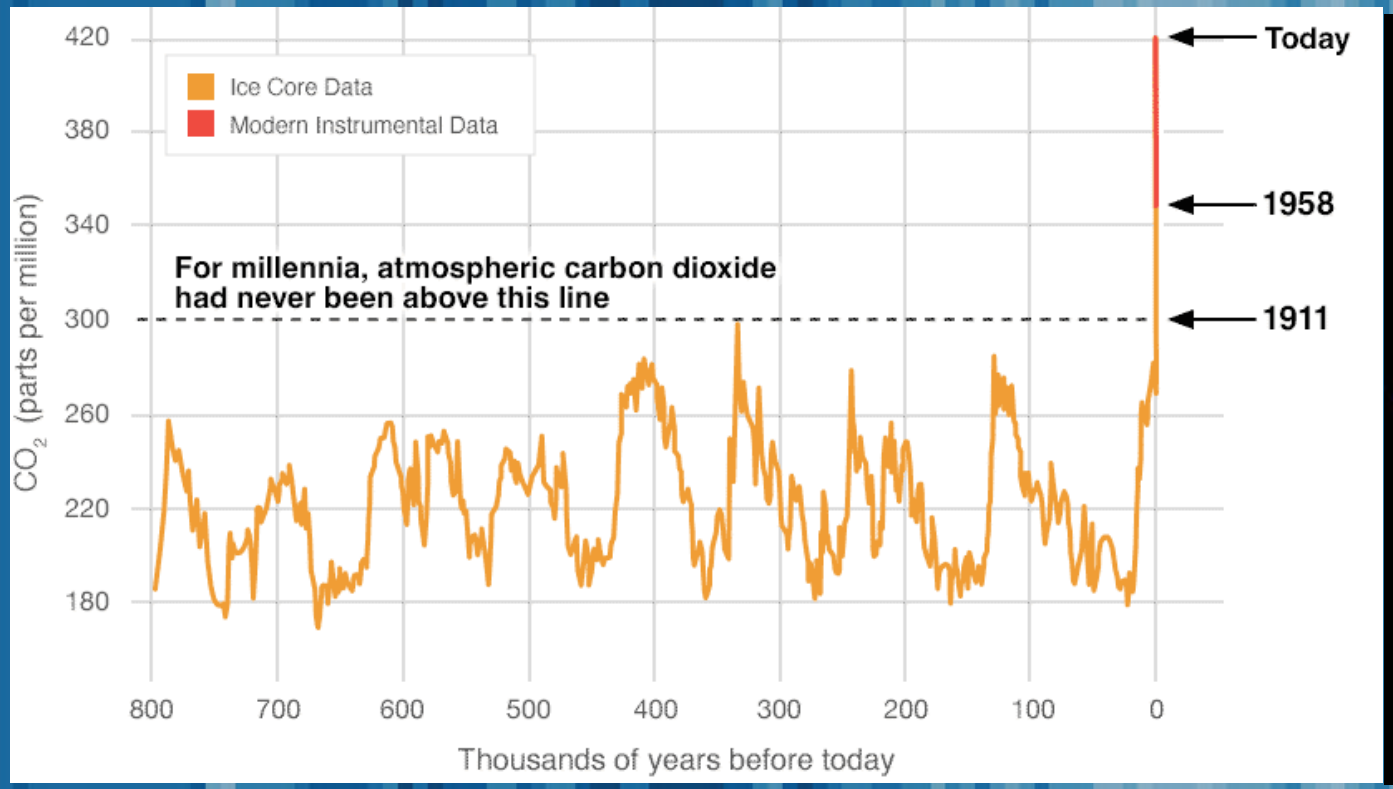
MASSACHUSETTS HIGHWAY ASSOCIATION 1893

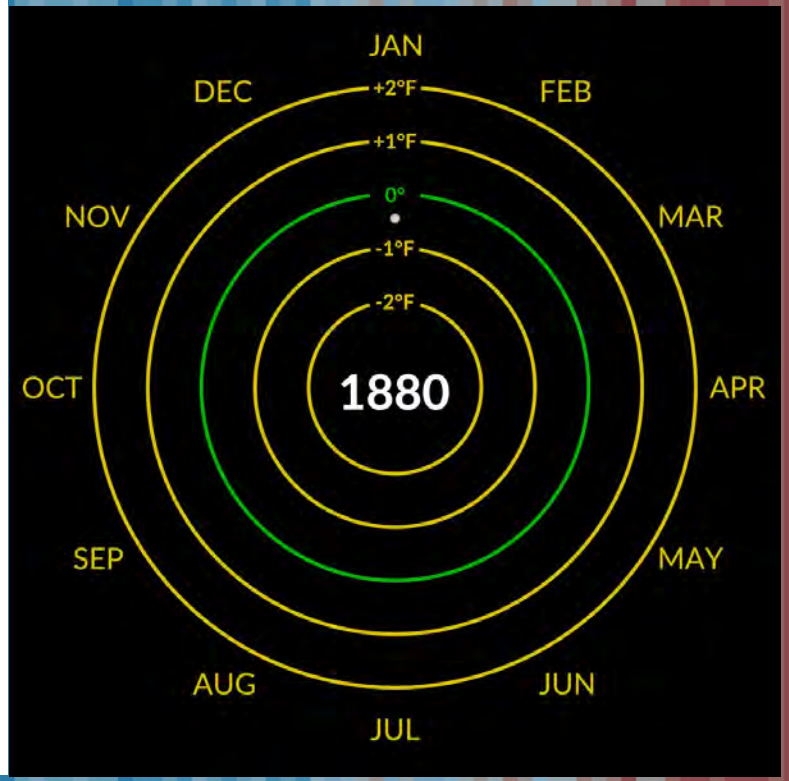


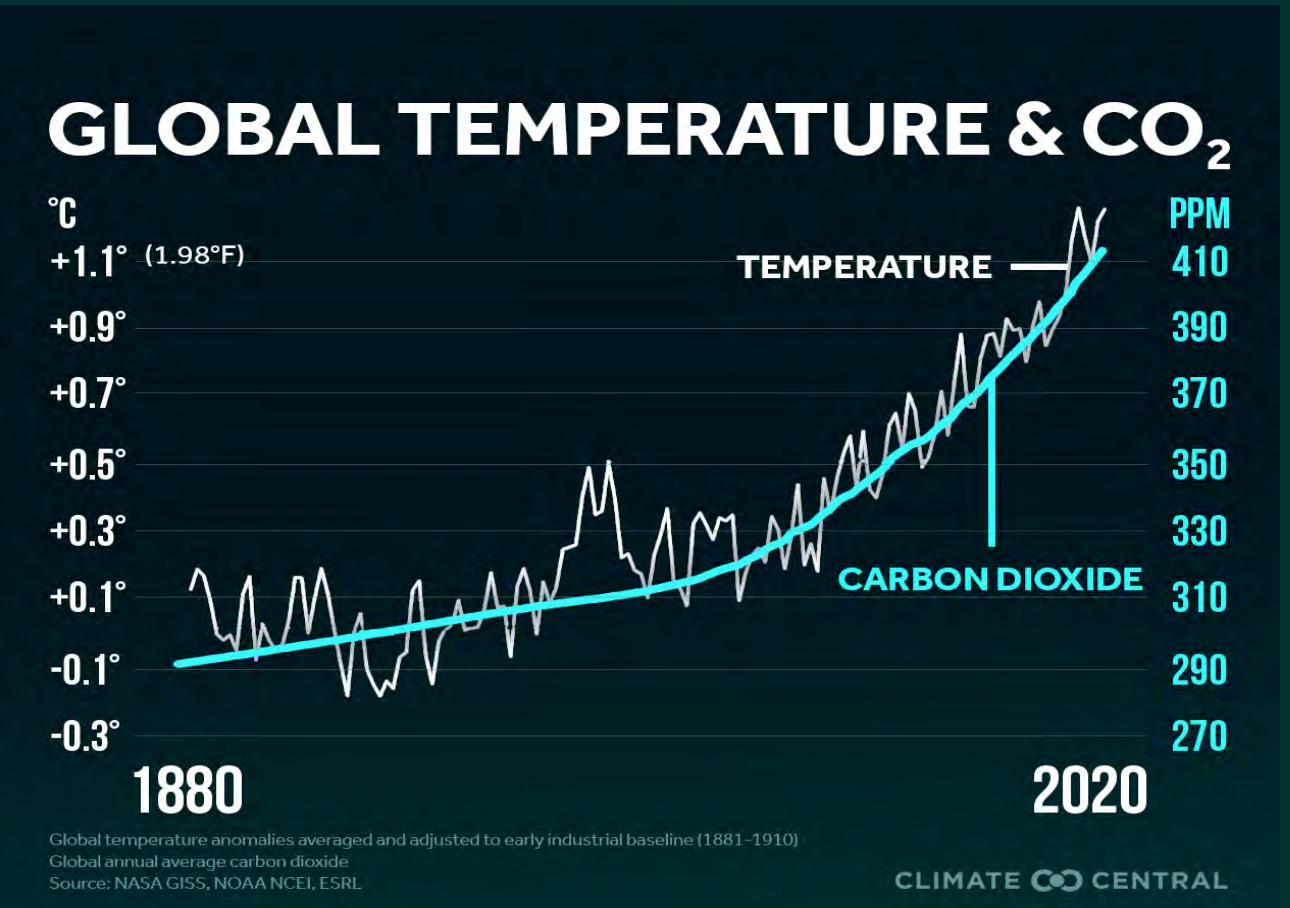
WHERE I'VE WORKED

WHEC – Rochester, NY
WTEN – Albany, NY
WNEM – Saginaw, MI
WRGB – Albany, NY
WISN – Milwaukee, WI
WBTS – Boston, MA
KCCI – Des Moines, IA
Woods Hole Group, Inc.

Understanding Climate Change







INDUSTRIAL REVOLUTION BEGINS

A LOOK BACK IN TIME

METHOD	DATASET
TREE RINGS	Up to 5,000 years
ICE CORES	>100,000 years
OCEAN SEDIMENT	Up to 5,000,000 years

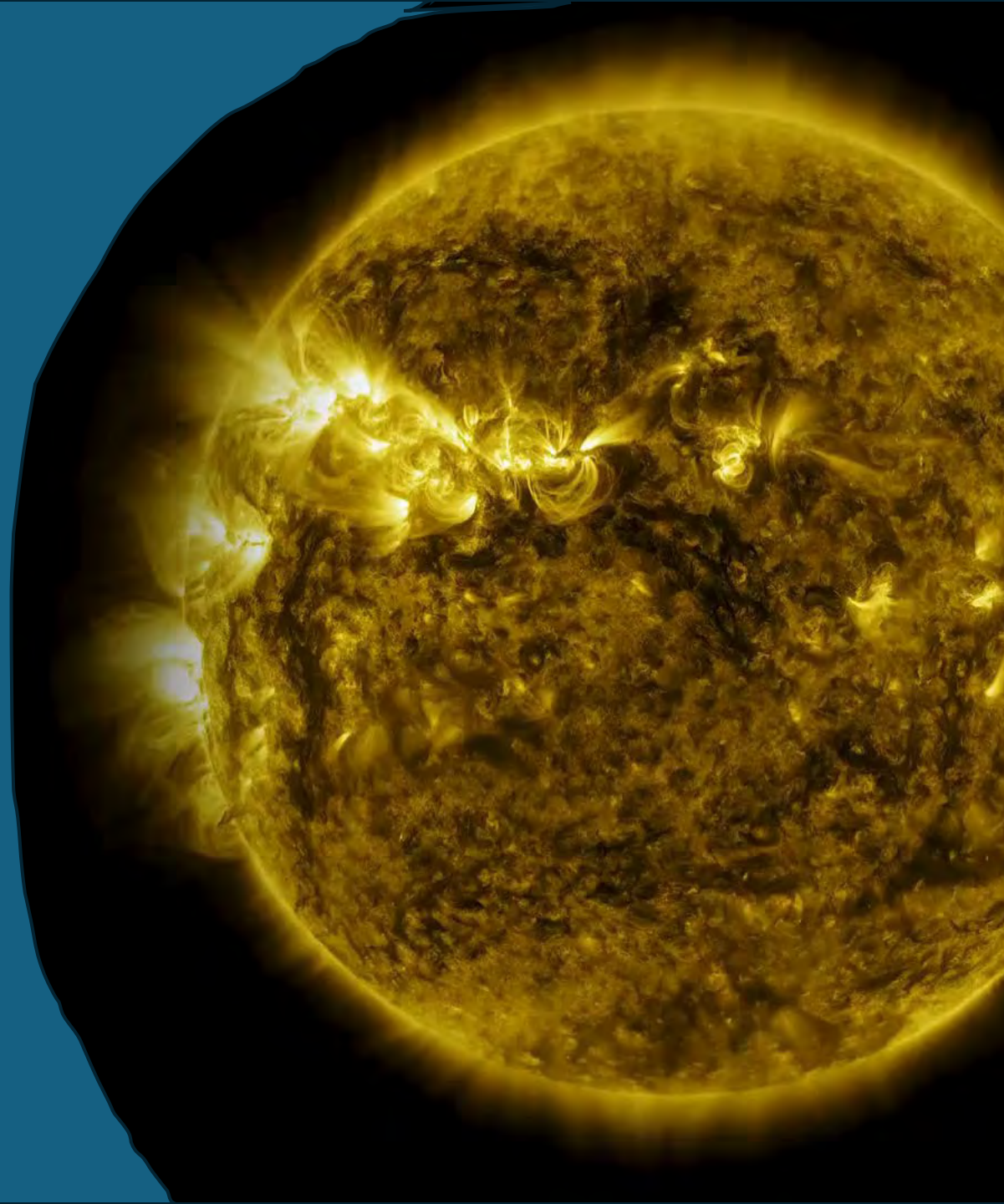
IS IT REALLY US?

Natural Variability: Despite natural fluctuations, extensive analysis indicates that the observed warming trend cannot be solely attributed to natural factors – i.e. El Nino, NAO, etc.

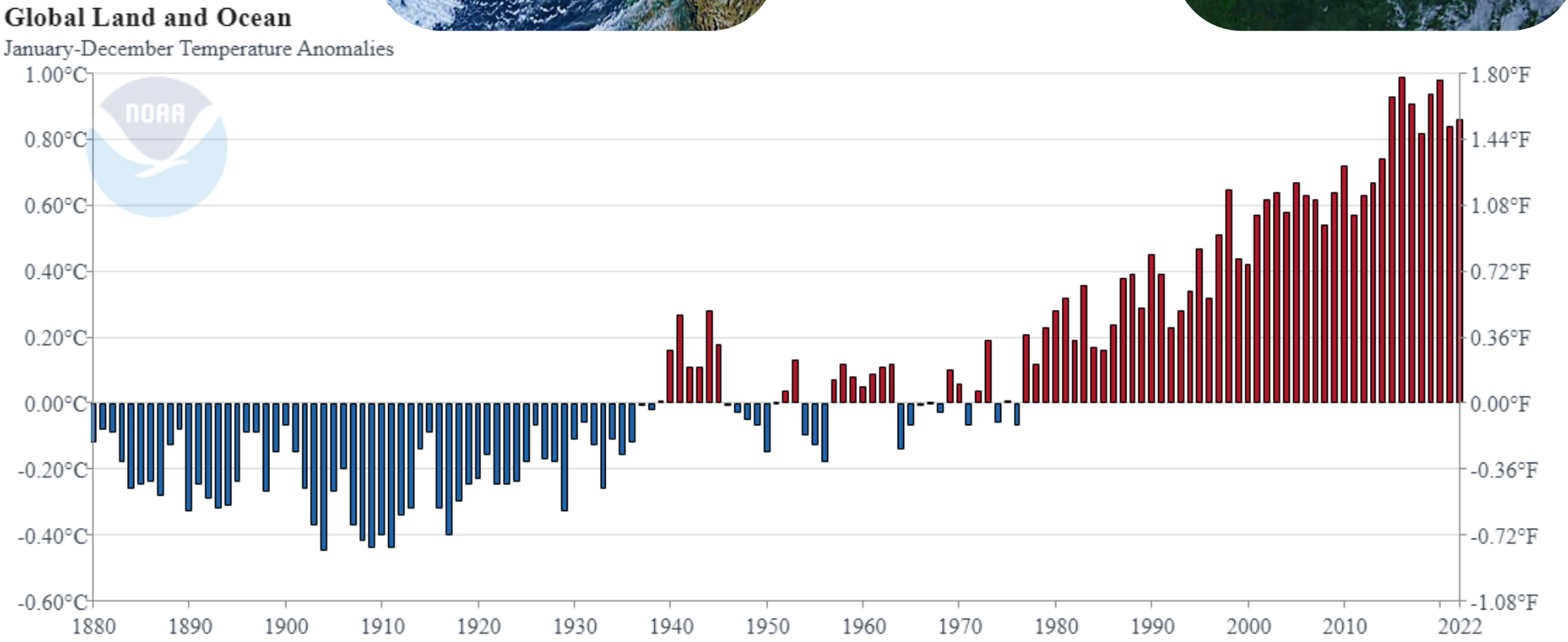
Volcanic Activity: While volcanic eruptions can temporarily cool the planet by emitting sulfur dioxide, they do not account for the sustained warming observed over the long term.

Solar Variability: While changes in solar activity can influence climate on shorter timescales, they cannot fully explain the rapid and consistent warming observed in recent decades. They last approximate 11 years.

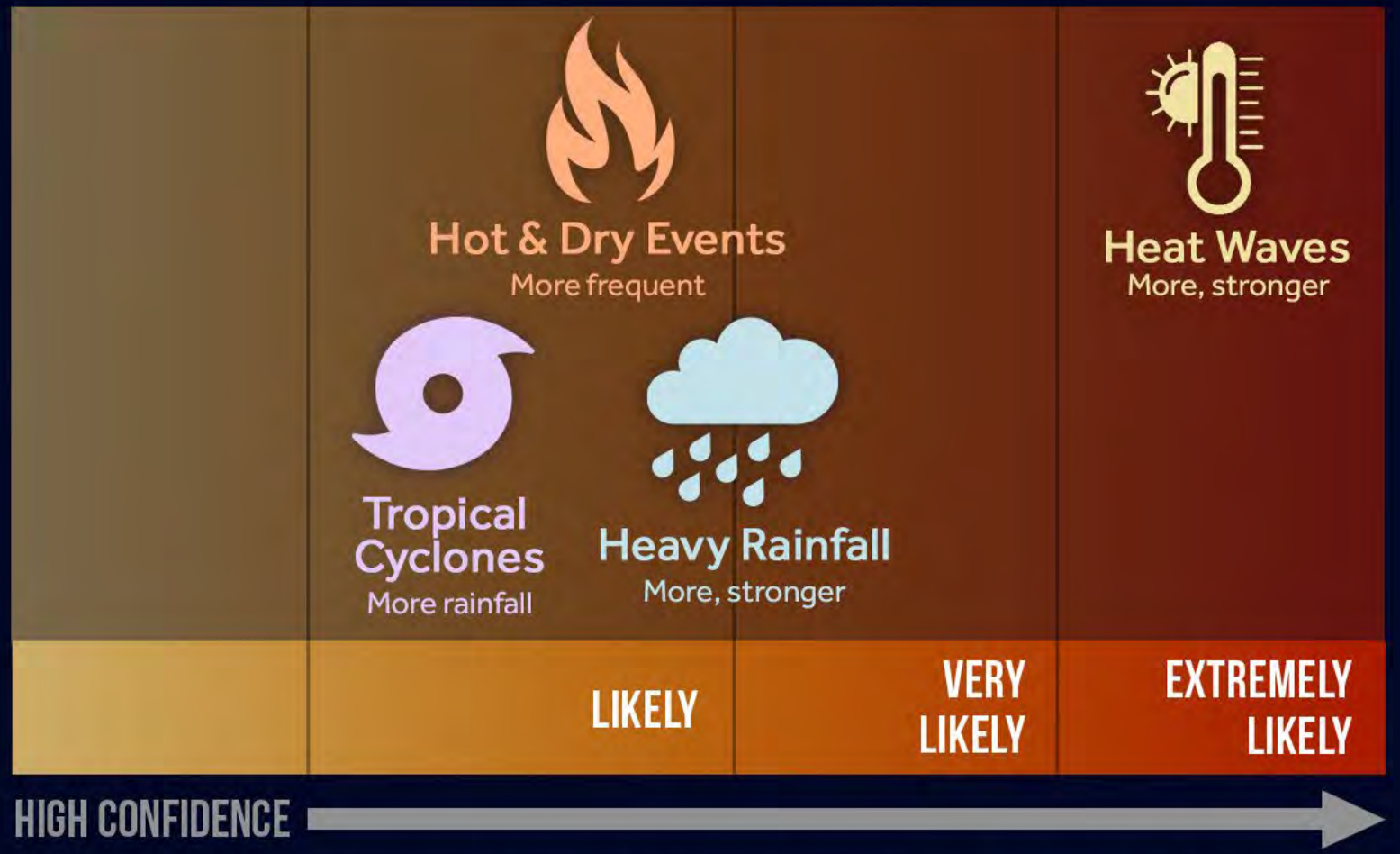
Milankovitch Cycles: Long-term changes in Earth's orbit and axial tilt, known as Milankovitch cycles, occur over thousands of years and do not match the rapid warming trend observed in recent decades.



GLOBAL TEMPERATURE ANOMALIES



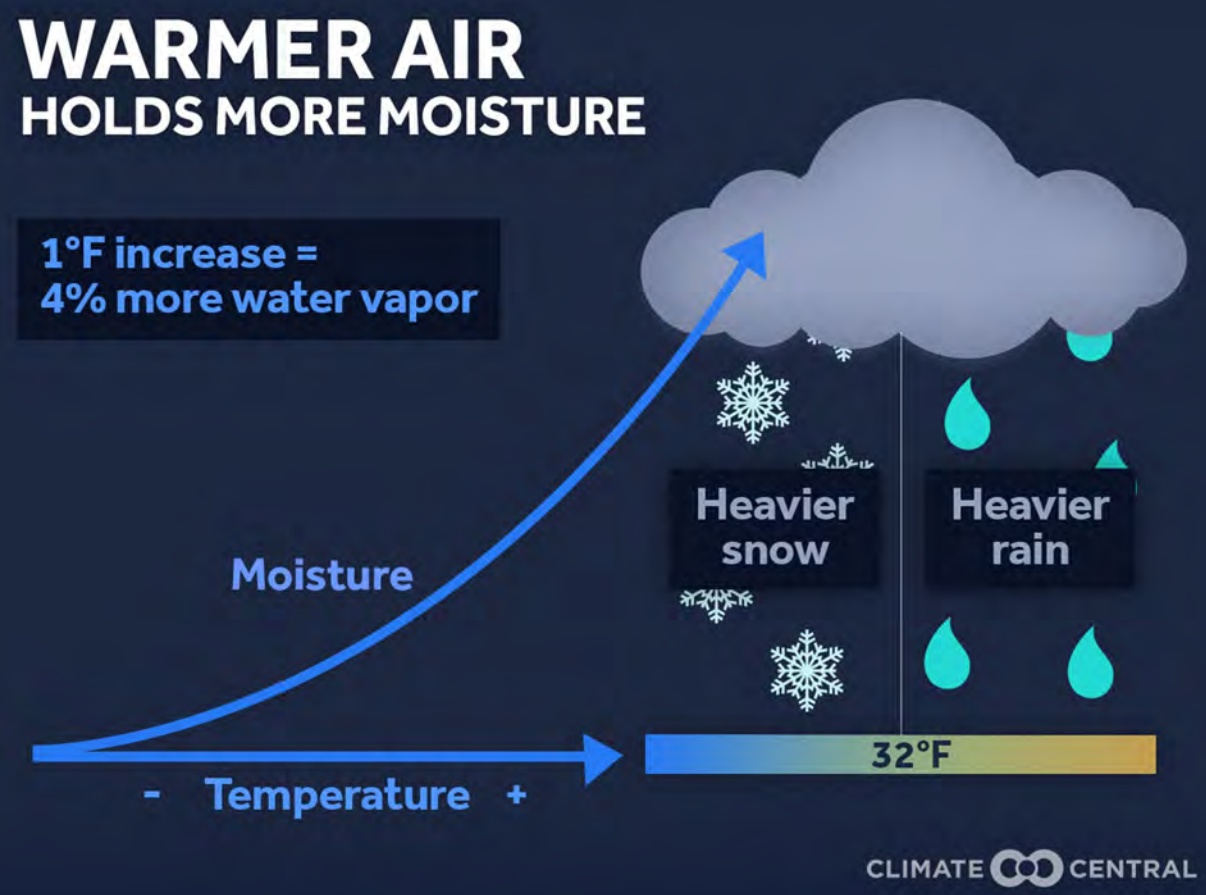
HUMAN INFLUENCE ON GLOBAL TRENDS



Likelihood of human influence on global trends in extremes: likely 66-100% probability; extremely likely 95-100% probability. Source: IPCC AR6 WGI (2021)

CLIMATE CENTRAL

For Every 1°F of Global Warming The Atmosphere Holds 4% More Moisture



Climate Change Resilience and the Commonwealth

Katherine Antos
Undersecretary of Decarbonization and Adaptation
MA Executive Office of Energy and Environmental Affairs

ResilientMass

Climate Change is Impacting Massachusetts

ResilientMass

RISING TEMPERATURES[1]

23–29 high heat days per year expected by **2050** and annual average temperature increase of **5.9 to 7.9°F.**

Those most likely to be affected from high heat include unhoused populations, those working outdoors, the elderly, infants, individuals with chronic diseases (e.g., asthma), and environmental justice and other priority populations.

Extreme temperatures are projected to increase annual transportation infrastructure maintenance costs by over **$140 million** by the end of the century.

CHANGES IN PRECIPITATION[2]

By **2070,** Massachusetts is expected to receive **12–42%** more winter precipitation.

Environmental justice and priority populations live near commercial and industrial buildings that have a **57% higher risk of flood** damage than the rest of the Commonwealth.

Annual economic flood damage is estimated to increase by **$9.3 million** by **2030** across the Commonwealth.

COASTAL FLOODING[3]

Massachusetts is planning for sea level rise by up to **2.5 feet by 2050** compared to present day (2008) if global emissions are not significantly reduced. Both tidal and storm-related flooding are projected to increase.

Risks and consequences from inundation will be more significant among sensitive assets such as hospitals, schools, prisons, care facilities, and underground and at-grade living quarters.

Coastal flooding is projected to cause over **$52 million** in damage annually to state-owned coastal properties, a **550%** increase from today.

SEVERE WEATHER[4]

Includes strong winds, tornadoes, extreme precipitation, and droughts. Precipitation amounts from the heaviest storms in the Northeast has increased by **55%** since **1958.**

High winds are of particular concern to coastal areas, where wind speeds can reach **110+ miles per hour.**

Populations living or working outdoors will be increasingly exposed to dangers of more frequent and increasingly severe weather.

Lightning was responsible for **$20.4 million** in damage in Massachusetts between 2002 and 2022.[5]

Transportation and Resilience

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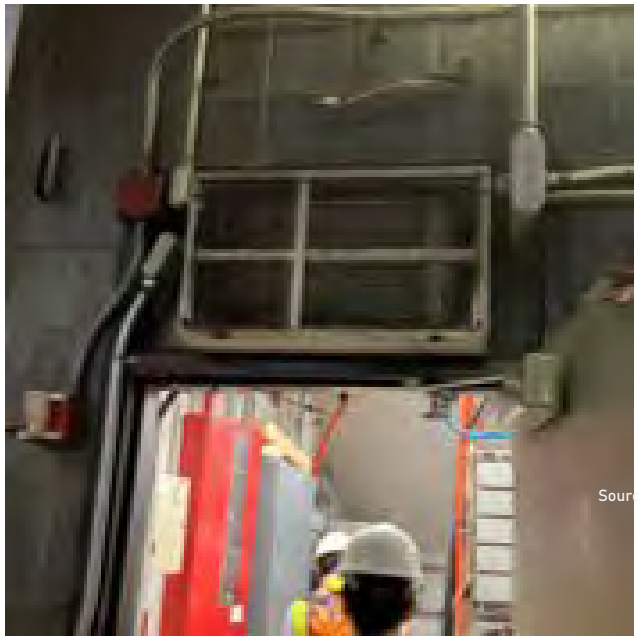
Impacts on health and safety, and infrastructure systems



Workers face increasing risk of extreme heat exposure, and communications + signaling equipment can easily fail due overheating.

Extreme heat causes tracks to buckle.

Low-lying tracks back-up with floodwater during coastal storms

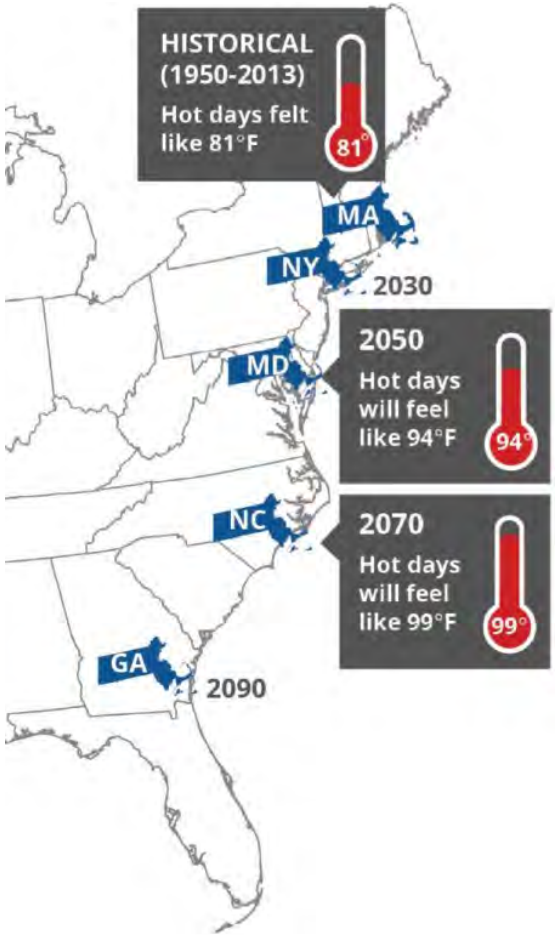
Washed out road in Leominster, CBS Boston September 2023

"…dropped nearly ten inches of rain in six hours… the rainfall was "a 200-year event", says Matthew Belk, a meteorologist with the National Weather Service in Boston." CBS News, Boston

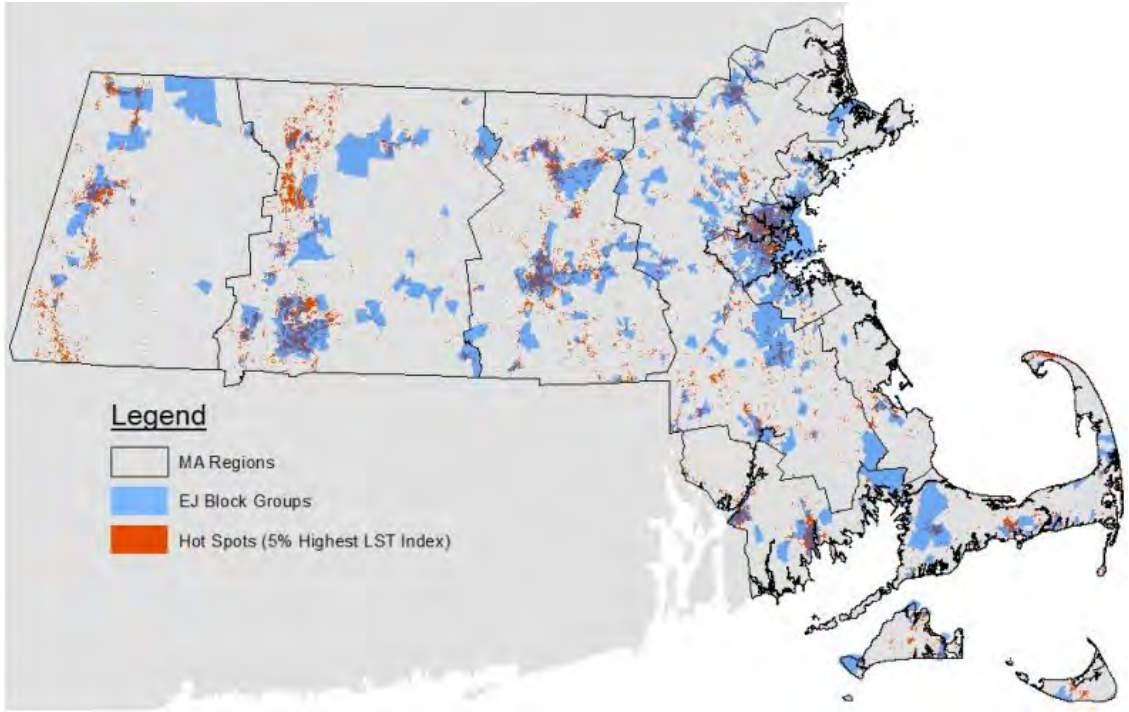
Rising Temperatures

ResilientMass

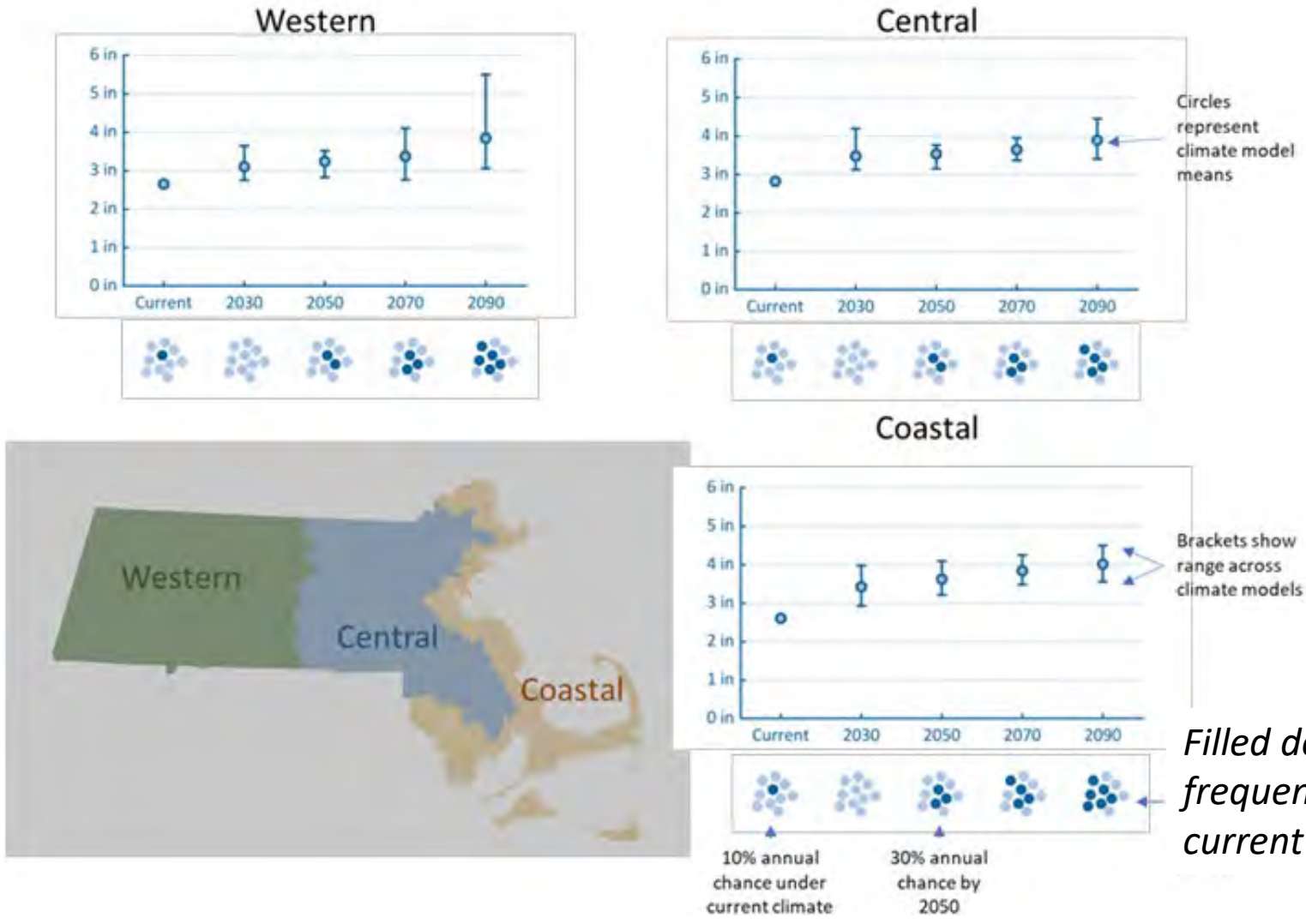
Change in Average Summertime Temperatures



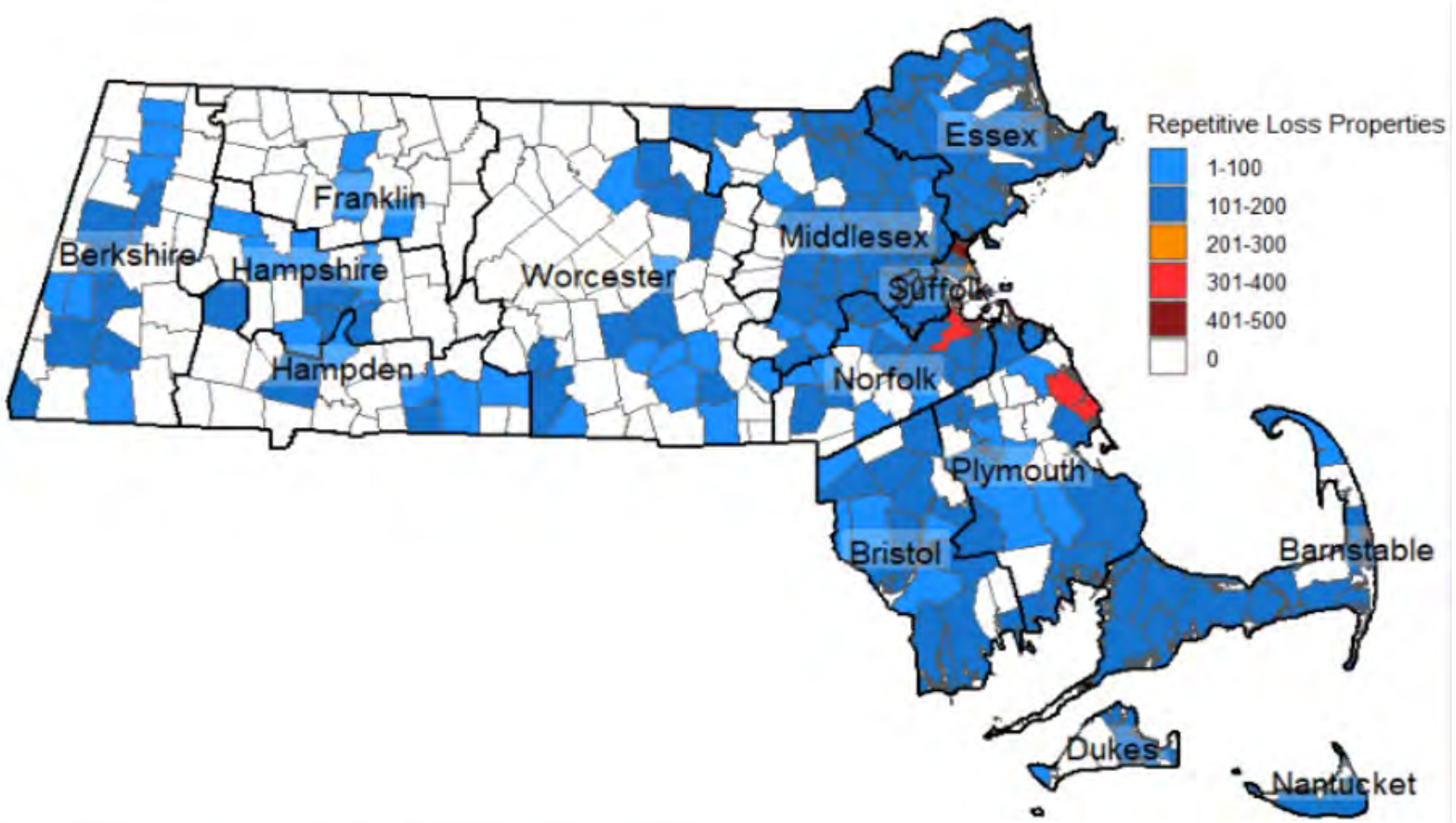
Land Surface Temperature Hot Spots and Environmental Justice Block Groups



Changes in Precipitation Intensity and Frequency



Repetitive Loss Sites: Coastal and Inland Flooding



Source: ERG analysis using data from FEMA (2022b).

A repetitive loss property is a property for which NFIP has paid two or more flood insurance claims of more than $1,000 within any 10-year period since 1978.

Figure 5.8-2. Count of NFIP repetitive loss properties per town.

Transportation and Resilience

Extreme future precipitation

Hydrologic Response

Impact on Infrastructure

Resilience investments will strengthen and protect our communities

MA experiencing increasing flood, storm, and heat impacts

5 flood disasters in 2023

MA's hottest summer on record in 2023

Rapid-onset drought and record wildfires fall 2024

MVP-funded resilience investments are working

- Pepperell: Sucker Brook dam removal and culvert upgrades performed well in 2023 storm events
- Deerfield: Culvert upgrade mitigated September 2023 flood impacts
- Northampton: Ecosystem restoration at golf course site mitigated downstream impacts in subsequent storm events

US Chamber of Commerce 2024 study showed that a $1 investment in resilience yields $13 in avoided damages, costs, and economic impact

Washed out road in Leominster, CBS Boston September 2023

Culvert upgrade as part of the 2022 Pepperell project.

Modeling Tools to Support Climate-Resilient Infrastructure

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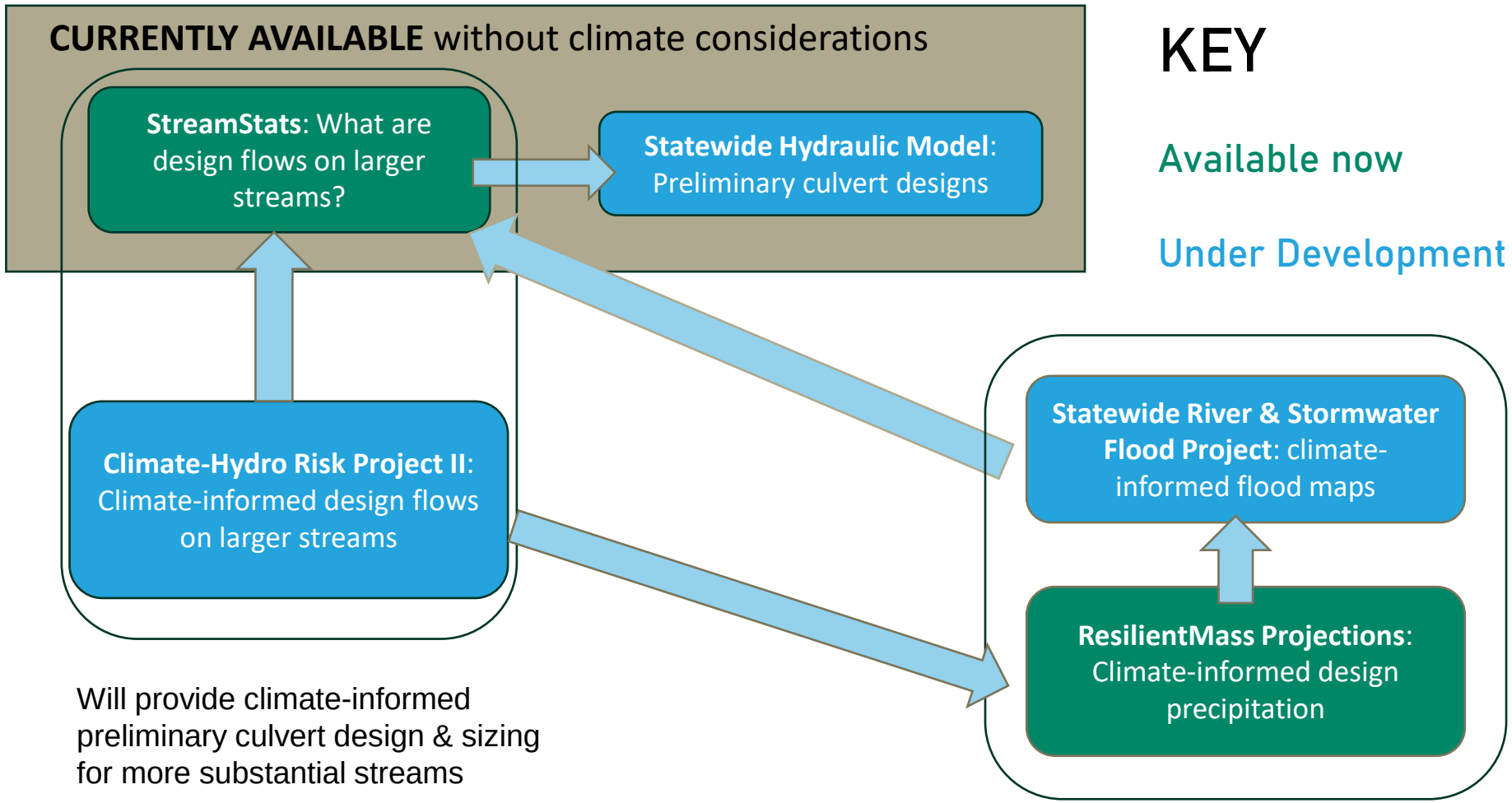

Will provide climate-informed preliminary culvert design & sizing for more substantial streams

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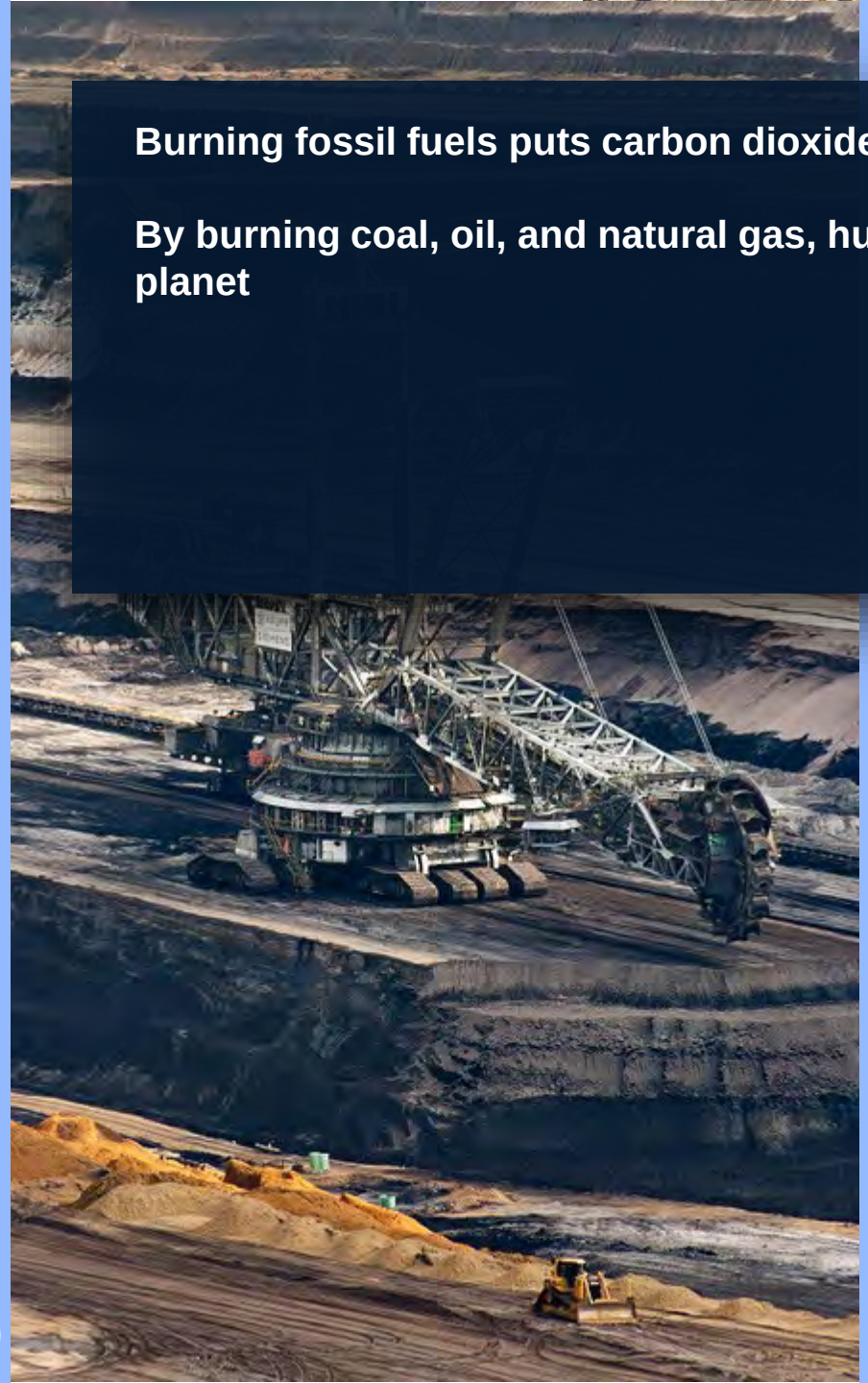
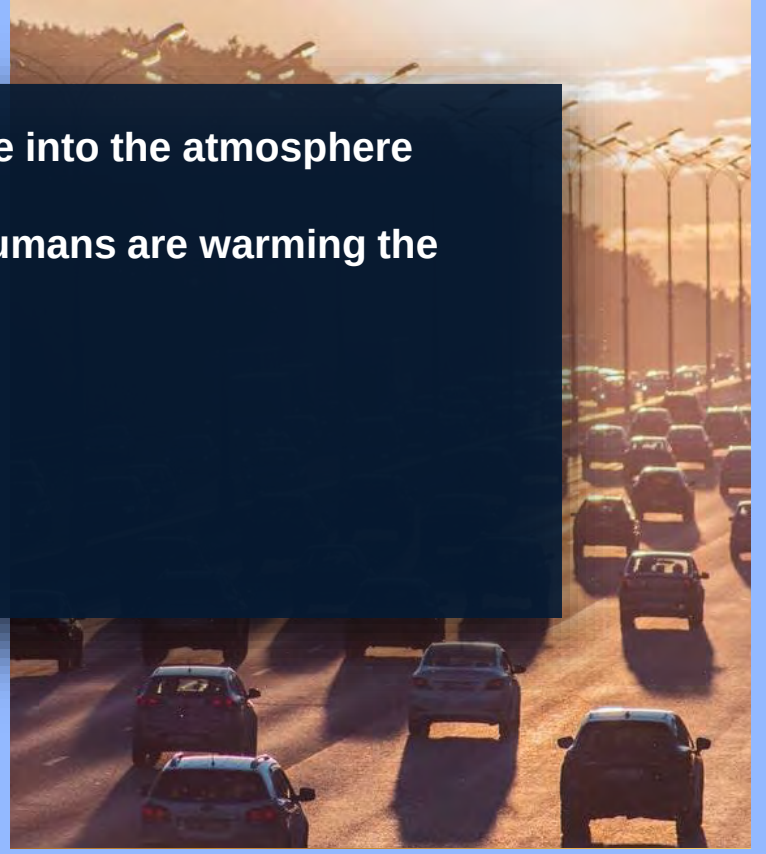
Our Changing Climate

CLIMATE CENTRAL

Burning fossil fuels puts carbon dioxide into the atmosphere

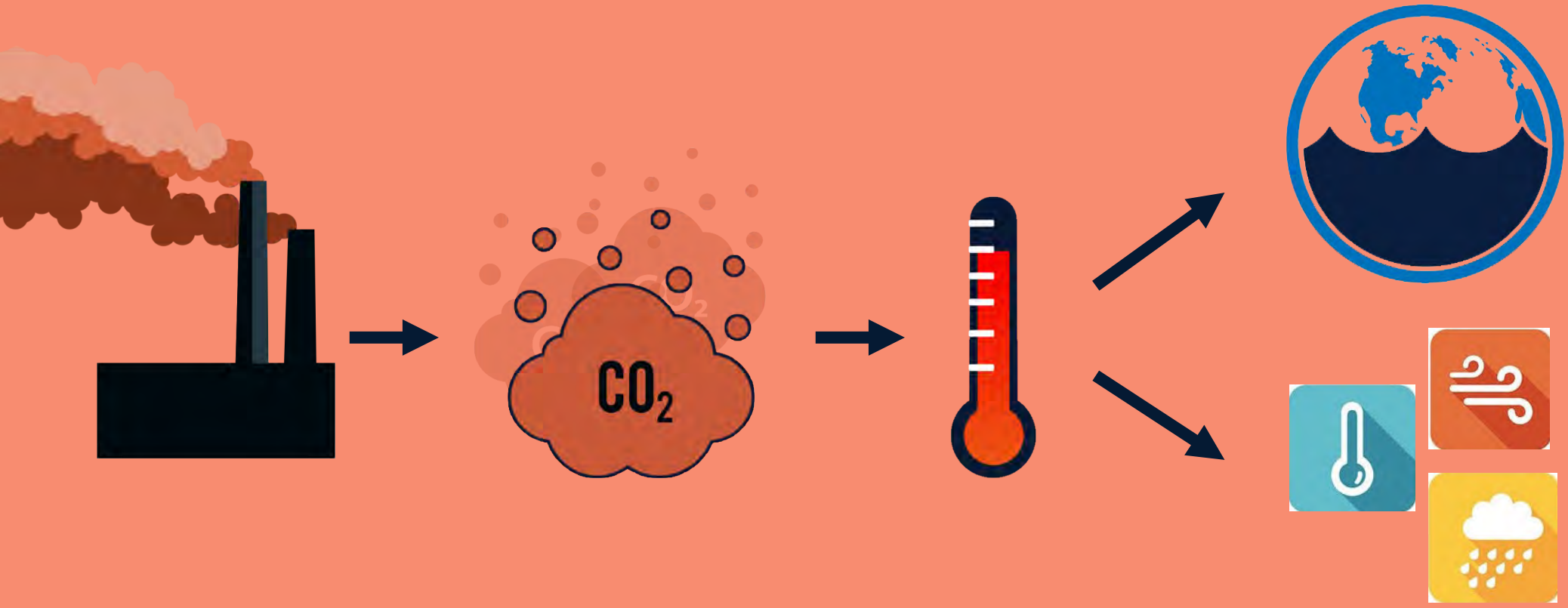
By burning coal, oil, and natural gas, humans are warming the planet





SIMPLE

Serious



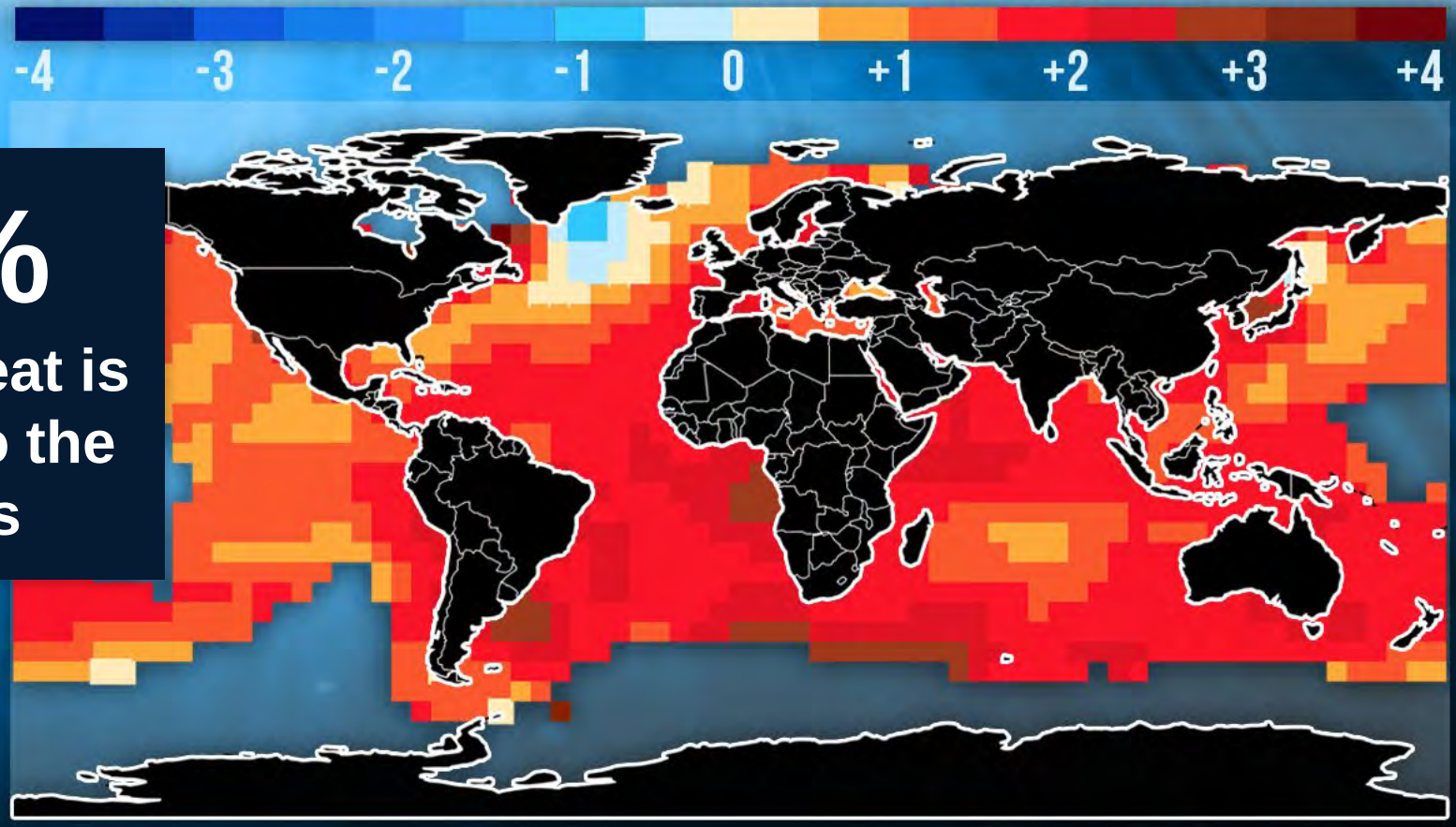
Rising seas

Wild weather

SERIOUS

OCEANS HEATING UP

Change in sea surface temperature (°F) since 1901:



93%

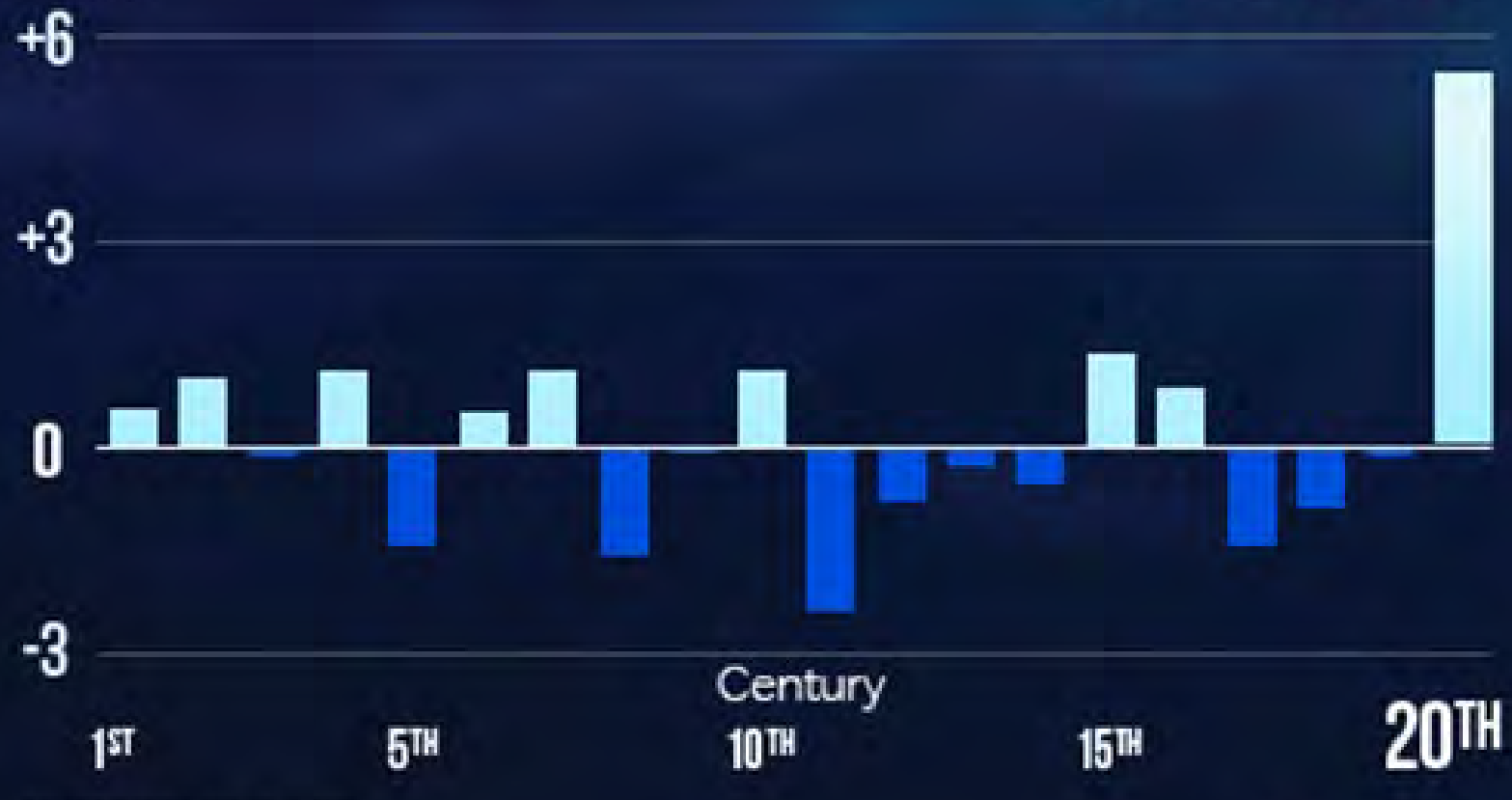
of extra heat is going into the oceans

Data through 2015. Gray indicates insufficient data
Source: IPCC, NOAA: Merged Land-Ocean Surface Temp Analysis

CLIMATE CENTRAL

SEA LEVEL RISE

BY CENTURY



Central reconstruction shown
Source: Kopp et al. 2016 (PNAS)

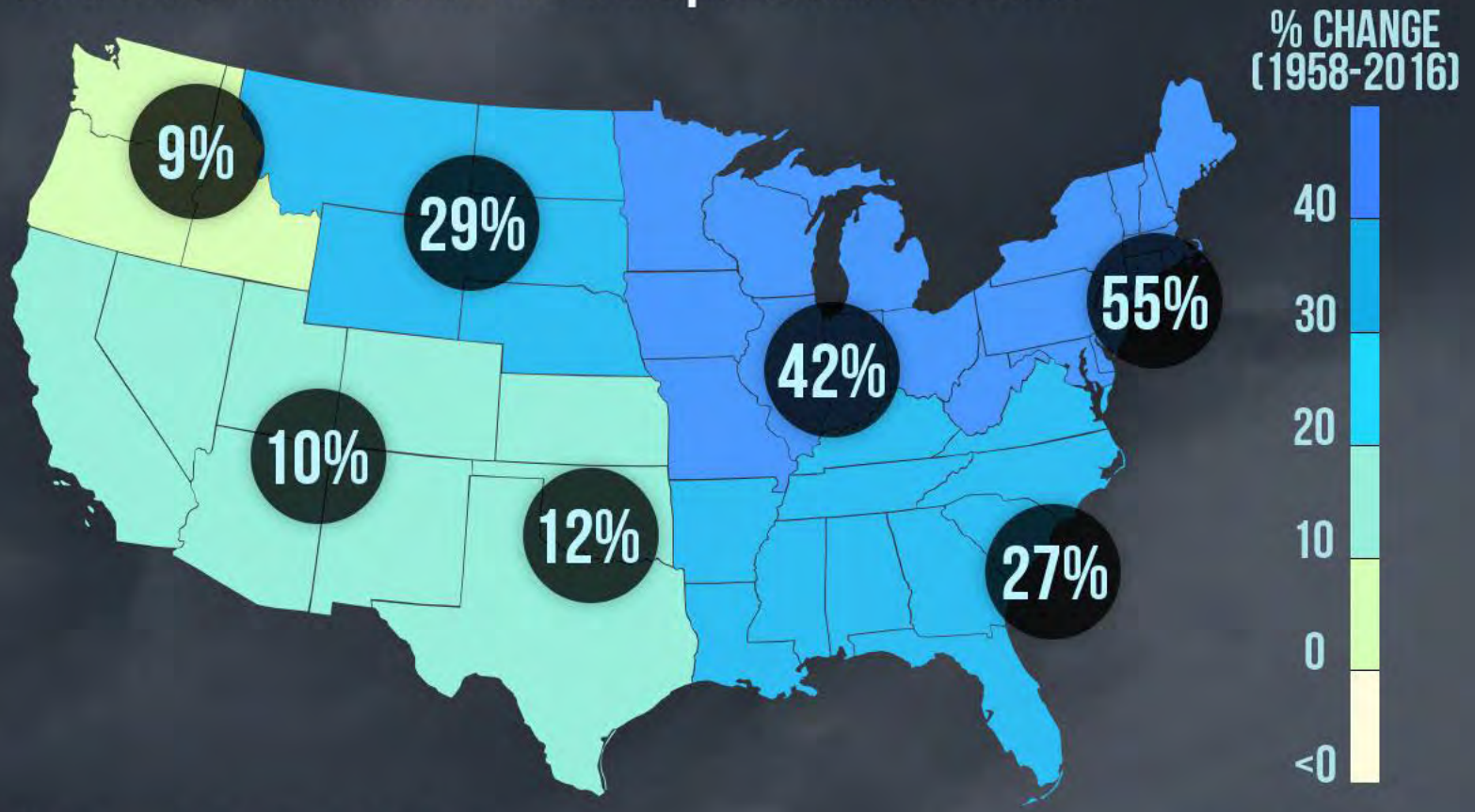
CLIMATE CENTRAL

SERIOUS

SERIOUS

MORE DOWNPOURS

Increase in Heaviest Precipitation Events

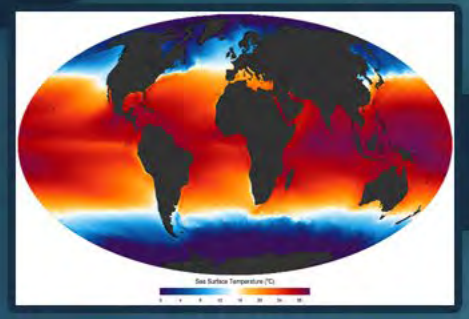


Heaviest events defined as top 1% of events
Source: USGCRP Climate Science Special Report 2017

CLIMATE CENTRAL

HURRICANES & CLIMATE CHANGE

What we know



Warmer water = more fuel

Heavier rain

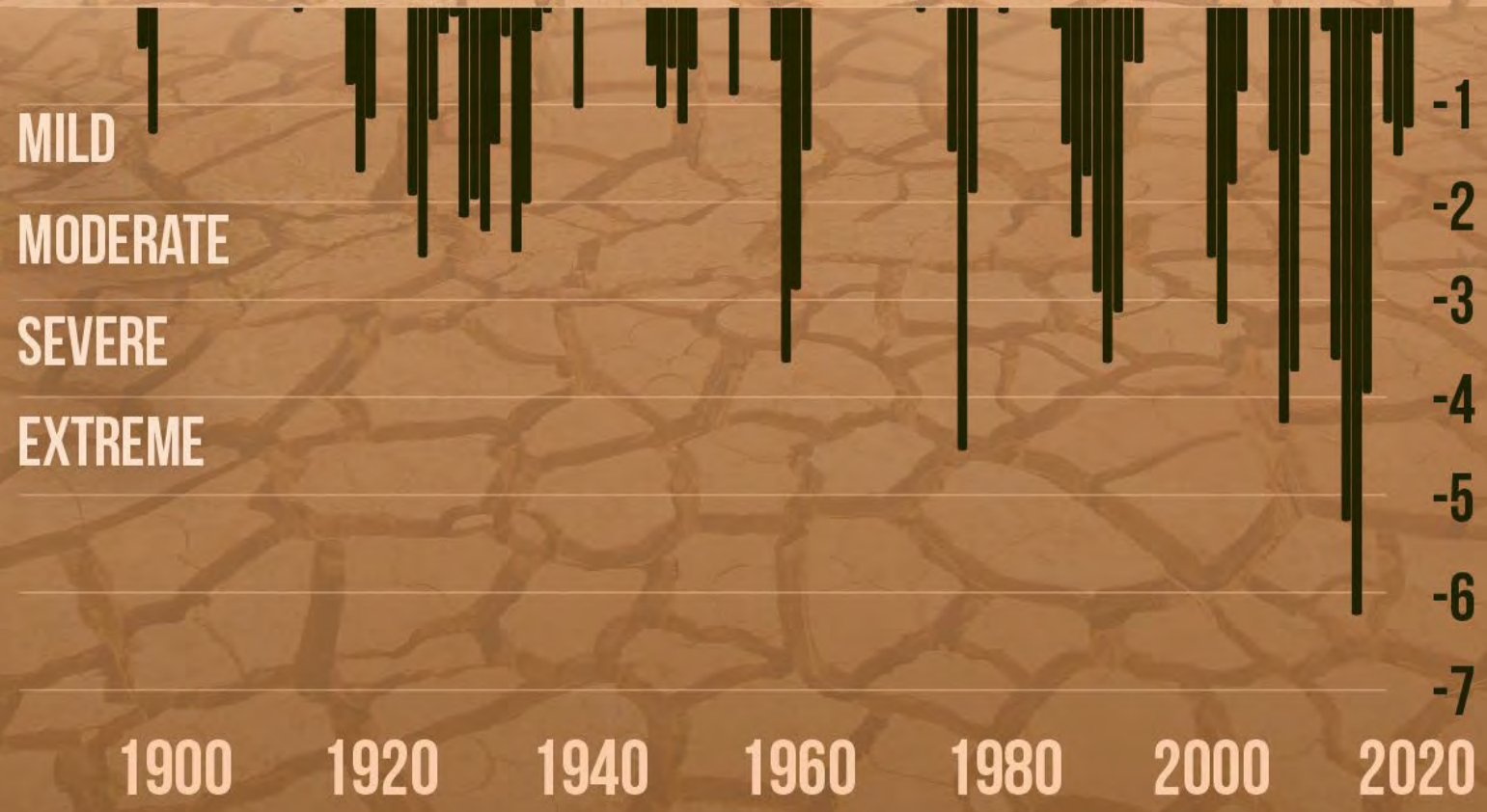
Higher storm surge

CLIMATE CENTRAL

SERIOUS

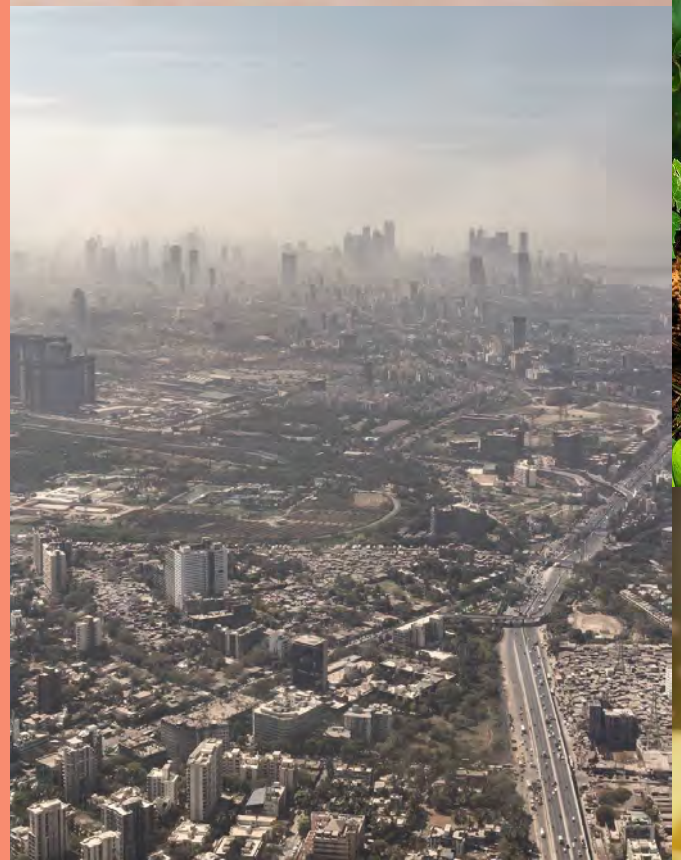
SERIOUS

WESTERN U.S. DROUGHT INDEX



Palmer Hydrological Drought Index 24 month average. NCEI West U.S. climate region (CA and NV).
Source: NCEI

CLIMATE CENTRAL

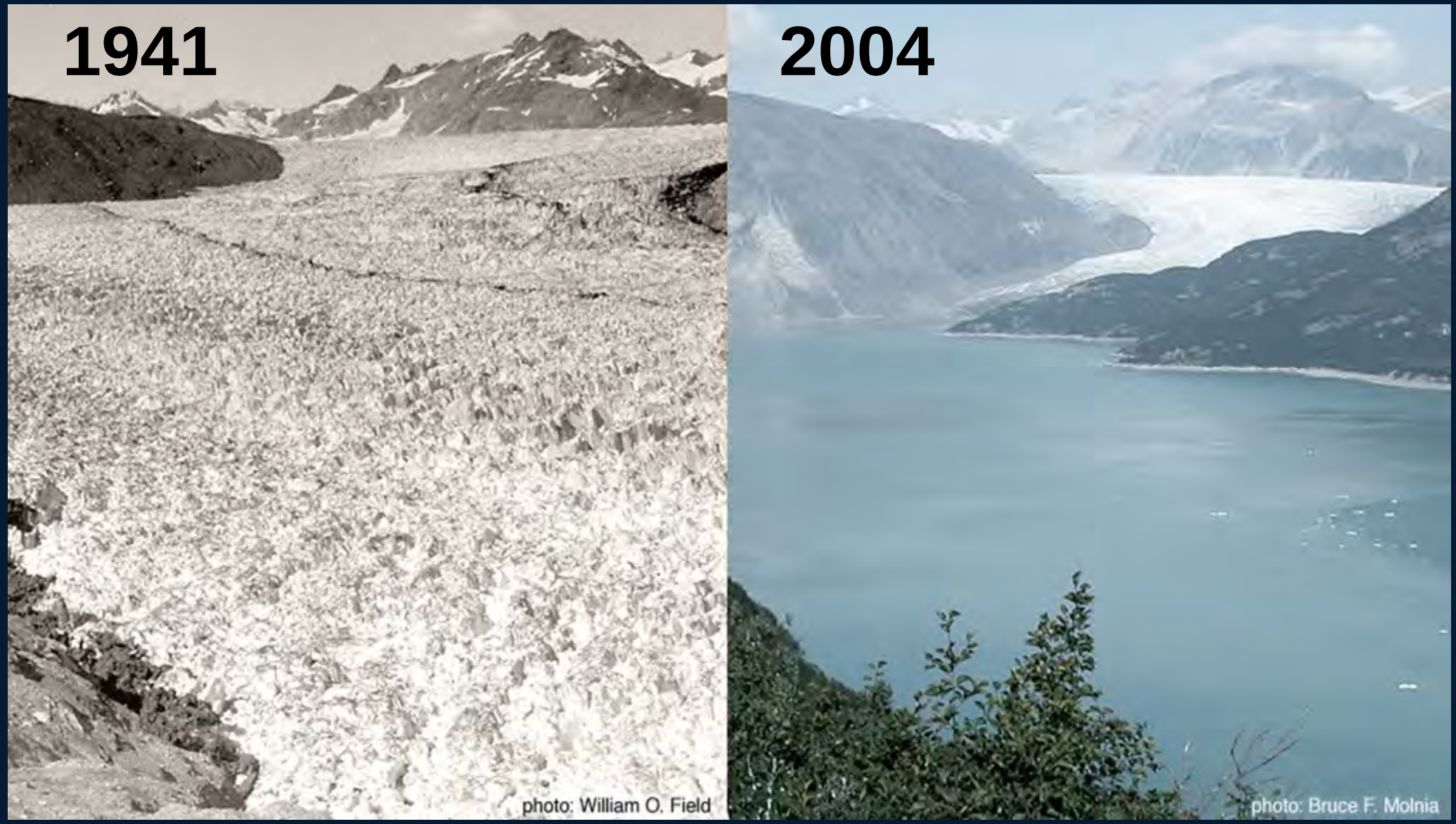


Health

- Worsening air quality
- More heat-related illnesses
- Longer, stronger allergy seasons
- Increasing risk of insect and food-borne diseases

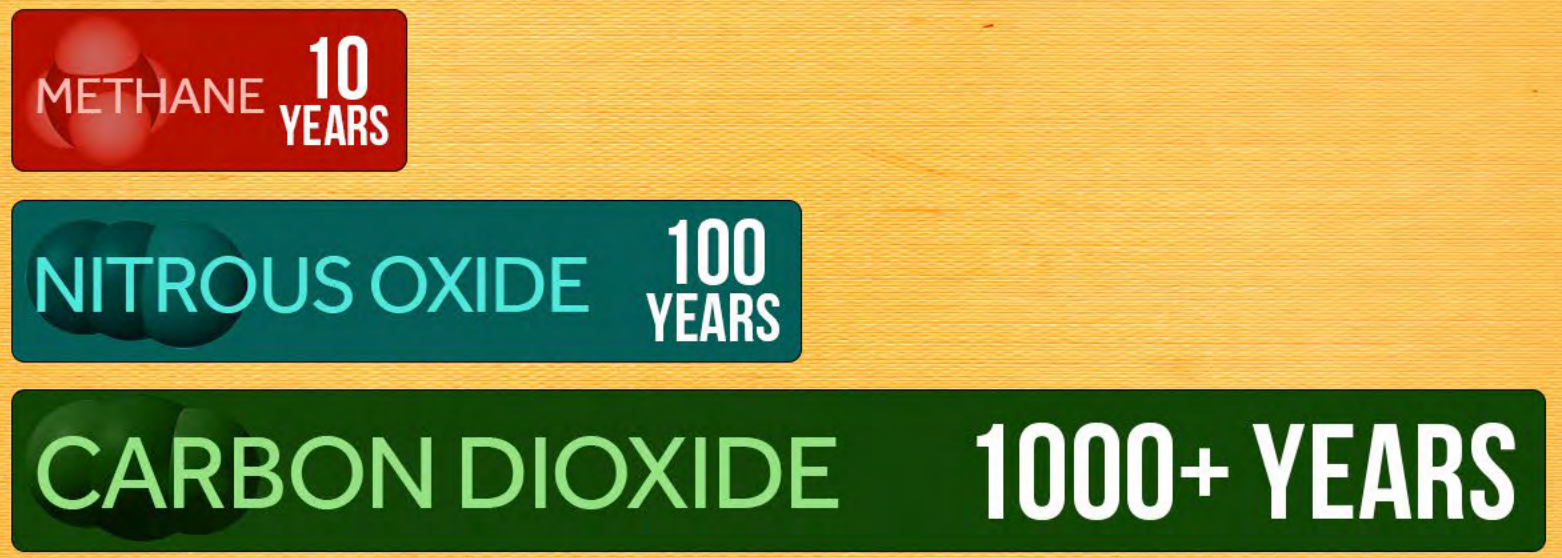
SERIOUS

SERIOUS



Alaska’s Muir Glacier

GREENHOUSE GASES LAST A LONG TIME



Numbers based on lifetime in atmosphere, not their warming potential

CLIMATE CENTRAL