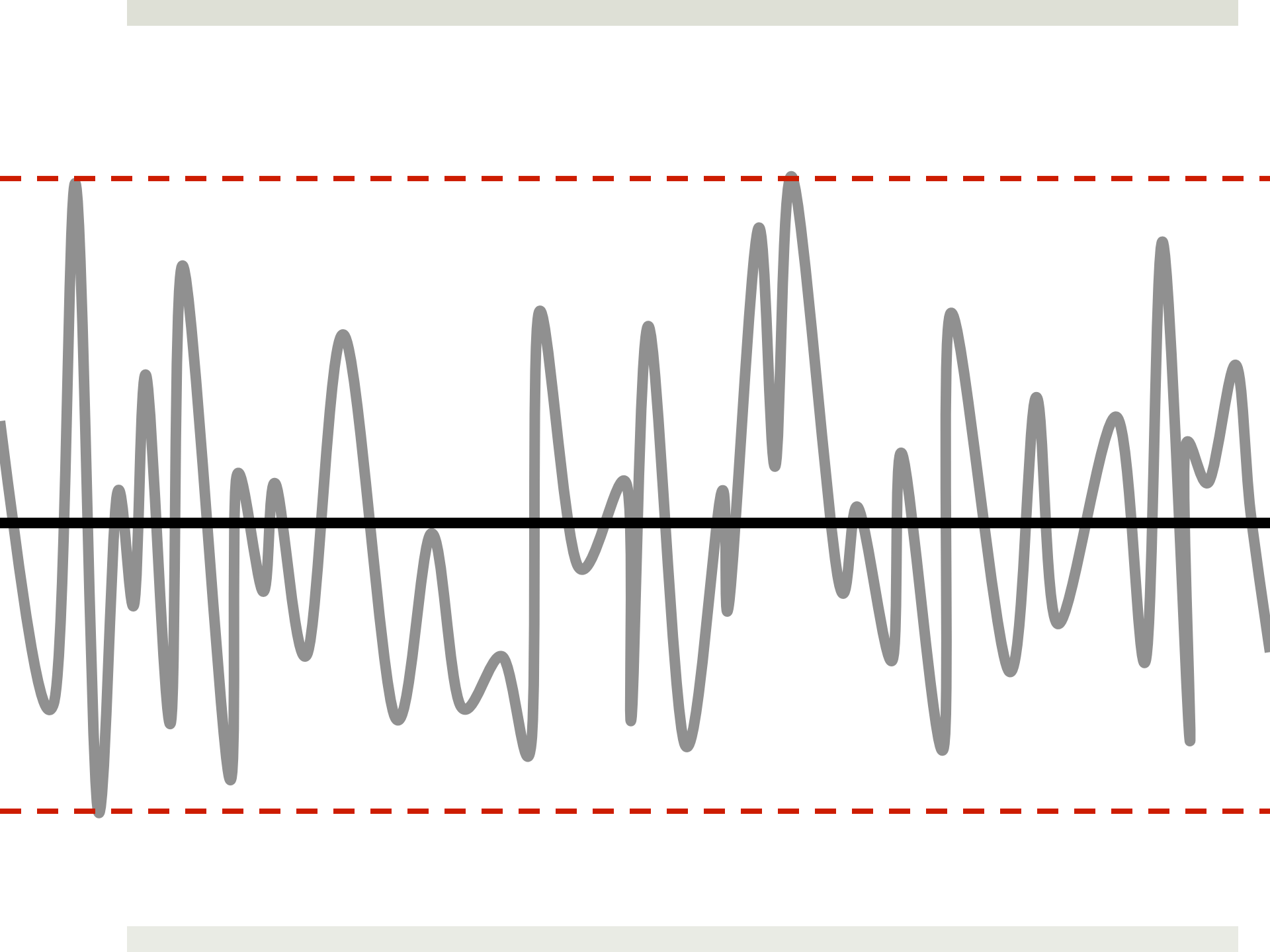


CLIMATE CHANGE

CONNECTING GLOBAL CHANGE TO LOCAL RESPONSE

KATHARINE HAYHOE

Climate Science Center, Texas Tech University

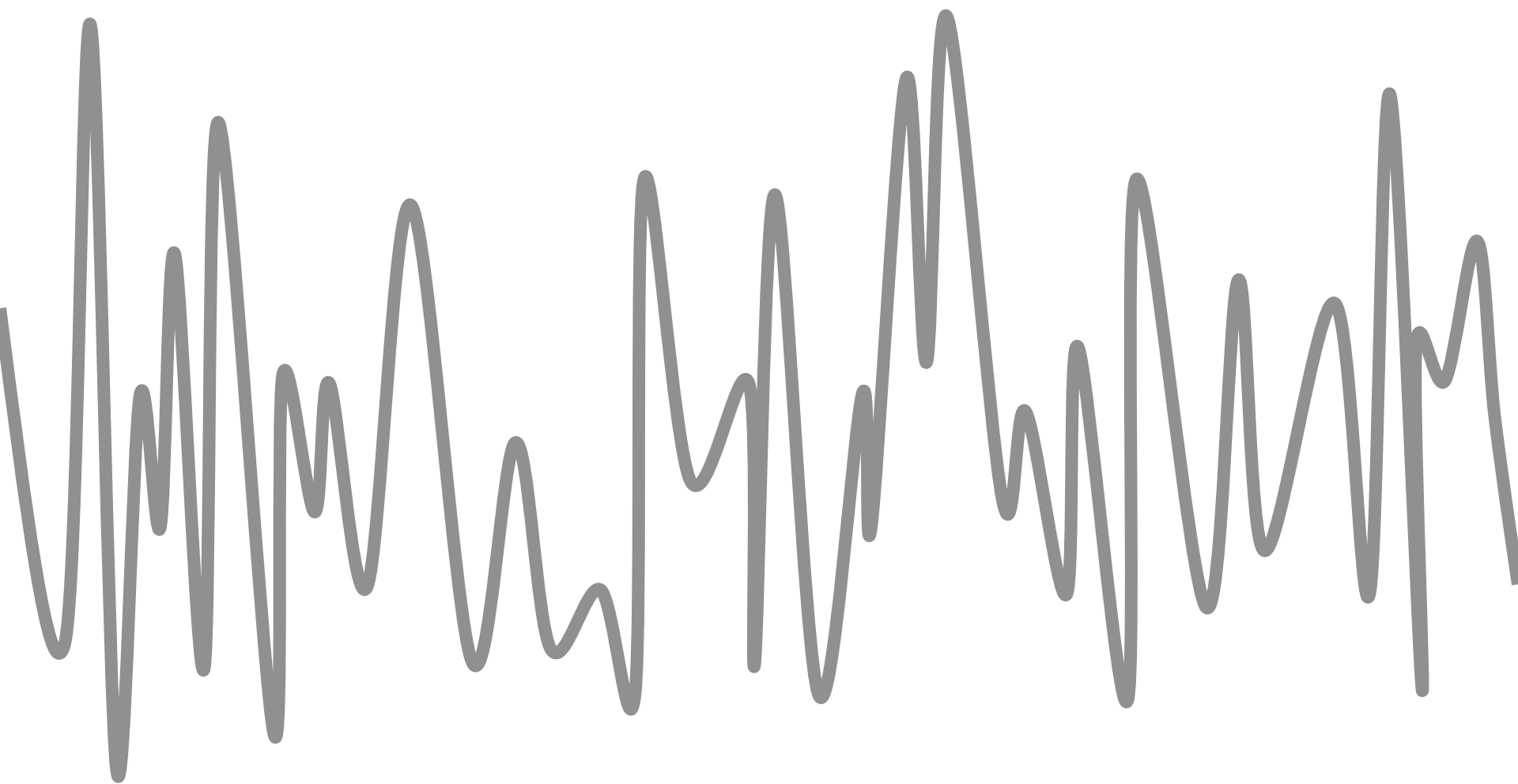


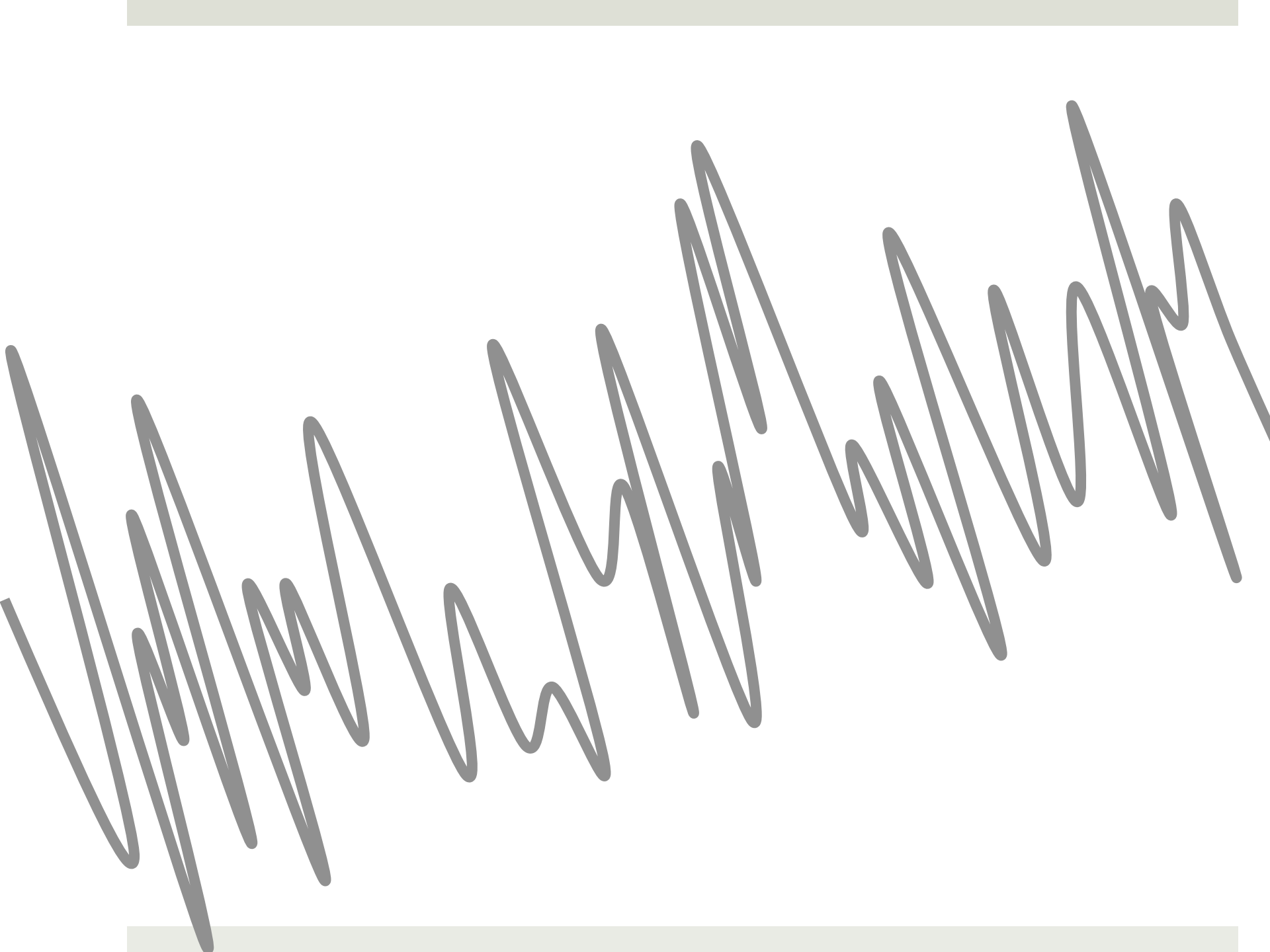
Building codes

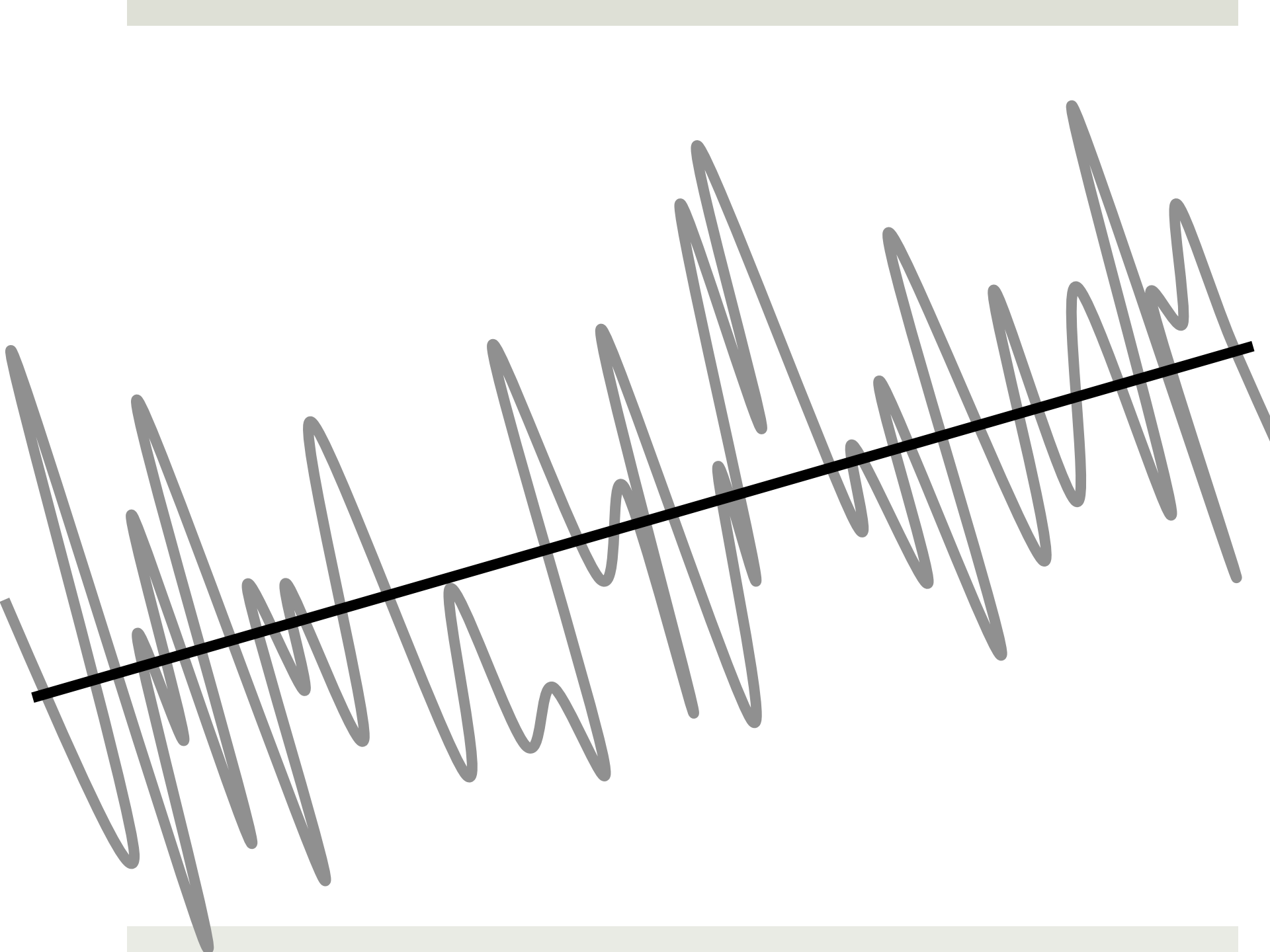
Water supply

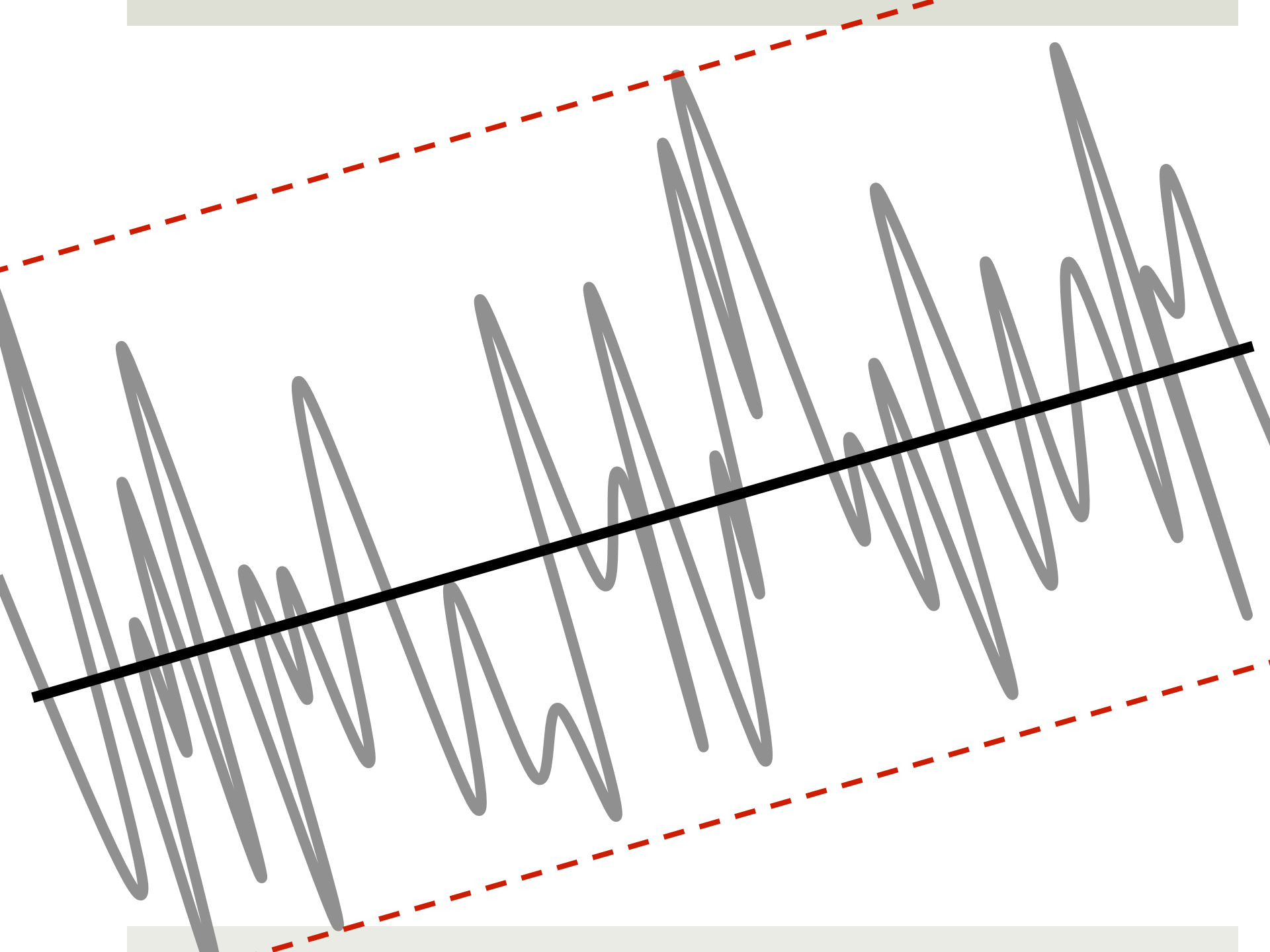
Crop yields

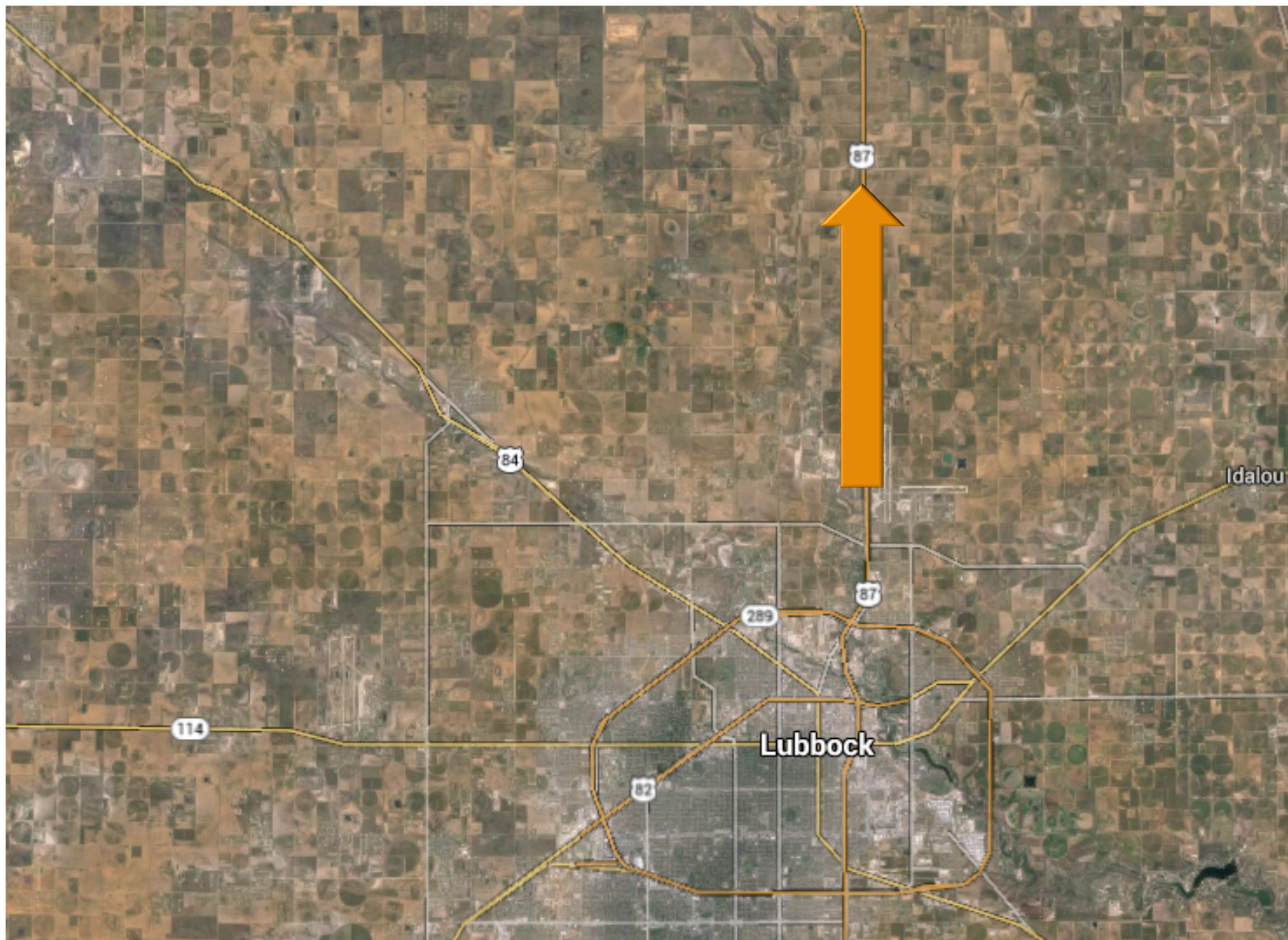
National security













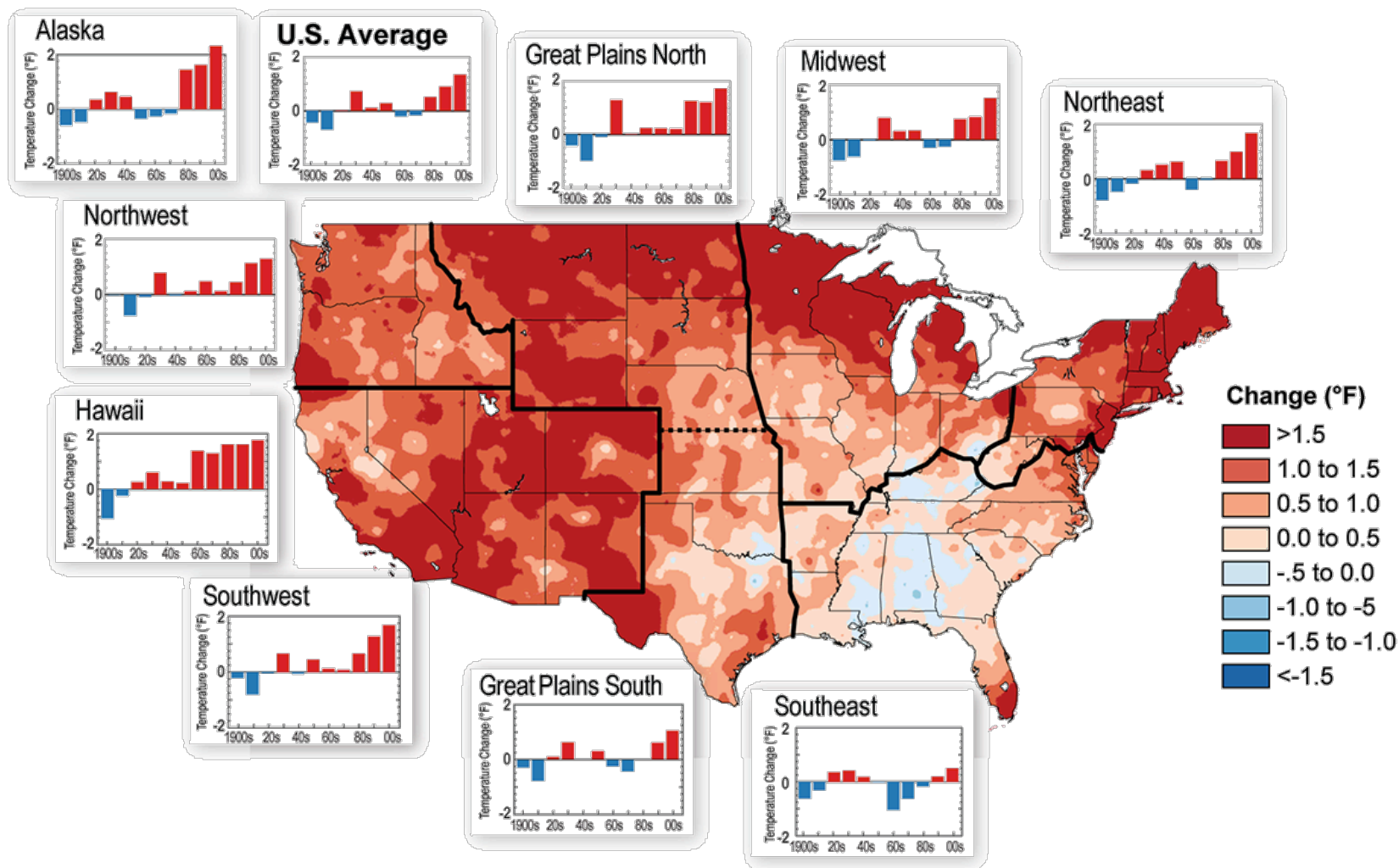
Planning for the future
based on the past
is like driving down the road
looking in the rear-view mirror.



Is there a curve in the road?

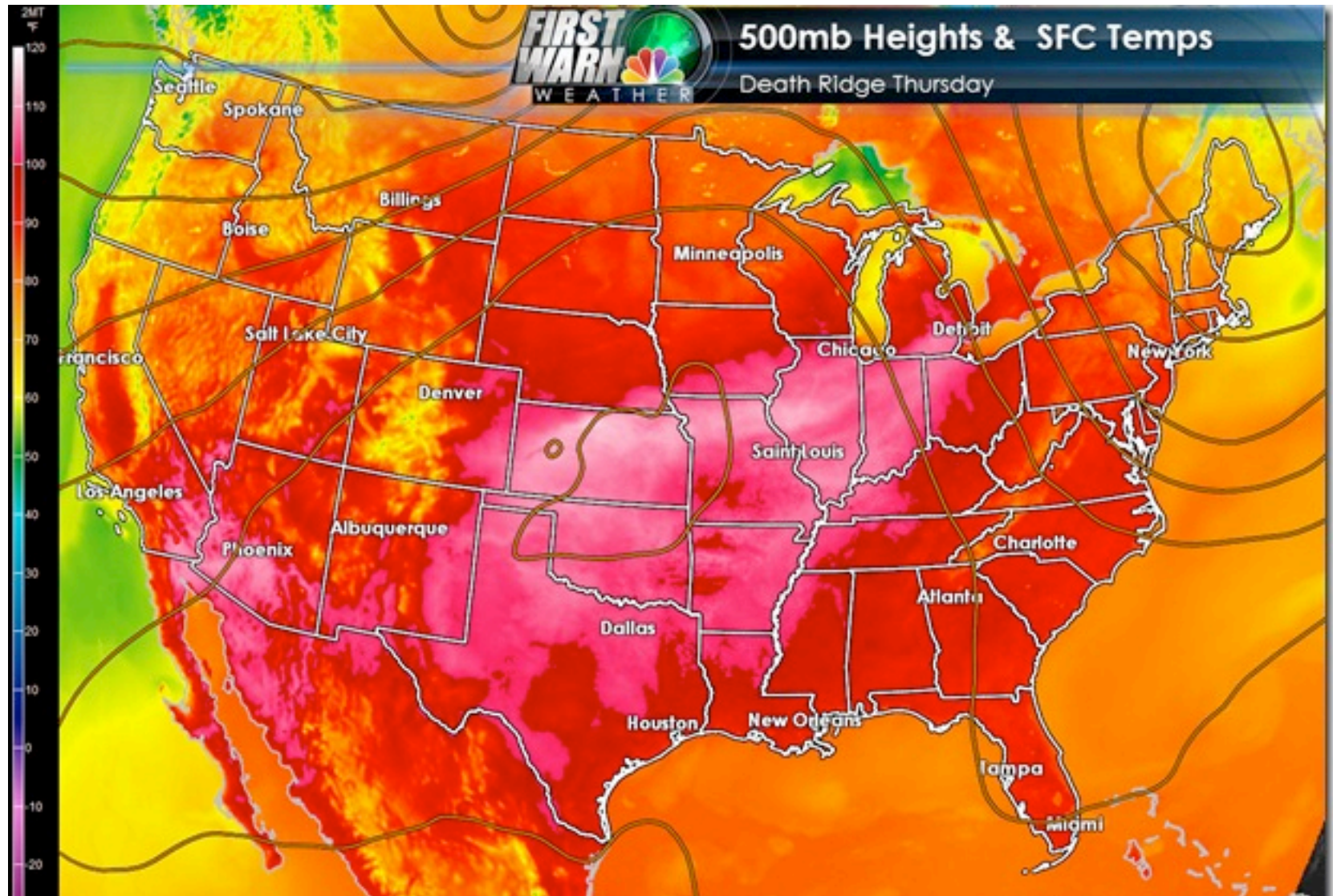
PART ONE

The U.S. is getting warmer

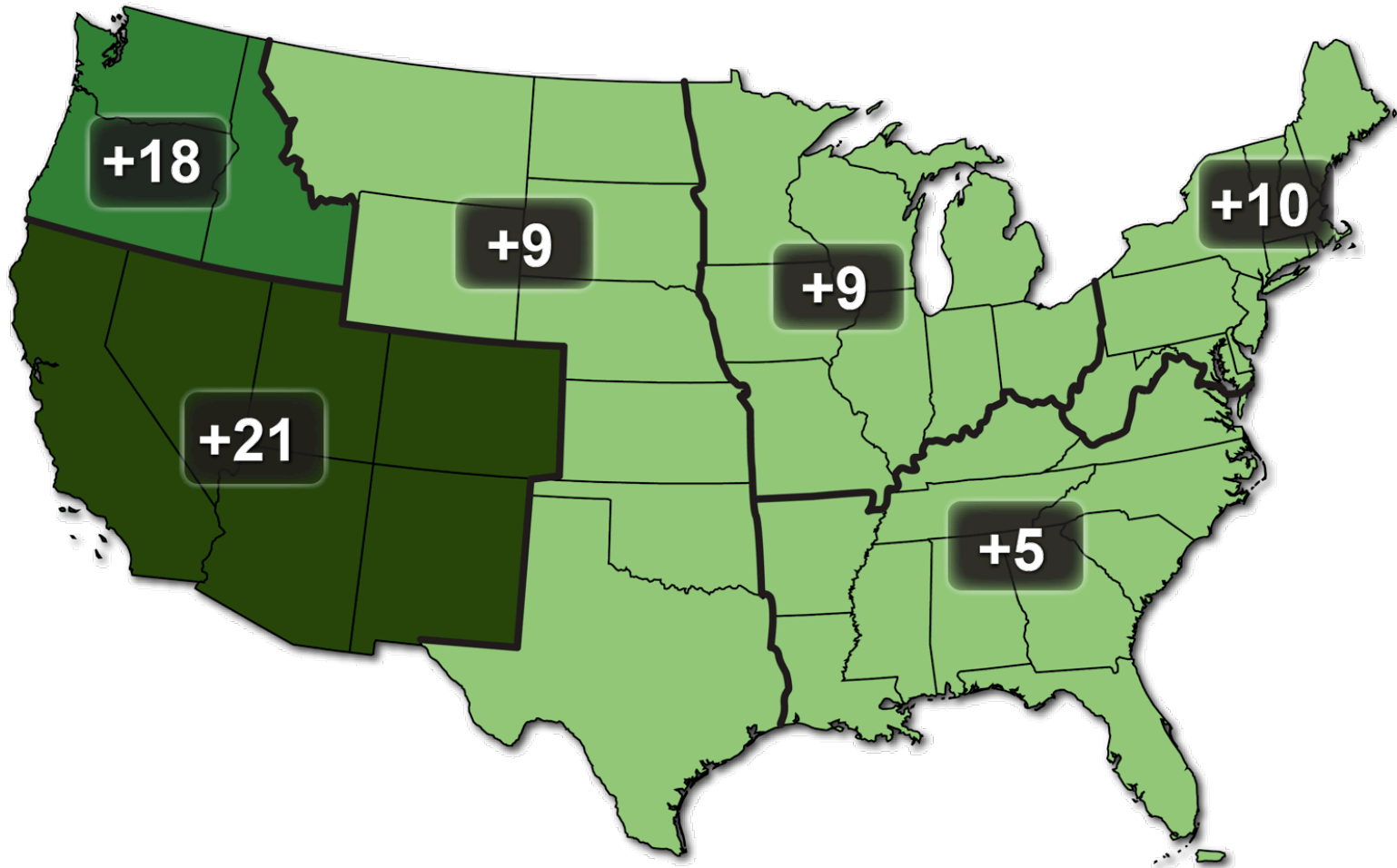


2014 U.S. National Climate Assessment

Heat waves are stronger and more frequent



Growing season has lengthened



Increases in Annual Number of Days



2014 U.S. National Climate Assessment

How climate change is killing the aspen forests of the American Southwest



Ryan Cooper



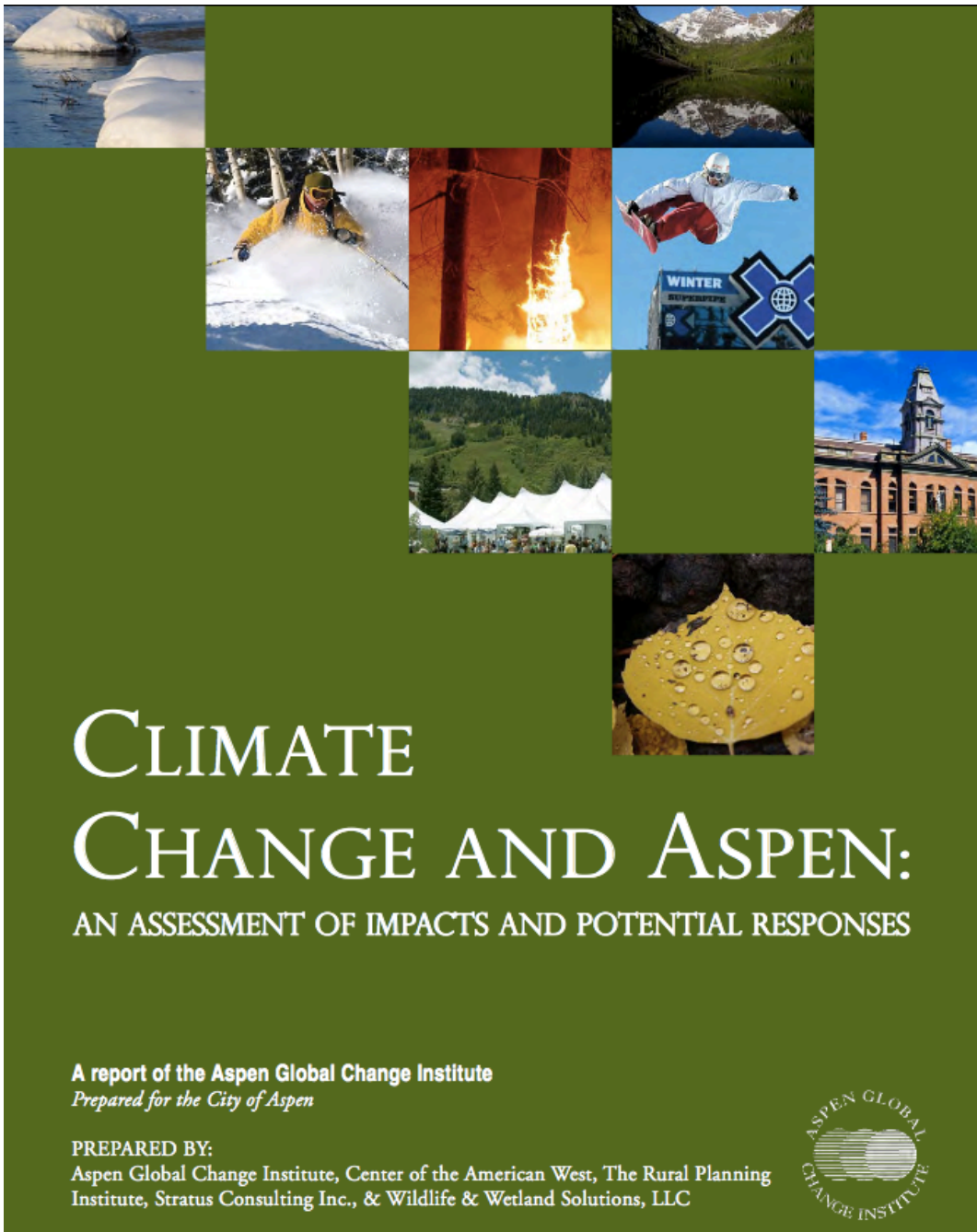


Will climate change ruin Aspen's economy?

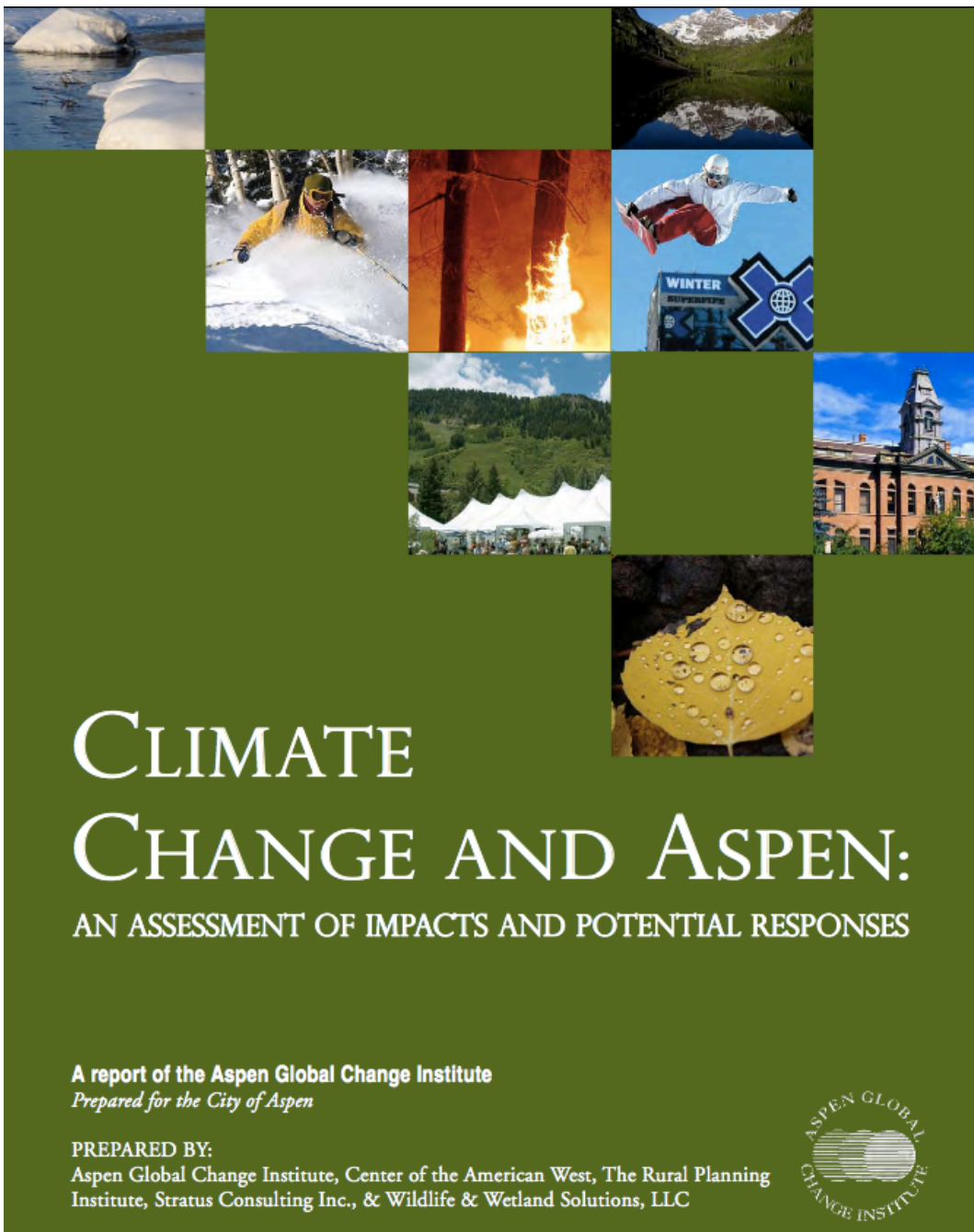
Readers React Ski towns like Aspen should do more than just adapt to climate change



Aspen, at nearly 8,000 feet elevation, now averages 23 fewer days below freezing each year than it did before 1980, making snowfall more unreliable. (John Moore / Getty Images)

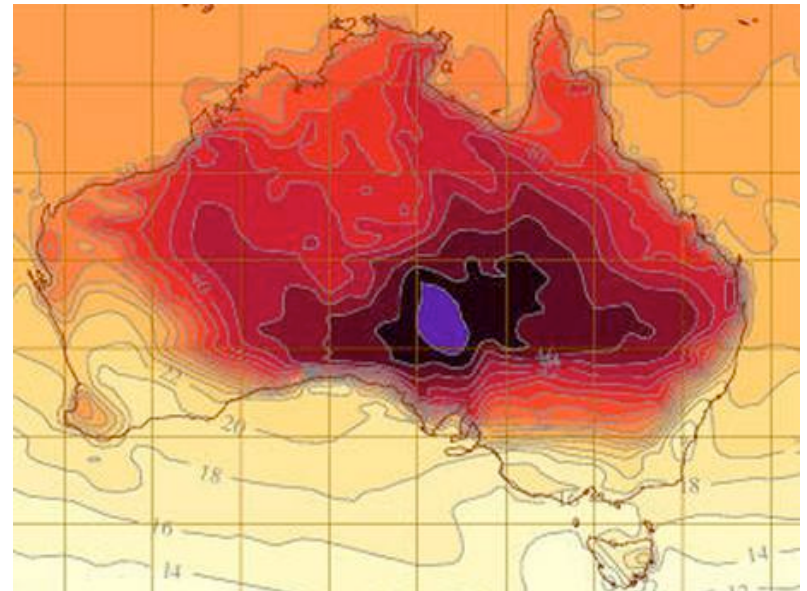
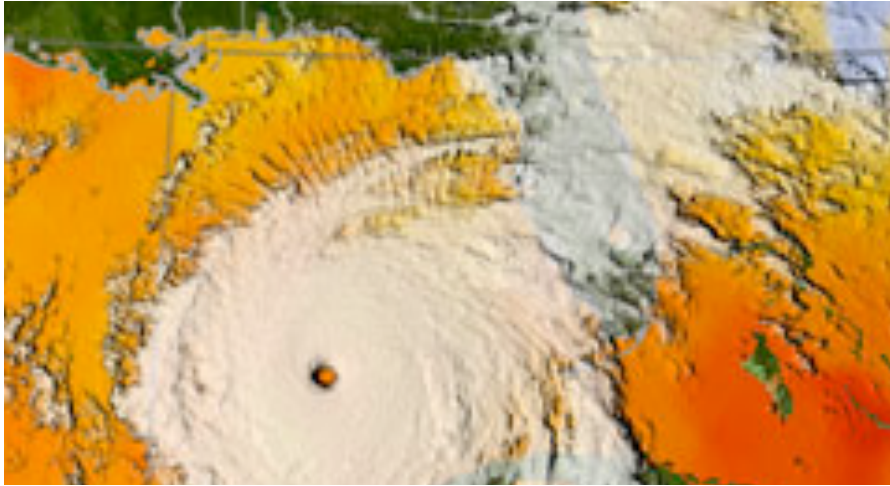


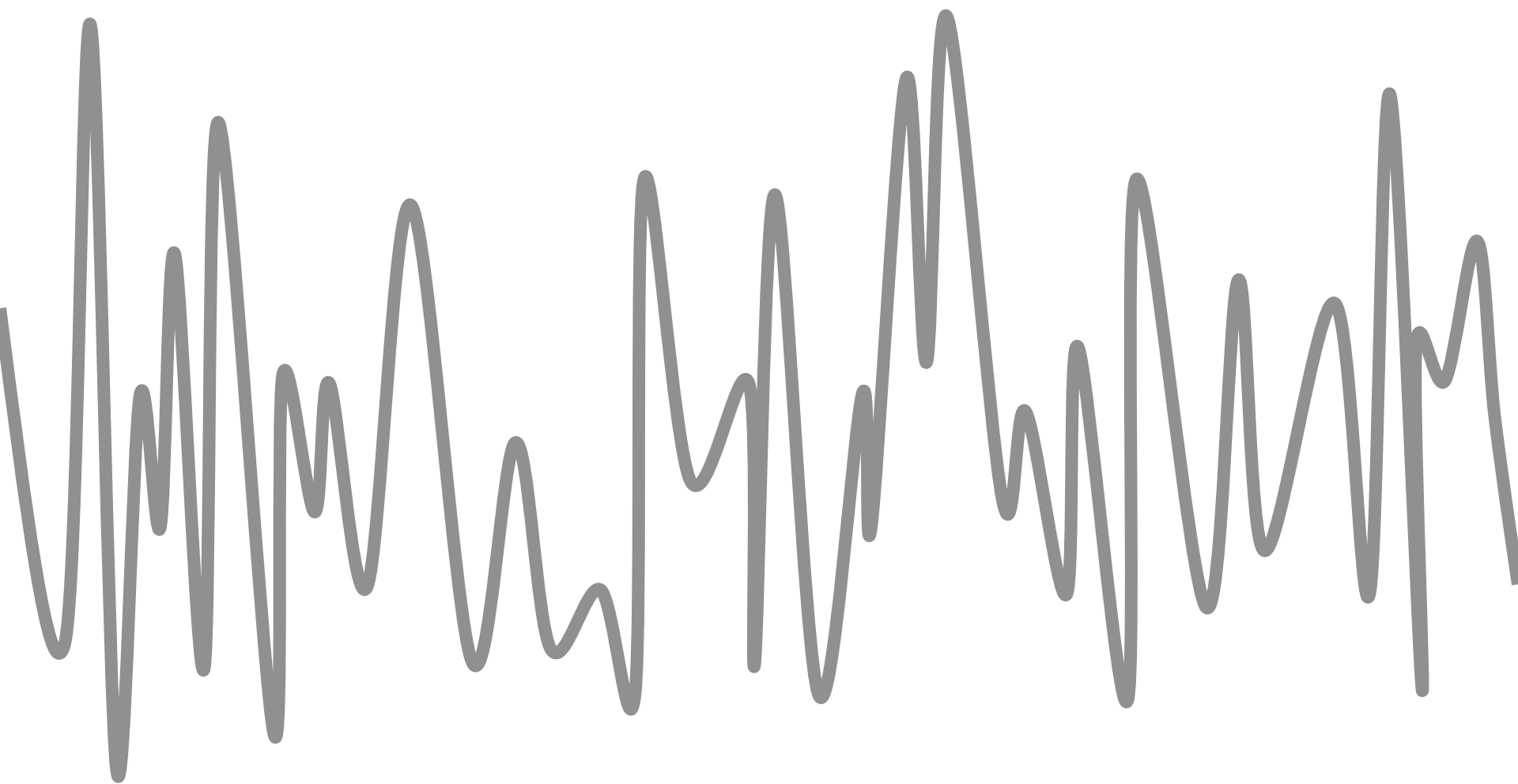
- Warmer temperatures and reduced snowfall
- Greater risk of water shortages
- Fire size and frequency will increase
- Aspen's environment will start looking more like the mid-Roaring Fork Valley

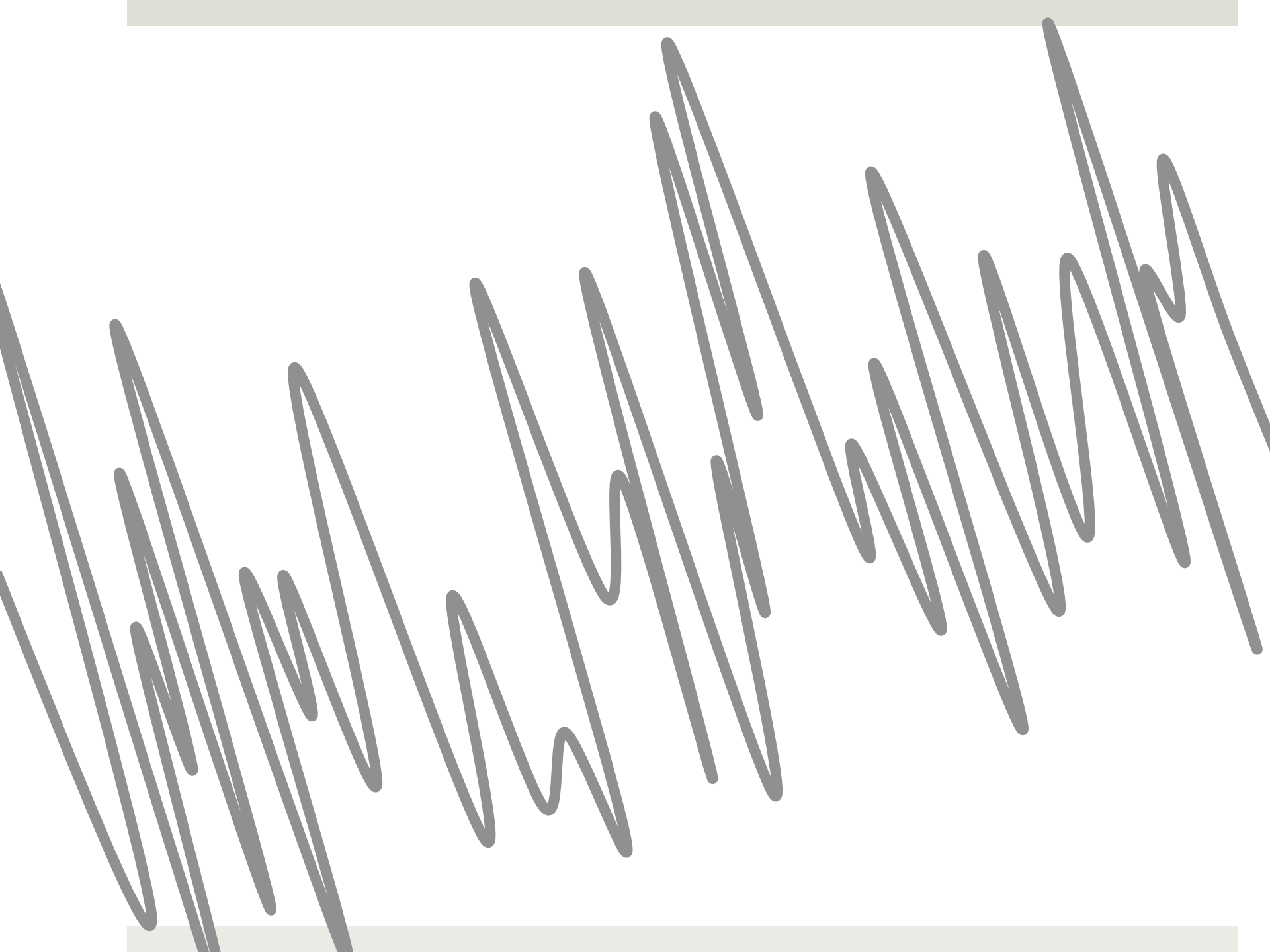


- Warmer temperatures and reduced snowfall
- Greater risk of water shortages
- Fire size and frequency will increase
- Aspen's environment will start looking more like the mid-Roaring Fork Valley
- **If the world follows a higher emissions pathway it will spell the end for skiing in Aspen**

Around the world, not just here





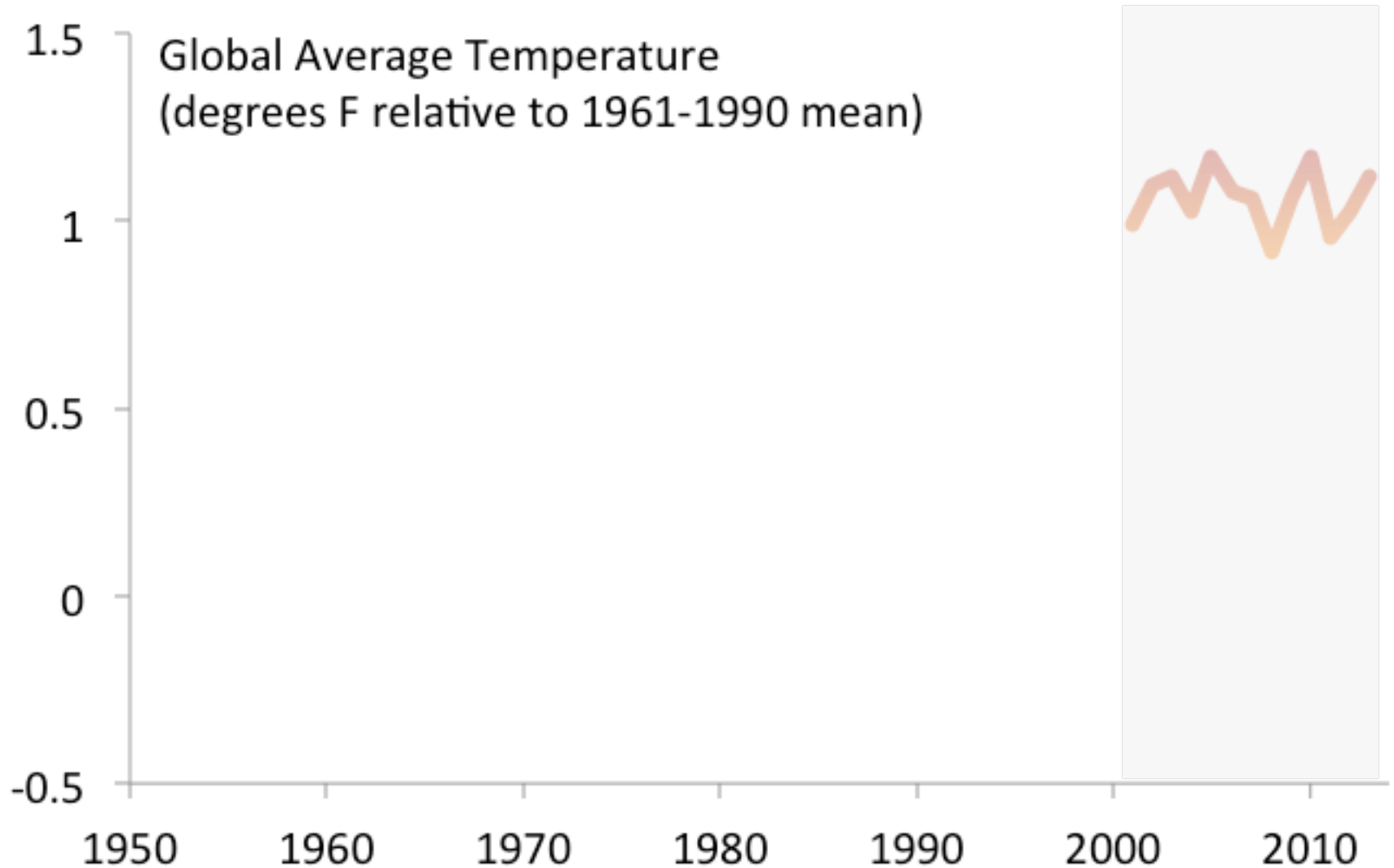




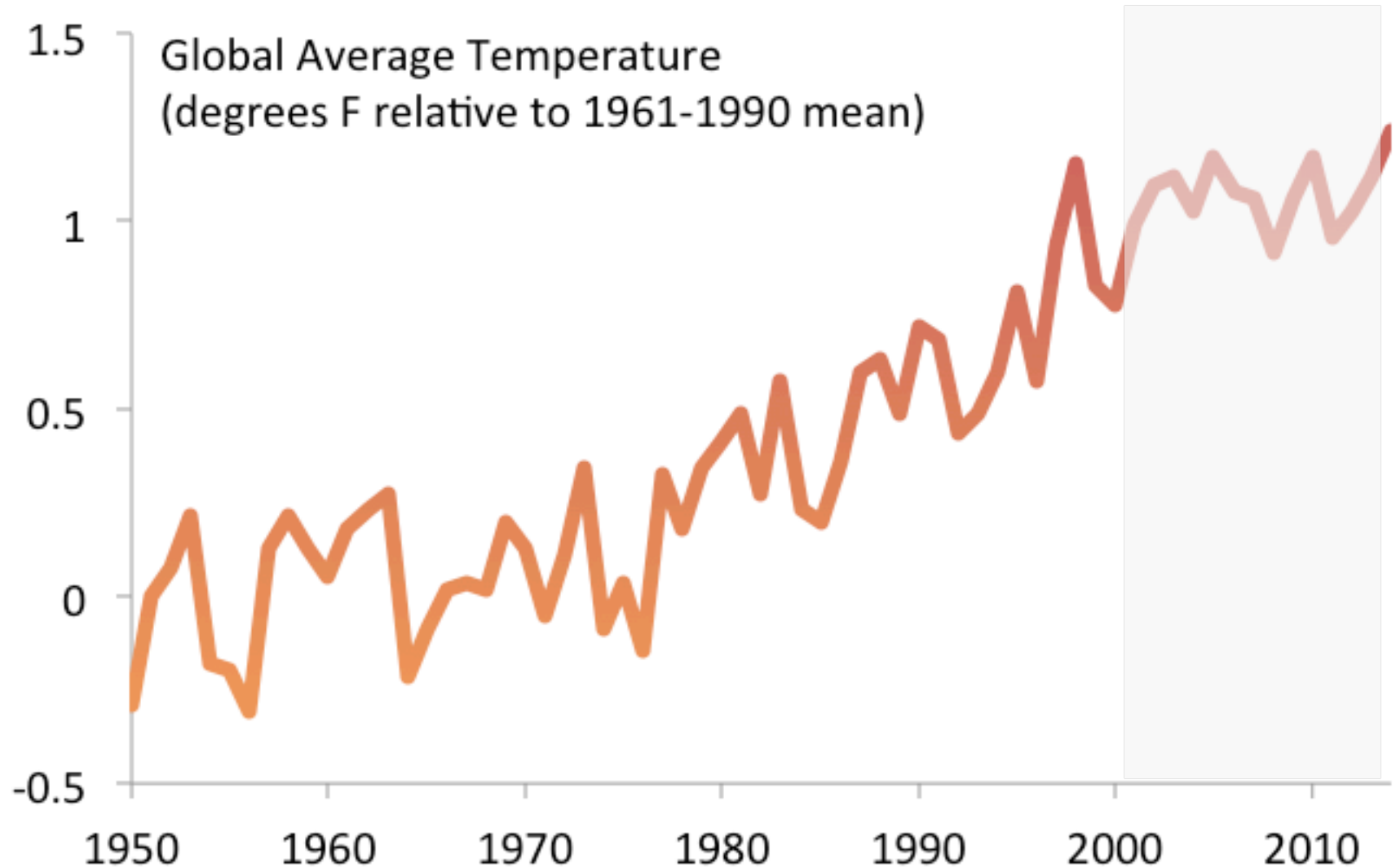
How can science help?

PART TWO

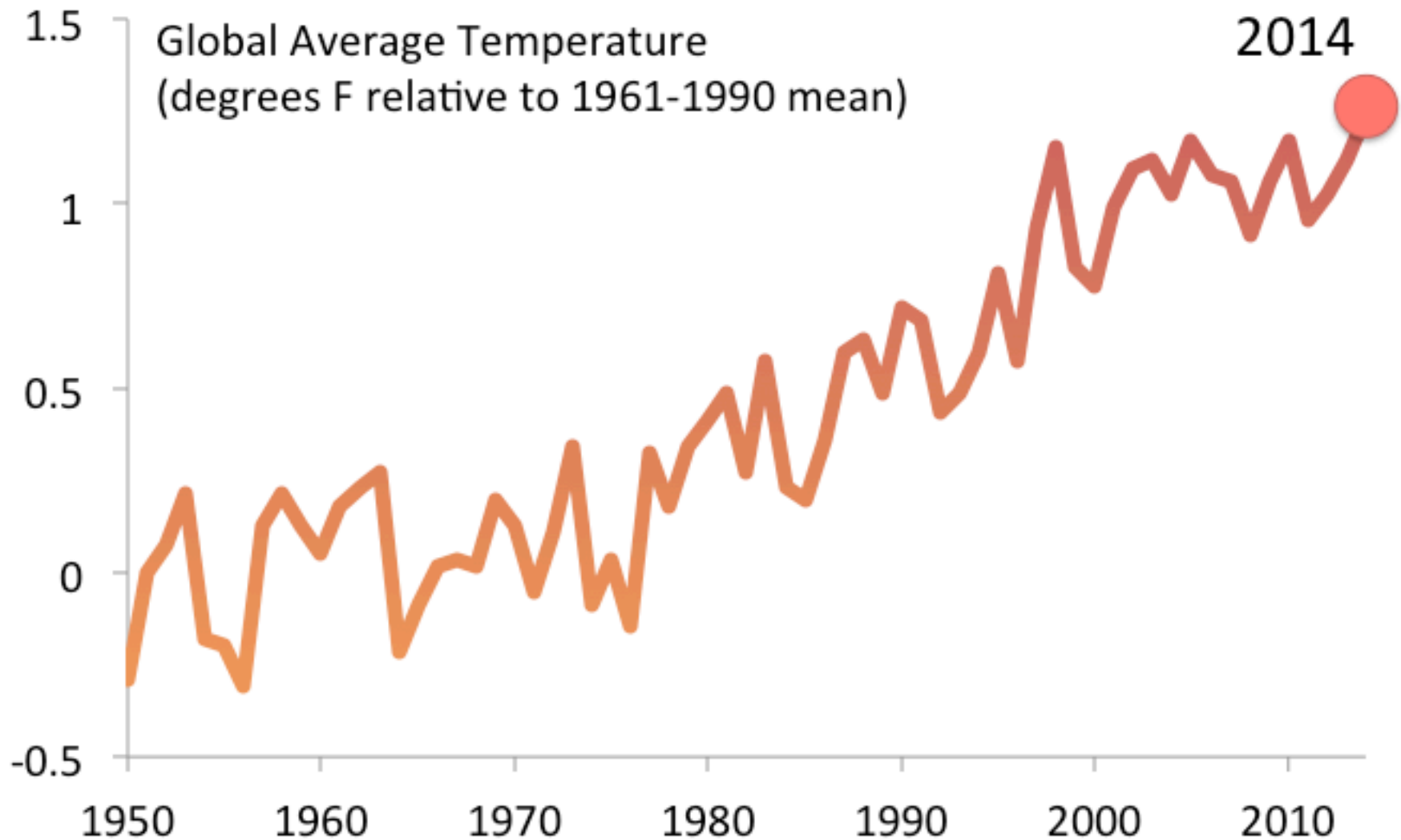
Is climate changing?



Yes, it really is

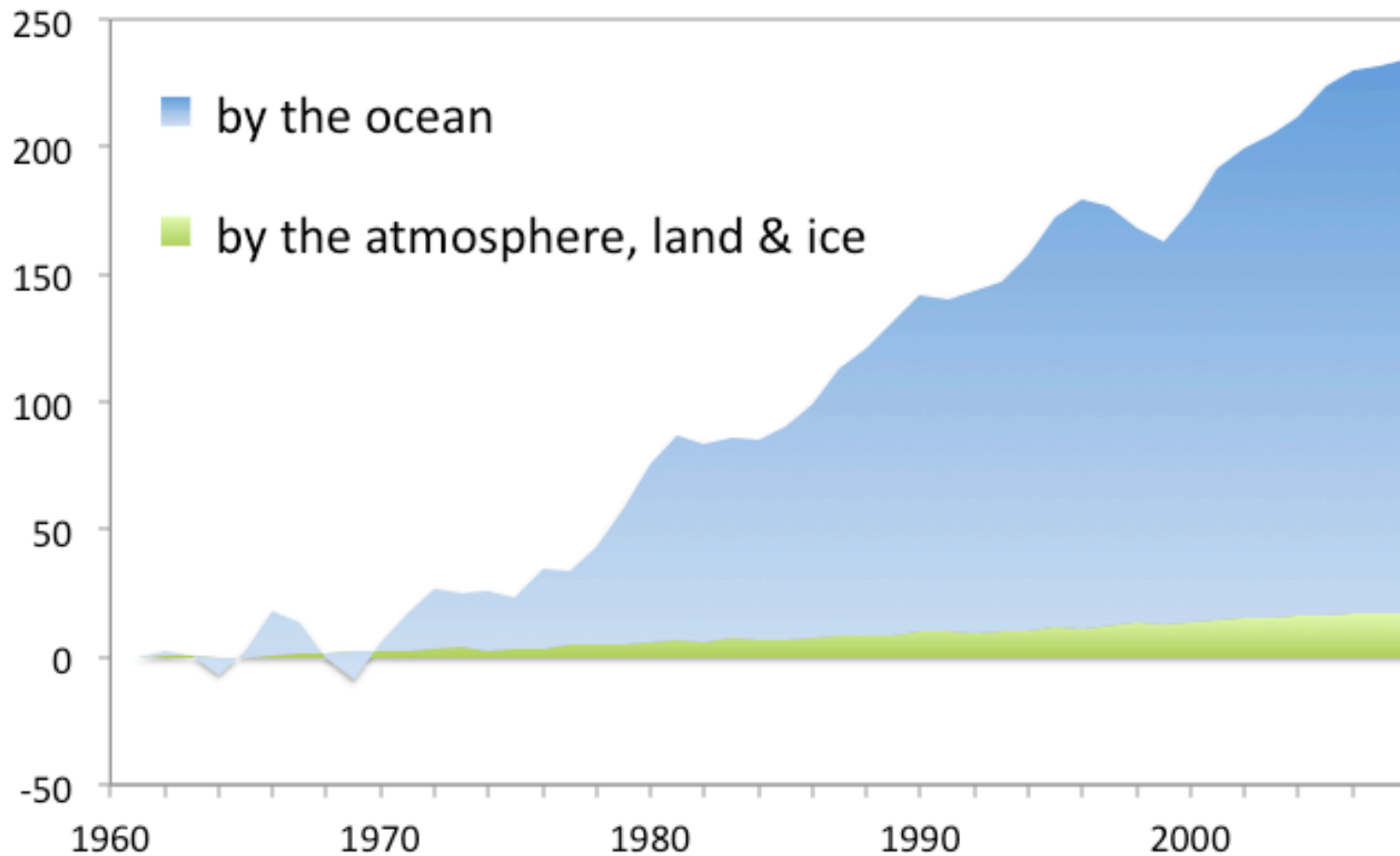


Science can tell us climate is changing



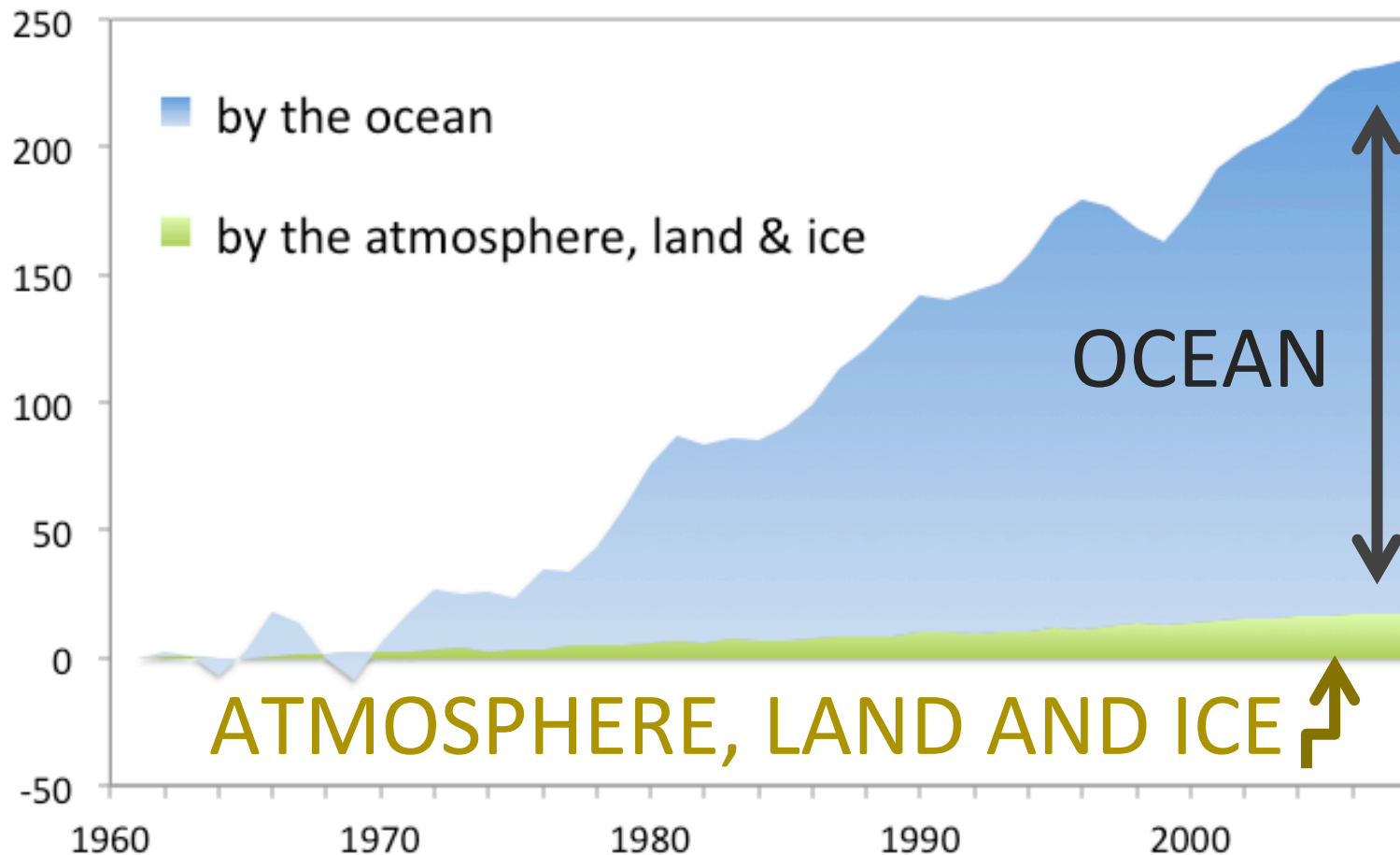
Air temperature is the tip of the iceberg of global warming

Increased Heat Absorbed by the Earth (10^{21}J)



Air temperature is the tip of the iceberg of global warming

Increased Heat Absorbed by the Earth (10^{21}J)



Science can explain WHY it's changing

Can't be the sun

we'd be getting cooler

Can't be natural cycles

the entire planet is warming

Can't be the earth's orbit

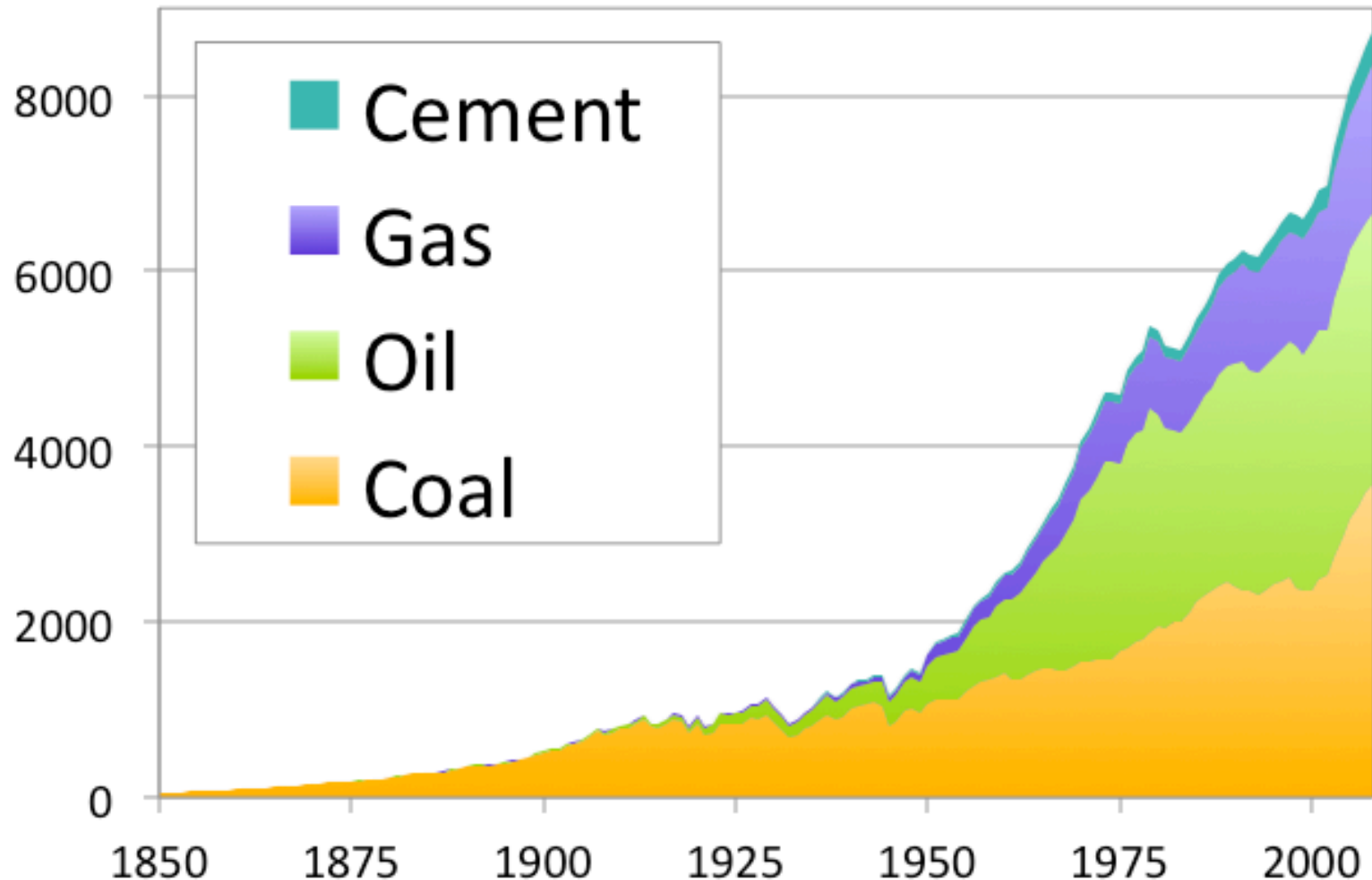
next thing coming is an ice age!

The Industrial Revolution



We've been producing a lot of this!

Carbon Emissions (million metric tons)



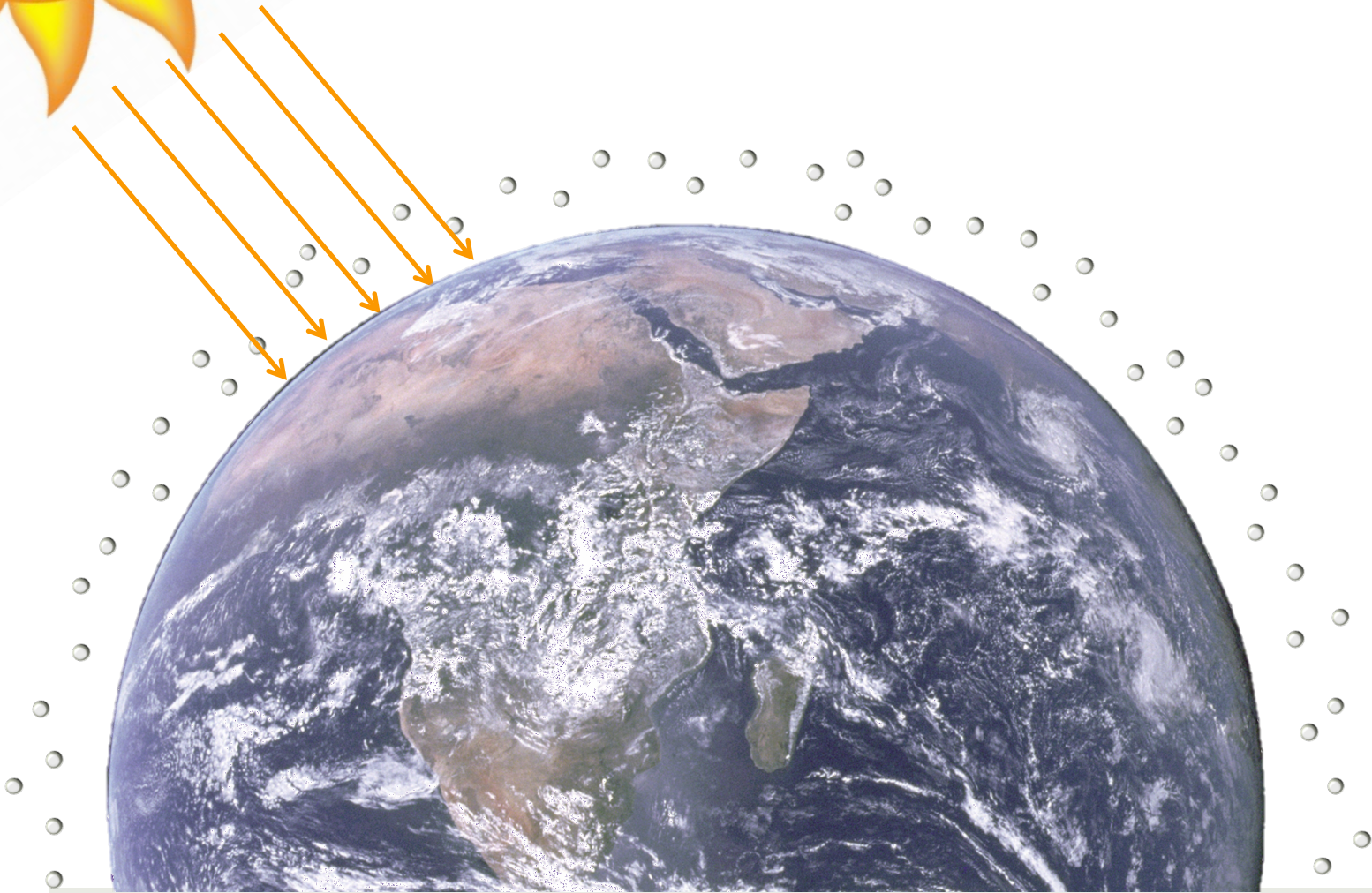
Burning coal, gas and oil
produces carbon dioxide



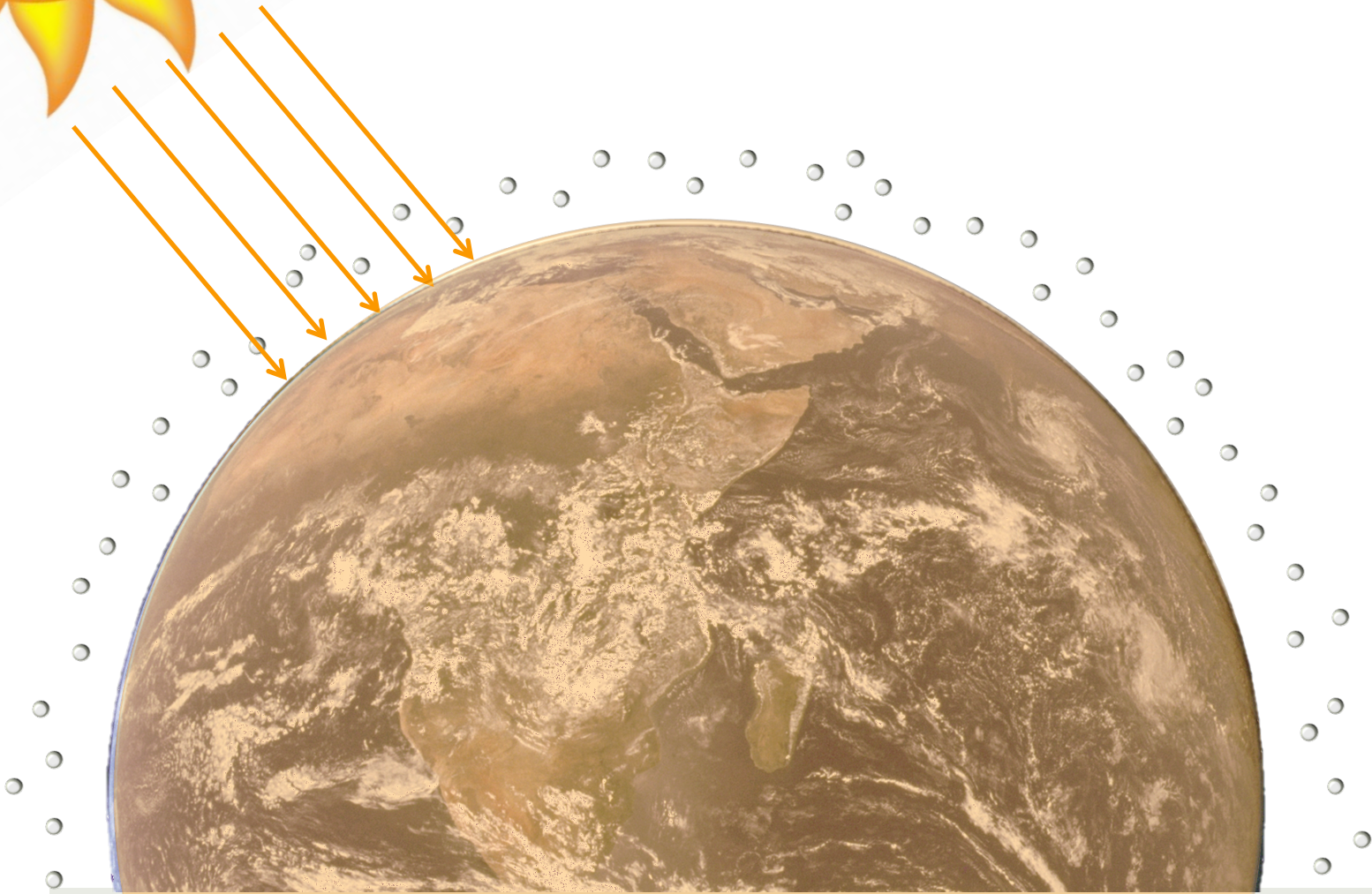
The NATURAL greenhouse effect



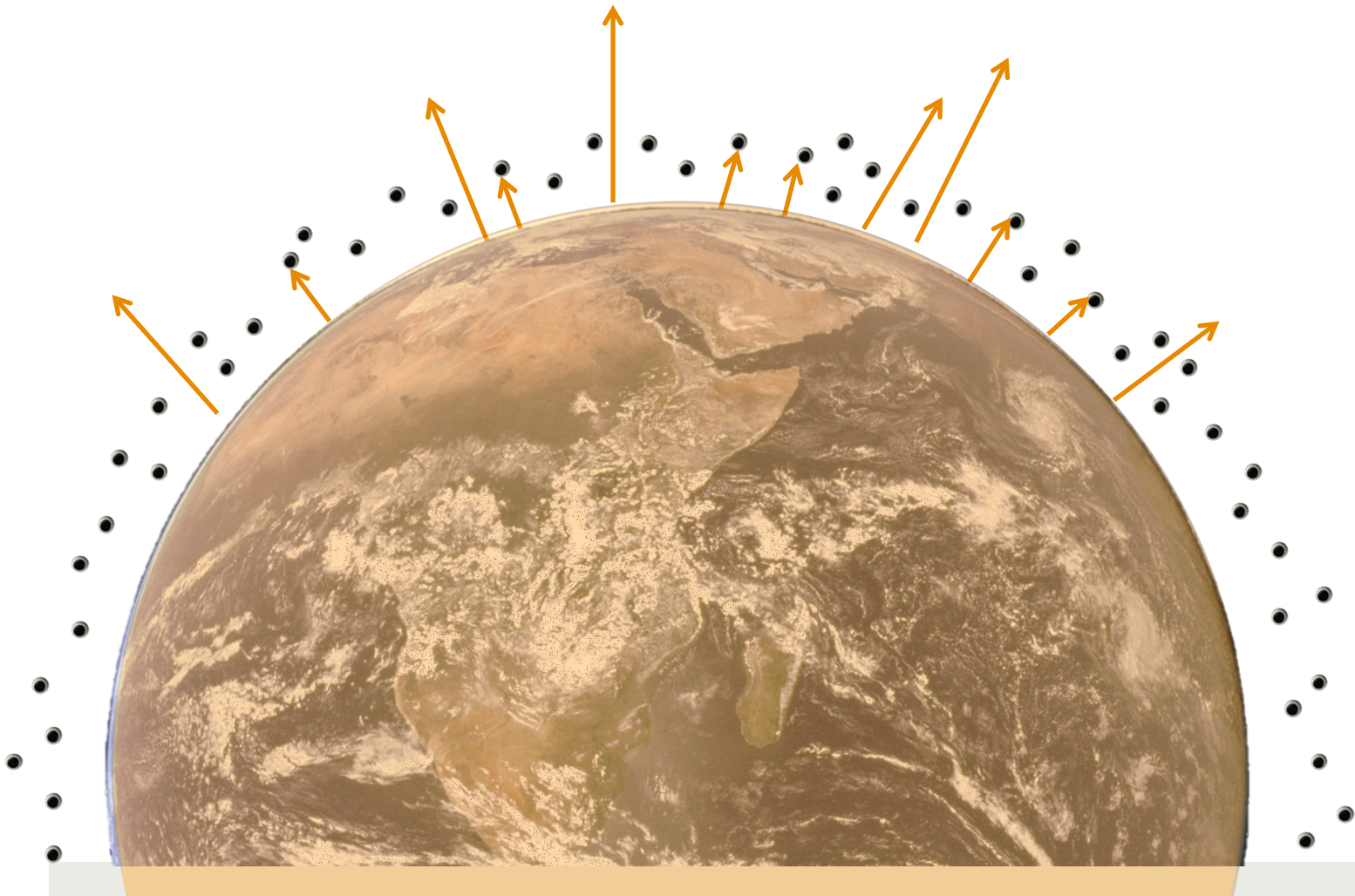
The NATURAL greenhouse effect



The NATURAL greenhouse effect

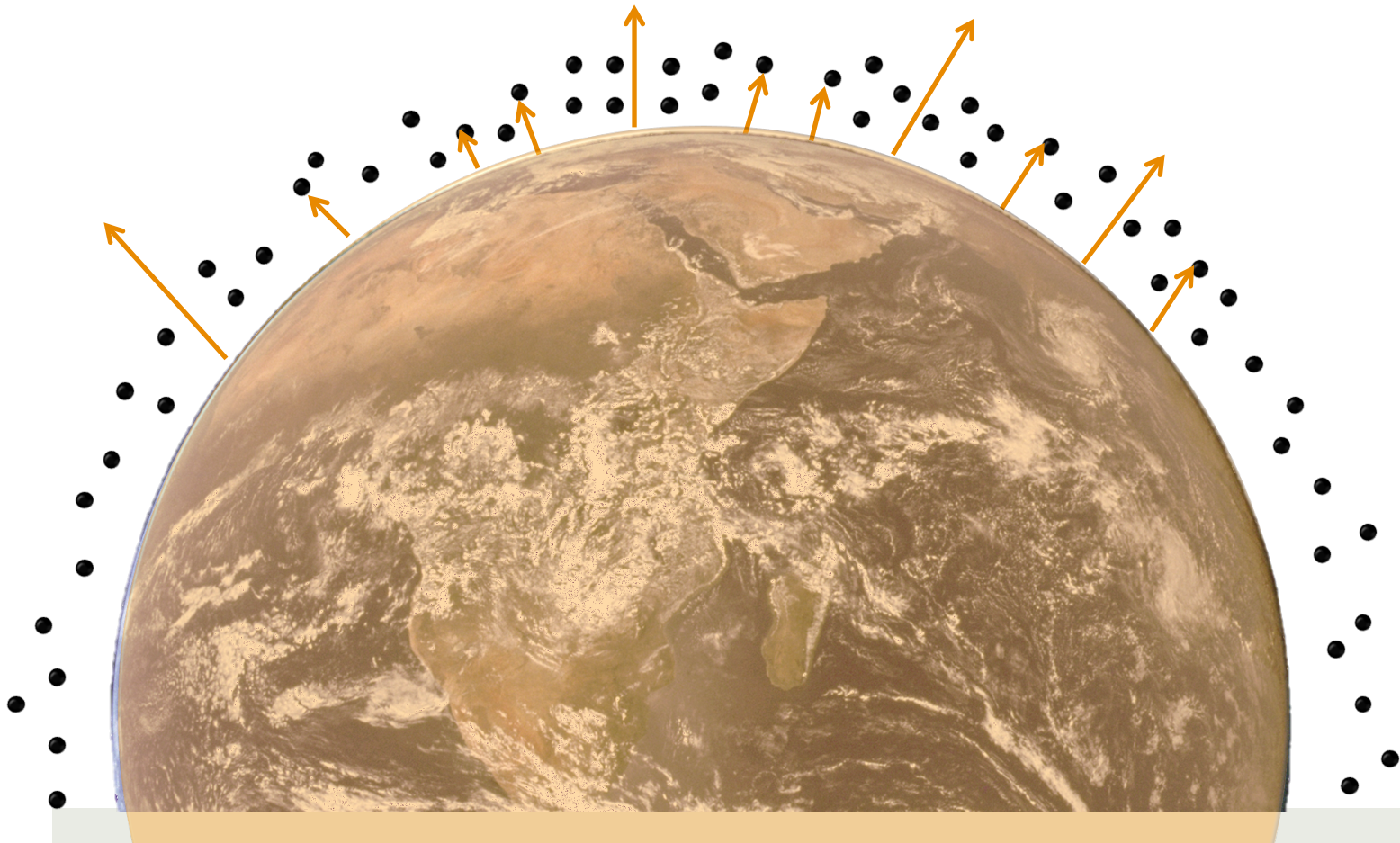


The NATURAL greenhouse effect



The ARTIFICIAL greenhouse effect

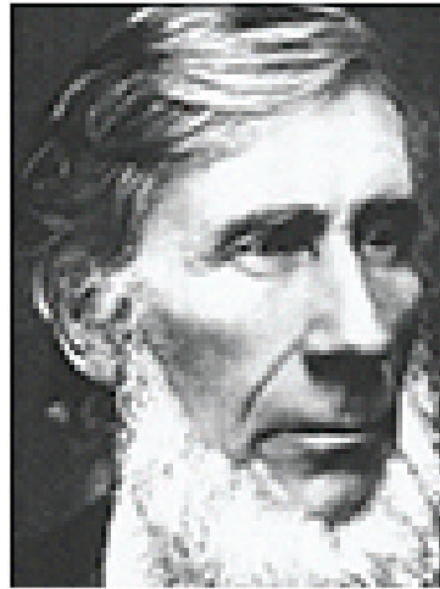
+43% more ●



(we've known this for a really long time)



Joseph Fourier
(French, 1768-1830)

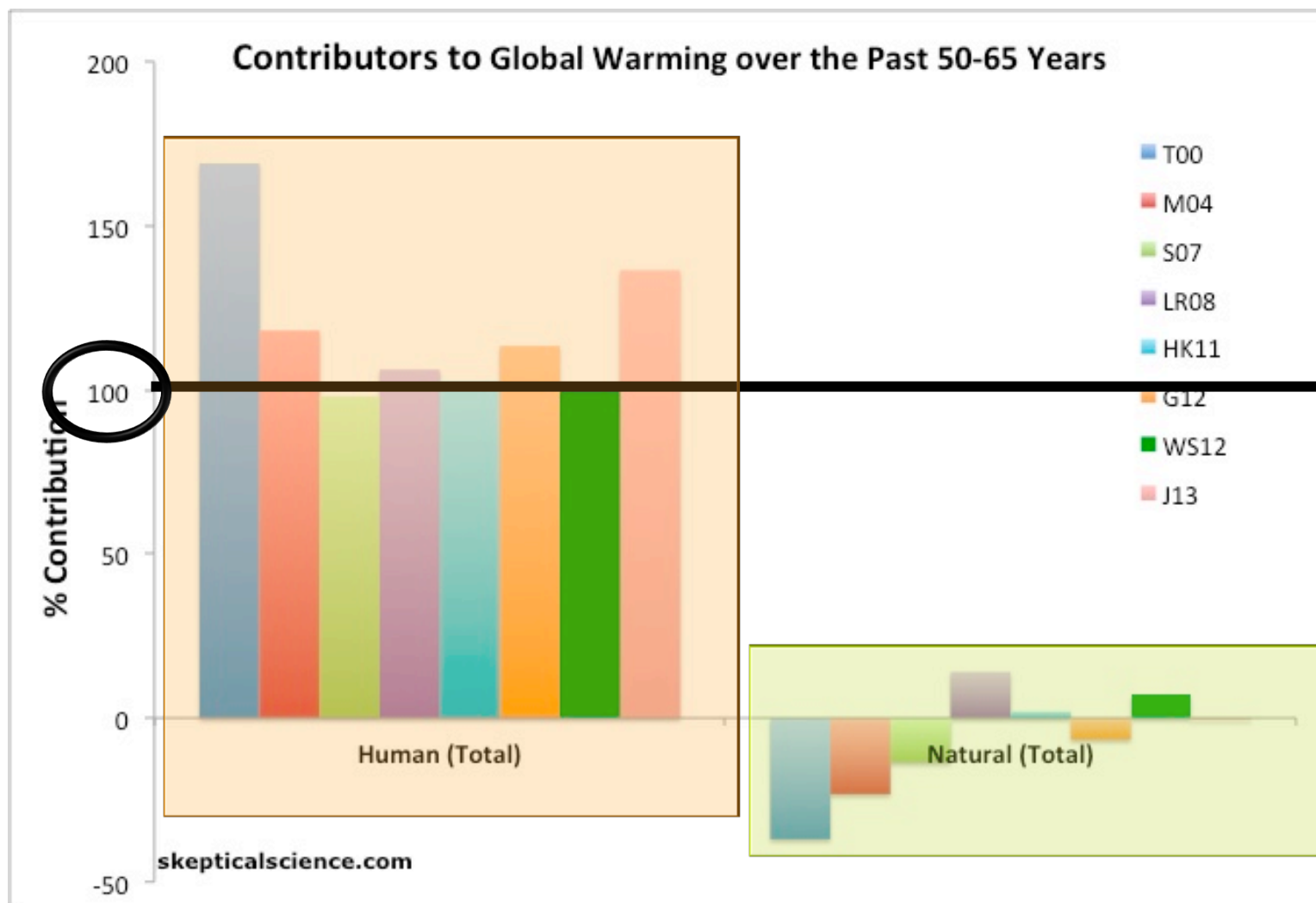


John Tyndall
(English, 1820-1893)

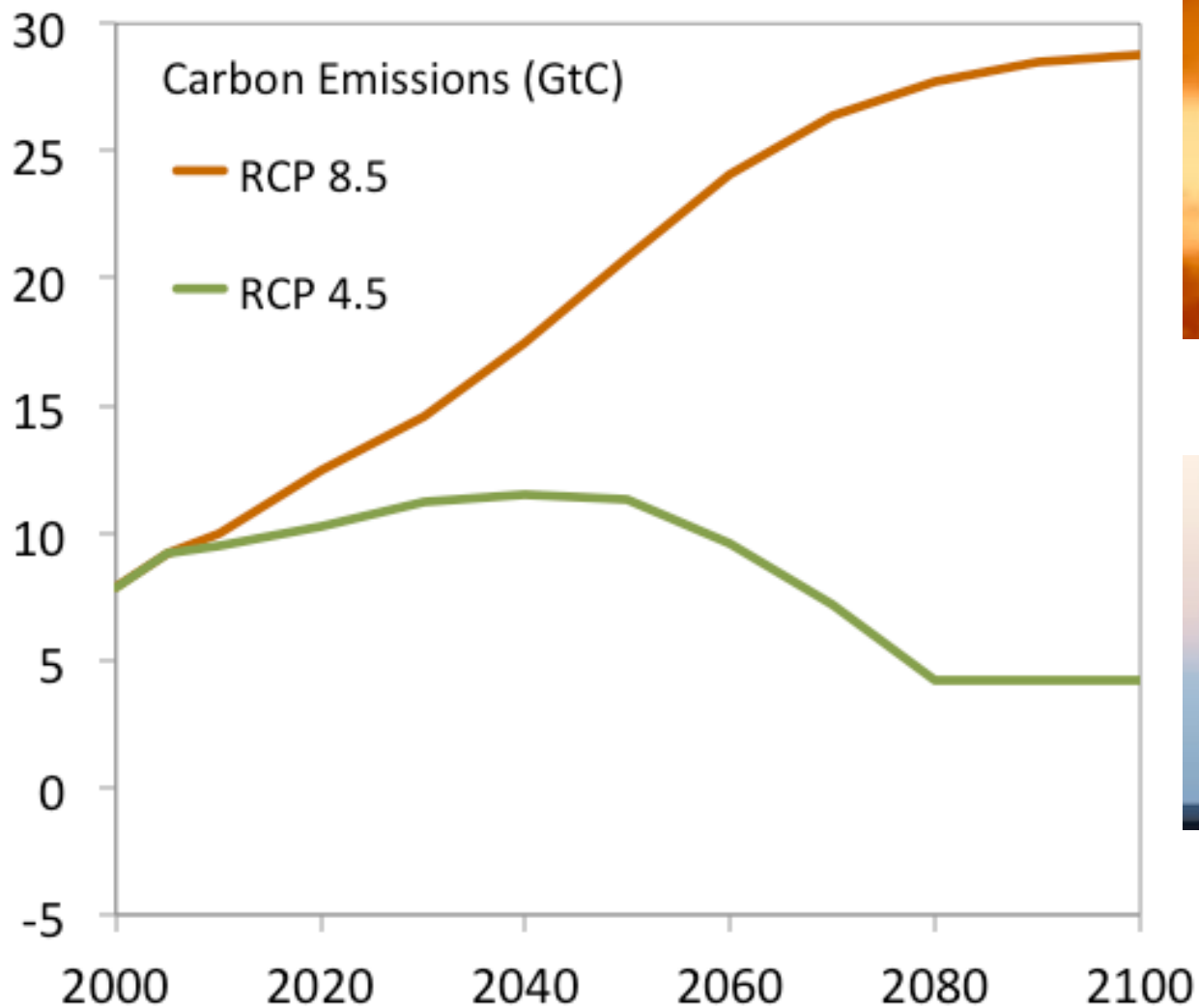


Svante Arrhenius
(Swedish, 1859-1927)

Science can tell us HOW MUCH of present-day warming is due to us

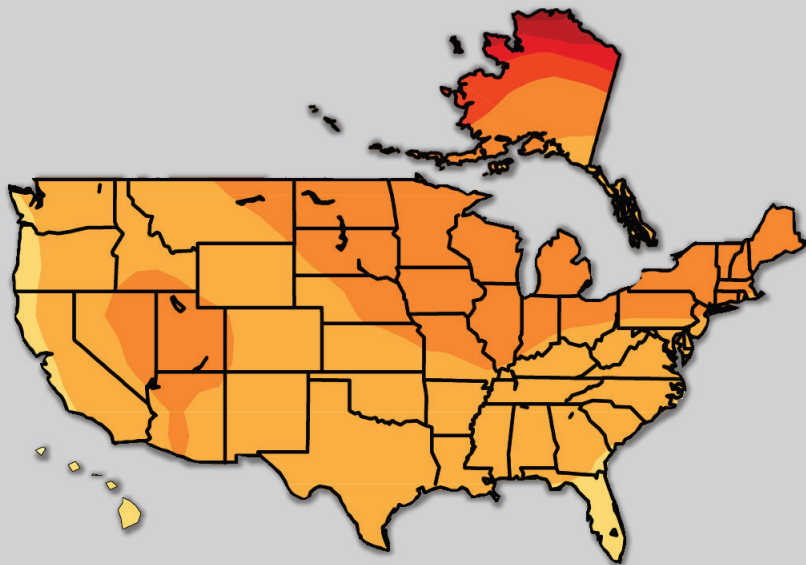


Science can quantify the impact of our choices today

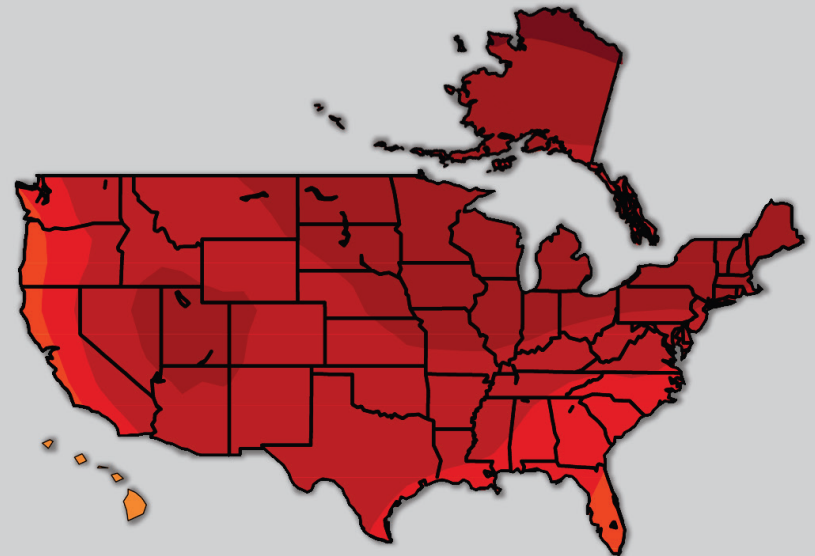


Science can show us what will happen depending on the choices we make

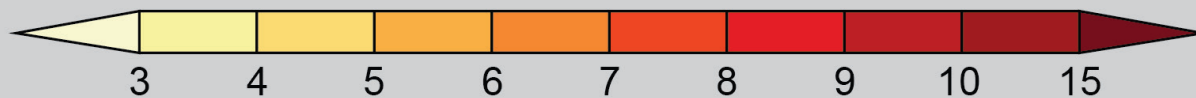
Lower Scenario



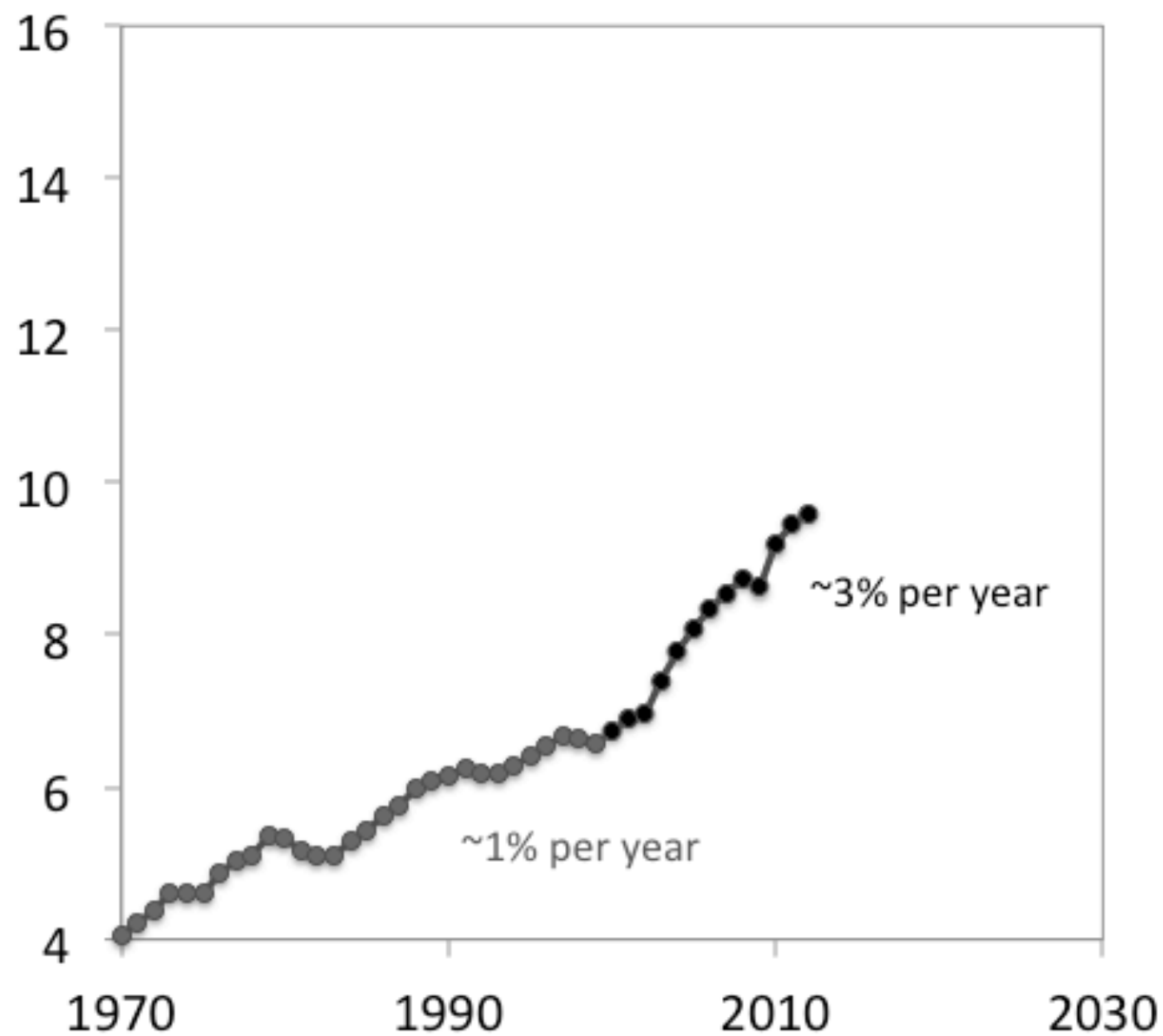
Higher Scenario



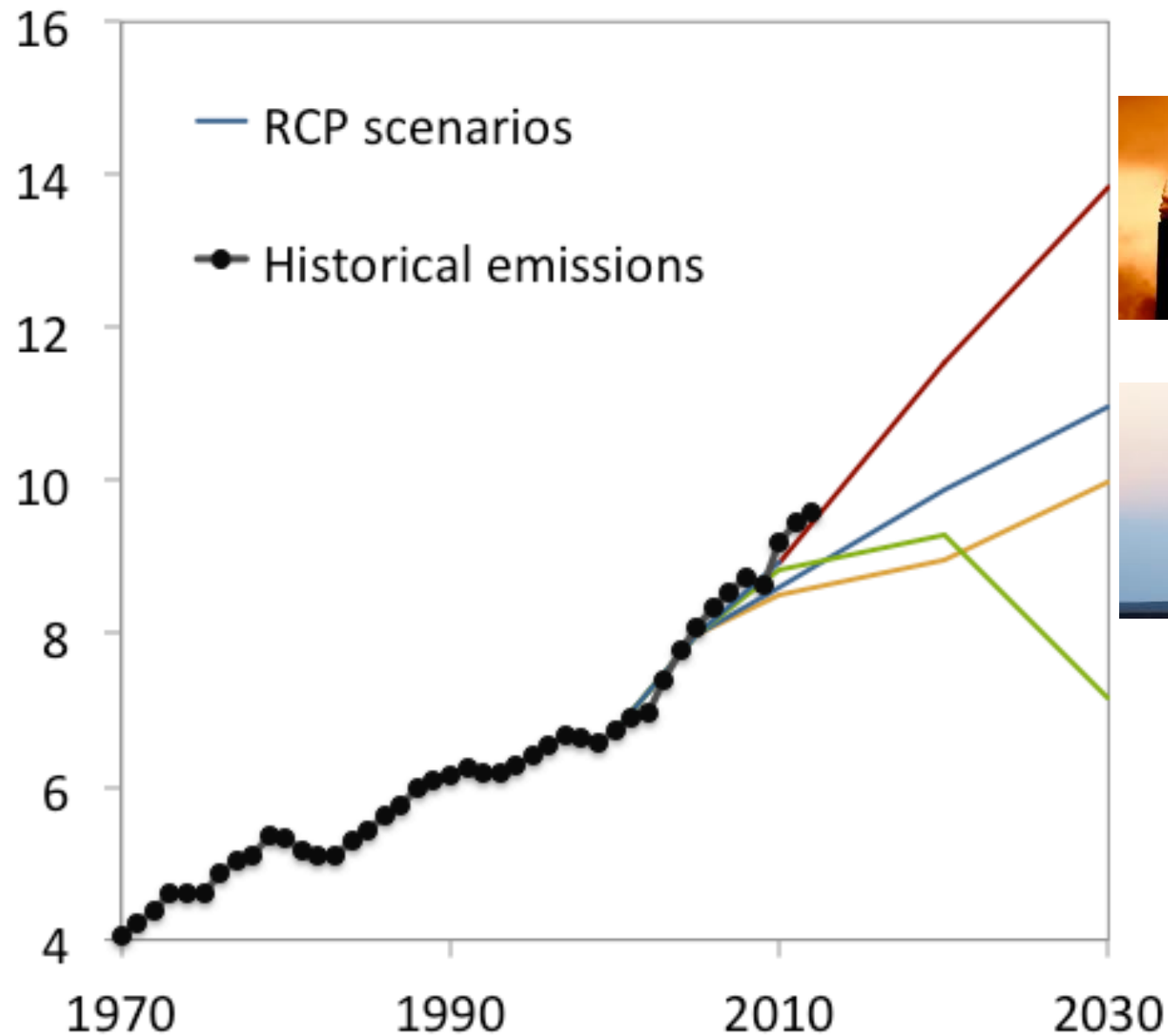
Degrees F



Fossil fuel emissions (GtC)



Fossil fuel emissions (GtC)



Science can't tell us WHAT TO DO

The ultimate objective of the UN Framework Convention on Climate Change is ... to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would **prevent dangerous anthropogenic interference with the climate system.**

UNFCCC 1990

Such a level should be achieved within a time frame sufficient to allow **ecosystems to adapt** naturally to climate change, to **ensure that food production is not threatened** and to **enable economic development to proceed** in a sustainable manner.

WHAT IS THAT LEVEL?

Some would say we've reached it

Most of >200
native Alaskan
villages at risk

12 out of 31



Others say 4°C is too far

FRIDAY, DECEMBER 07, 2012

- GC51H. GC51H. The Anthropocene: Confronting the Prospects of a +4°C World I (Video On-Demand)
Convener(s): Peter Frumhoff (Union of Concerned Scientists), Michael Ellis (British Geological Survey), Mark Williams (University of Leicester) and Jay Gullede (Ctr Climate & Energy Solutions)
8:00 AM - 10:00 AM; 104 (Moscone South)

Turn Down the Heat

Why a 4°C Warmer World
Must be Avoided



Even more split the difference

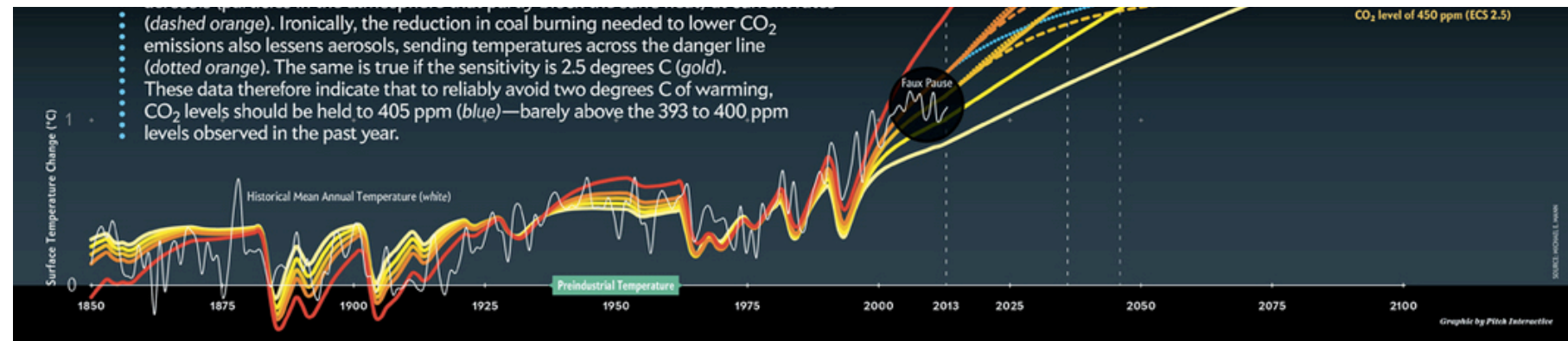
False Hope

The rate of global temperature rise may have hit a plateau, but a climate crisis still looms in the near future
By Michael E. Mann

Earth Will Cross the Climate Danger Threshold by 2036

The rate of global temperature rise may have hit a plateau, but a climate crisis still looms in the near future

Mar 18, 2014 | By Michael E. Mann



We basically have three choices:

MITIGATE



ADAPT



SUFFER



John Holdren

President's Science Advisor; Harvard University

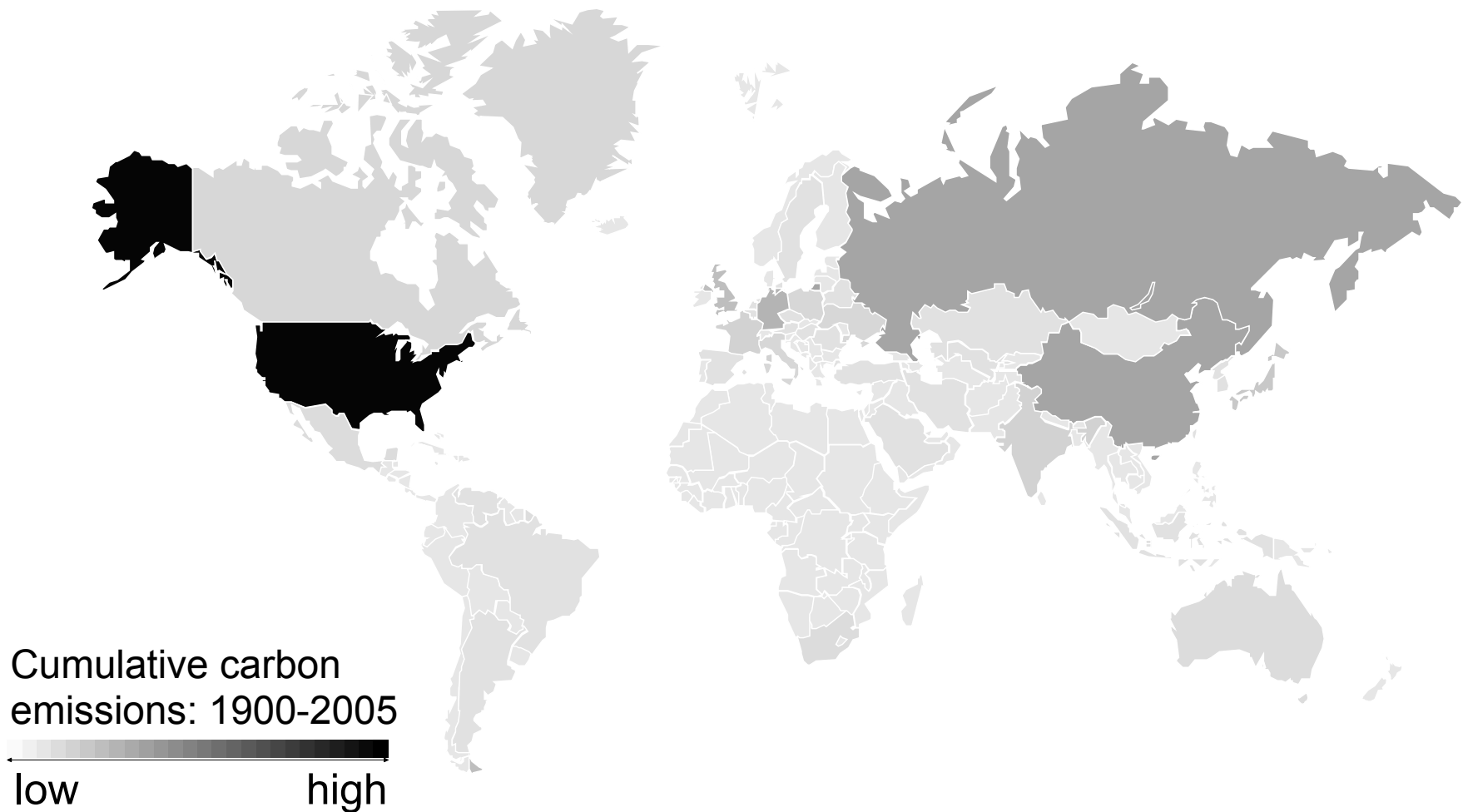
We're going to do some of each.
The question is what the mix is
going to be.

The more mitigation we do, the less
adaptation will be required, and
the less suffering there will be.

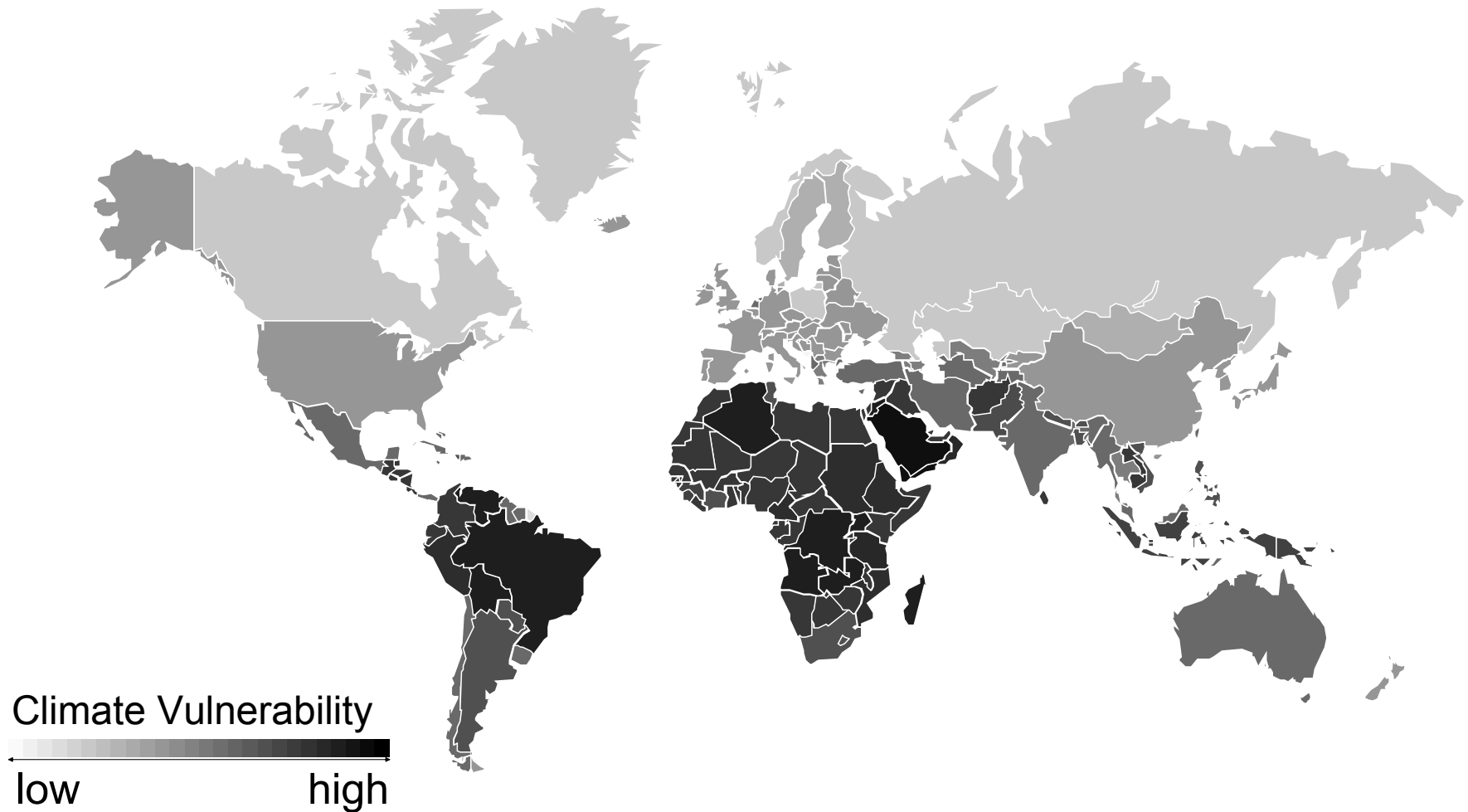
John Holdren

President's Science Advisor; Harvard University

Who is driving the problem?



Who is experiencing most impacts?





How can science inform this choice?

PART THREE

Science **cannot** define a single threshold or level for greenhouse gas stabilization or global mean temperature target to prevent dangerous impacts.

Science **can** quantify the impacts of a specific level or target and this information can be used by policymakers to assess what they consider to be 'dangerous'.

The primary challenge to this task is the uncertainty in future projections.

Why are future projections uncertain?

1. Natural variability is chaotic
2. Climate sensitivity is unknown
3. Climate models are imperfect
4. Future scenarios are driven by human activities

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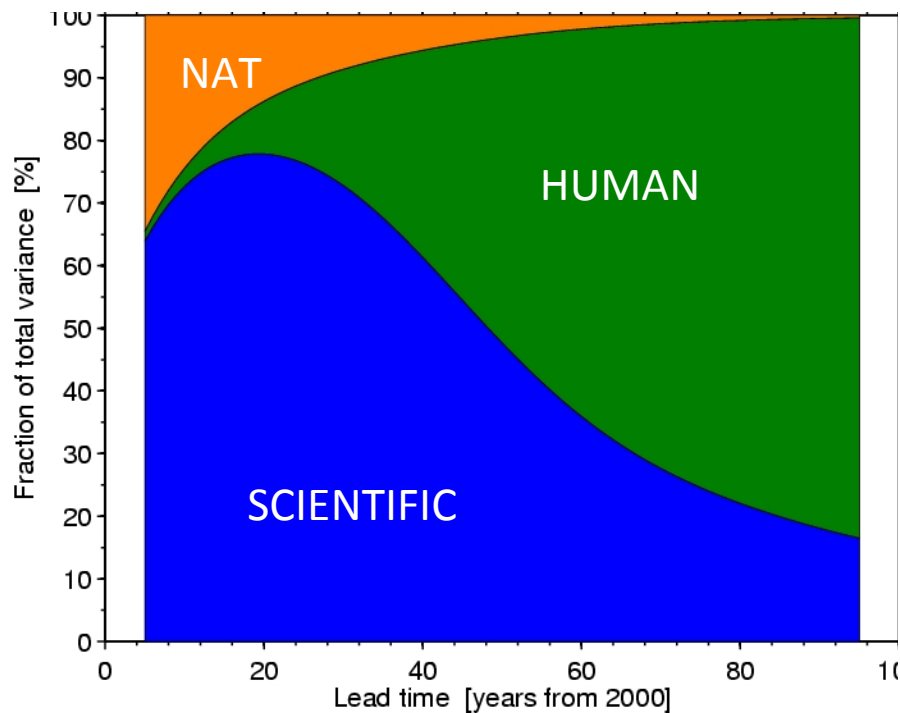
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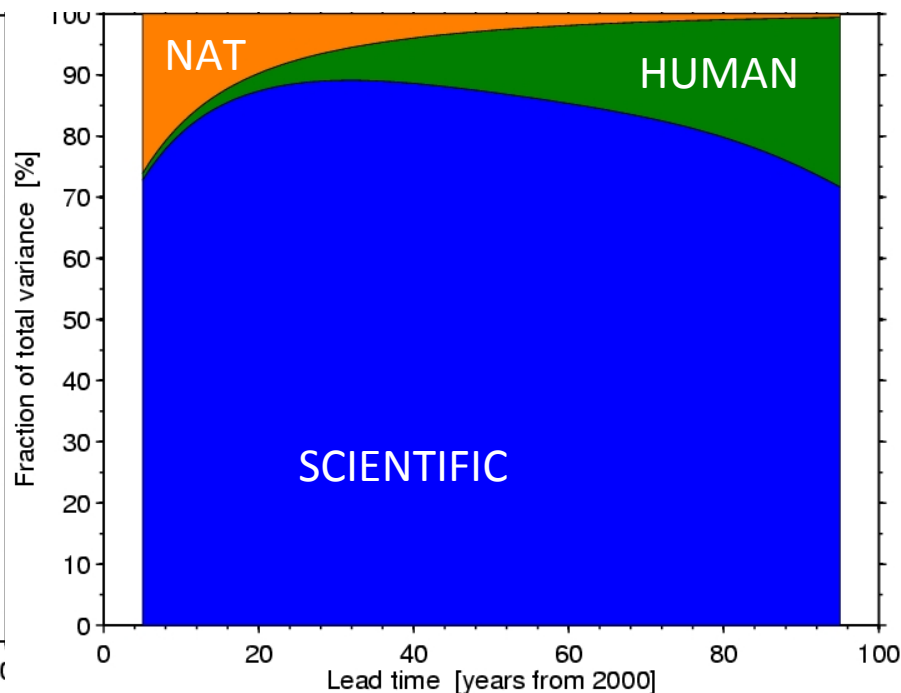
1. Natural variability is chaotic
2. Climate sensitivity is unknown
3. Climate models are imperfect
4. Future scenarios are driven by human activities

The importance of each different source of uncertainty varies in time

GLOBAL TEMPERATURE

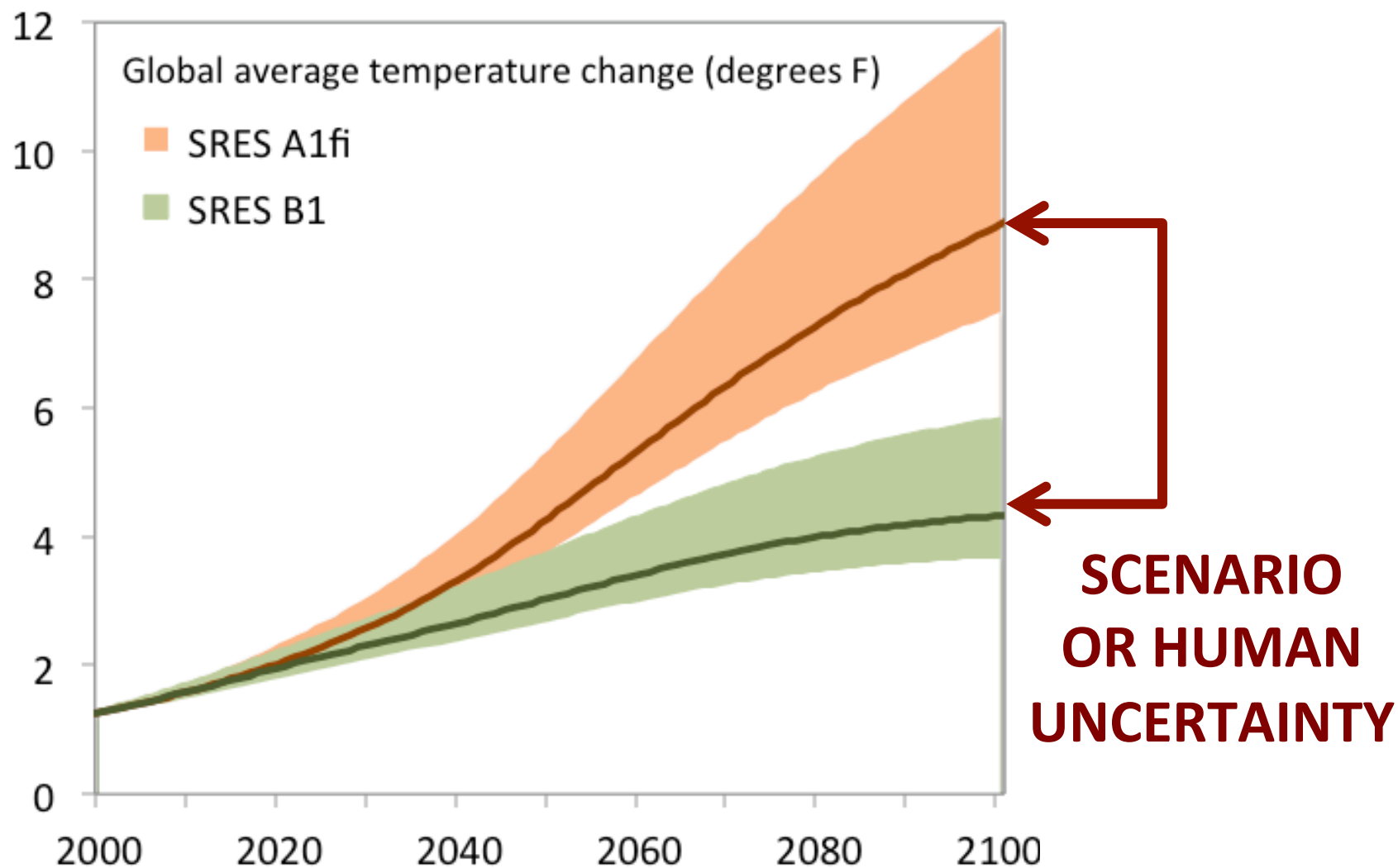


GLOBAL PRECIPITATION

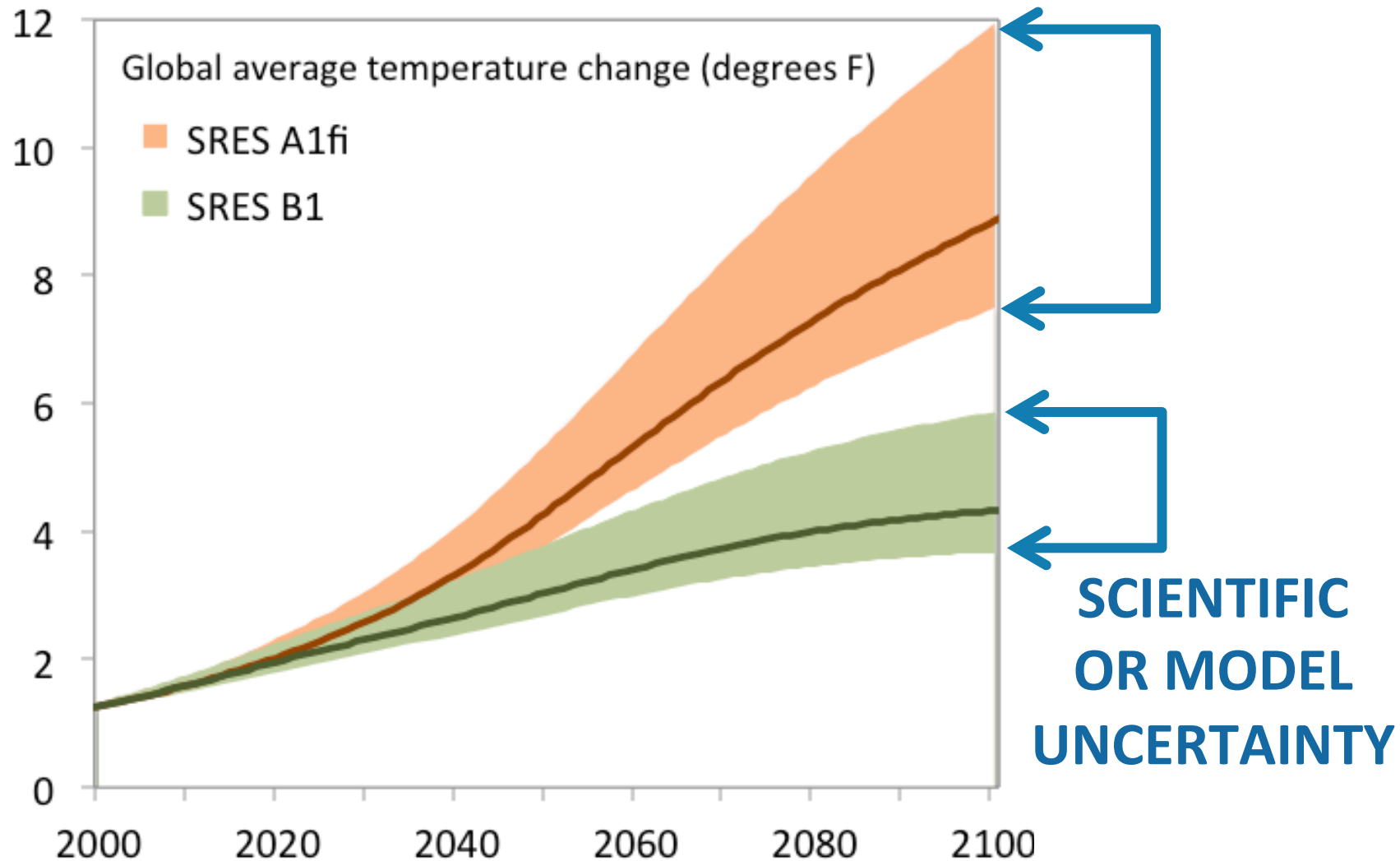


Hawkins & Sutton 2009, 2011

Use scenarios and global climate models that cover the range of known uncertainty

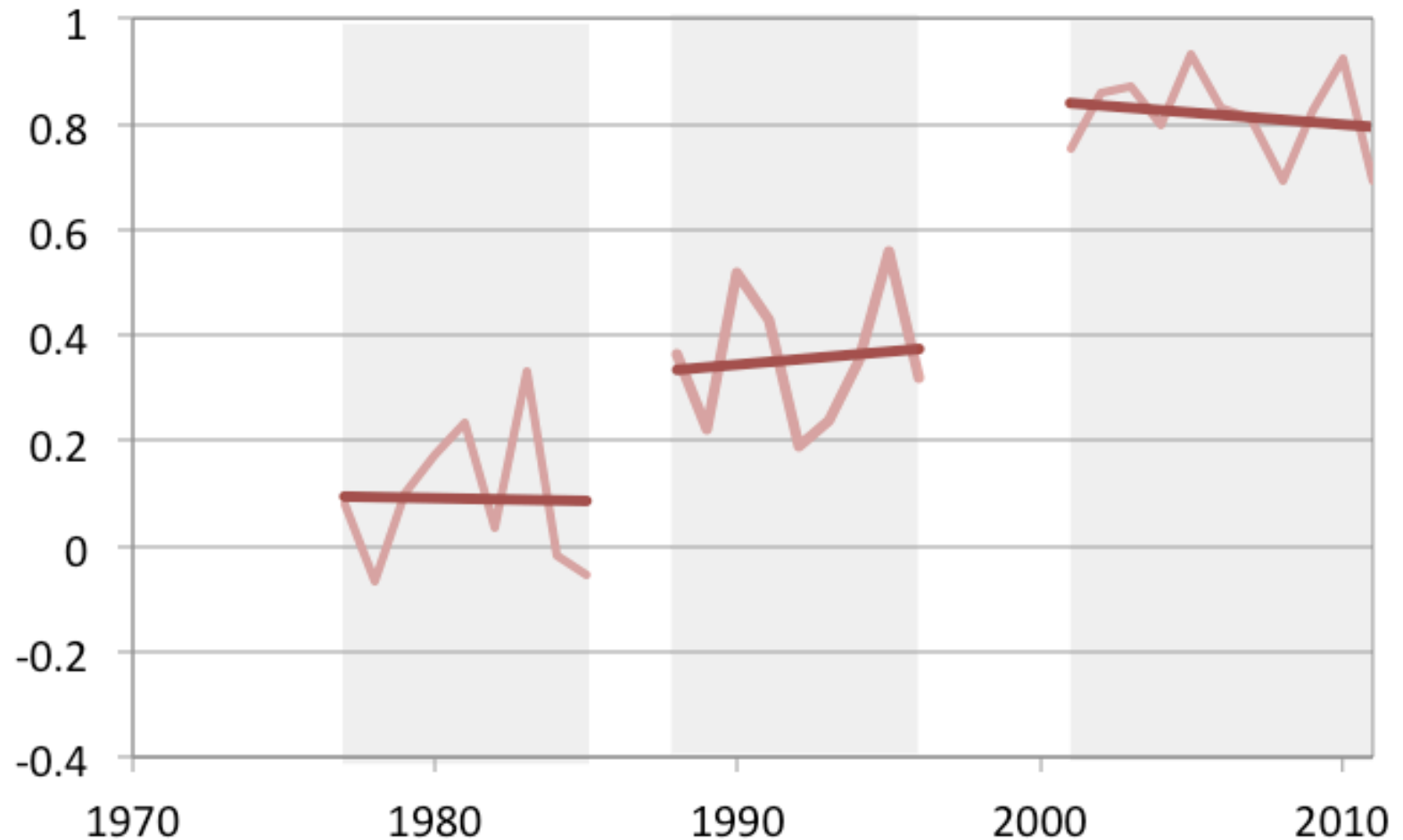


Use scenarios and global climate models that cover the range of known uncertainty



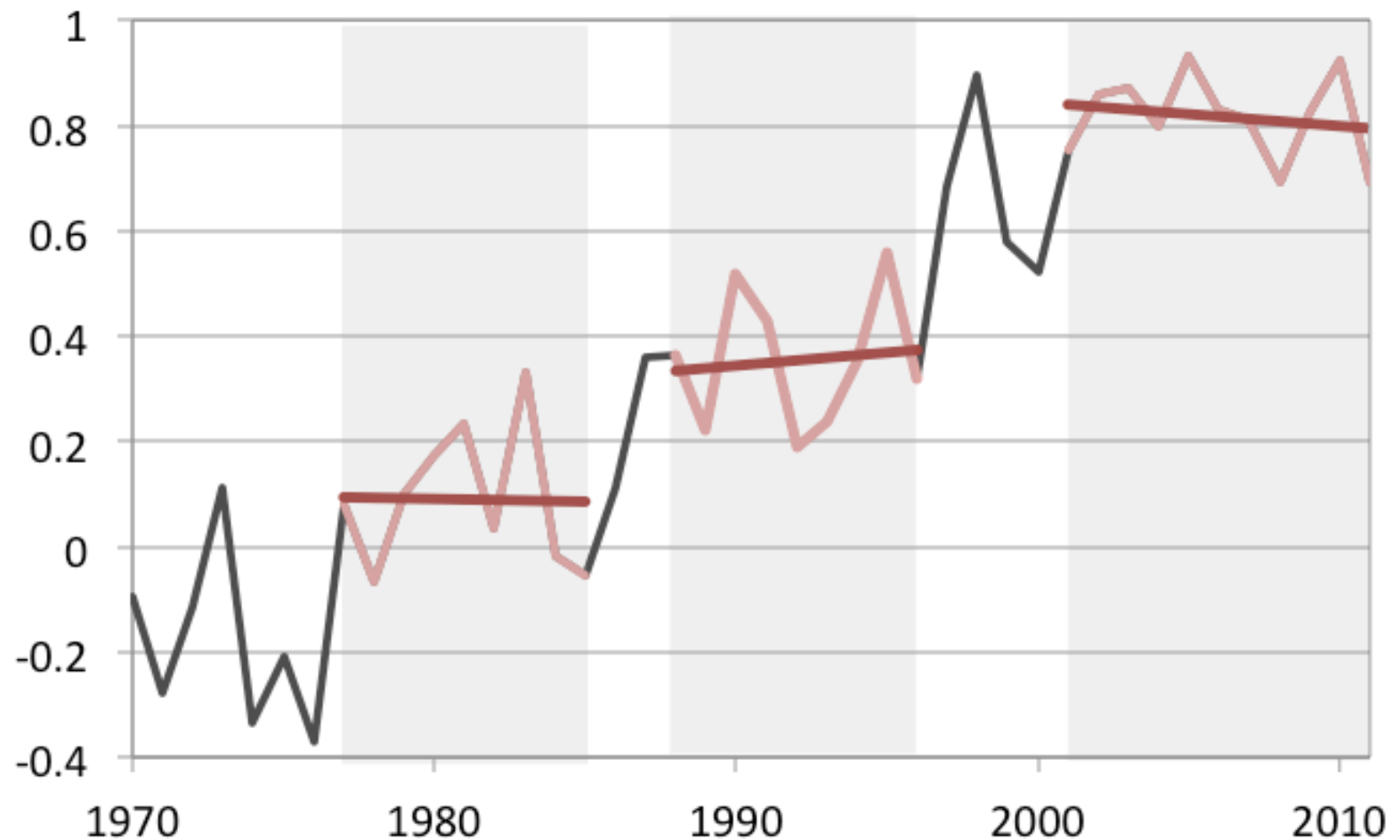
NATURAL VARIABILITY

Global Average Temperature (degrees F)



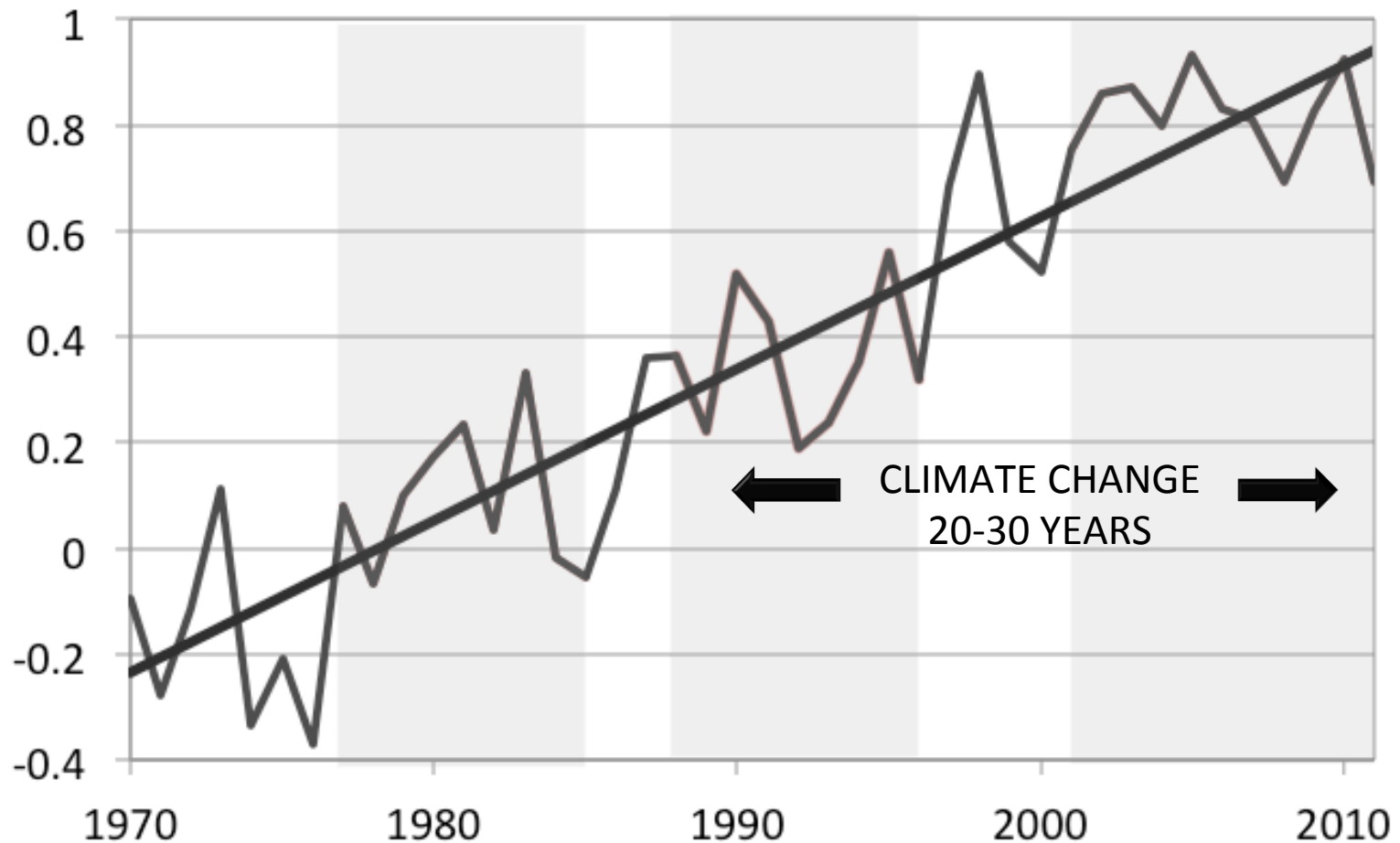
NATURAL VARIABILITY

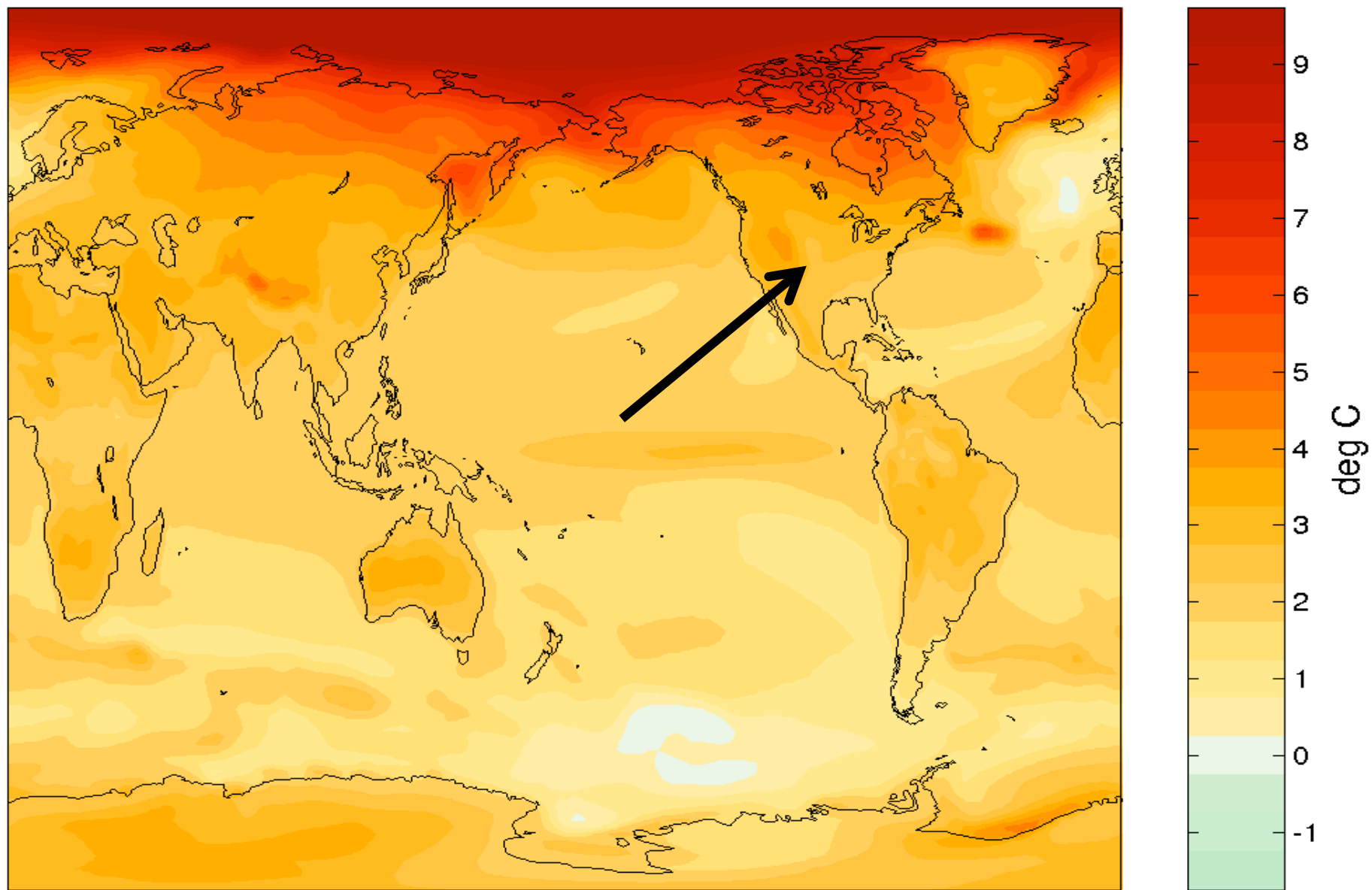
Global Average Temperature (degrees F)



Develop projections over appropriate time scales

Global Average Temperature (degrees F)





What is downscaling?

DOWNSCALING **introduces new information** into global climate model output to generate high-resolution climate projections

What is downscaling?

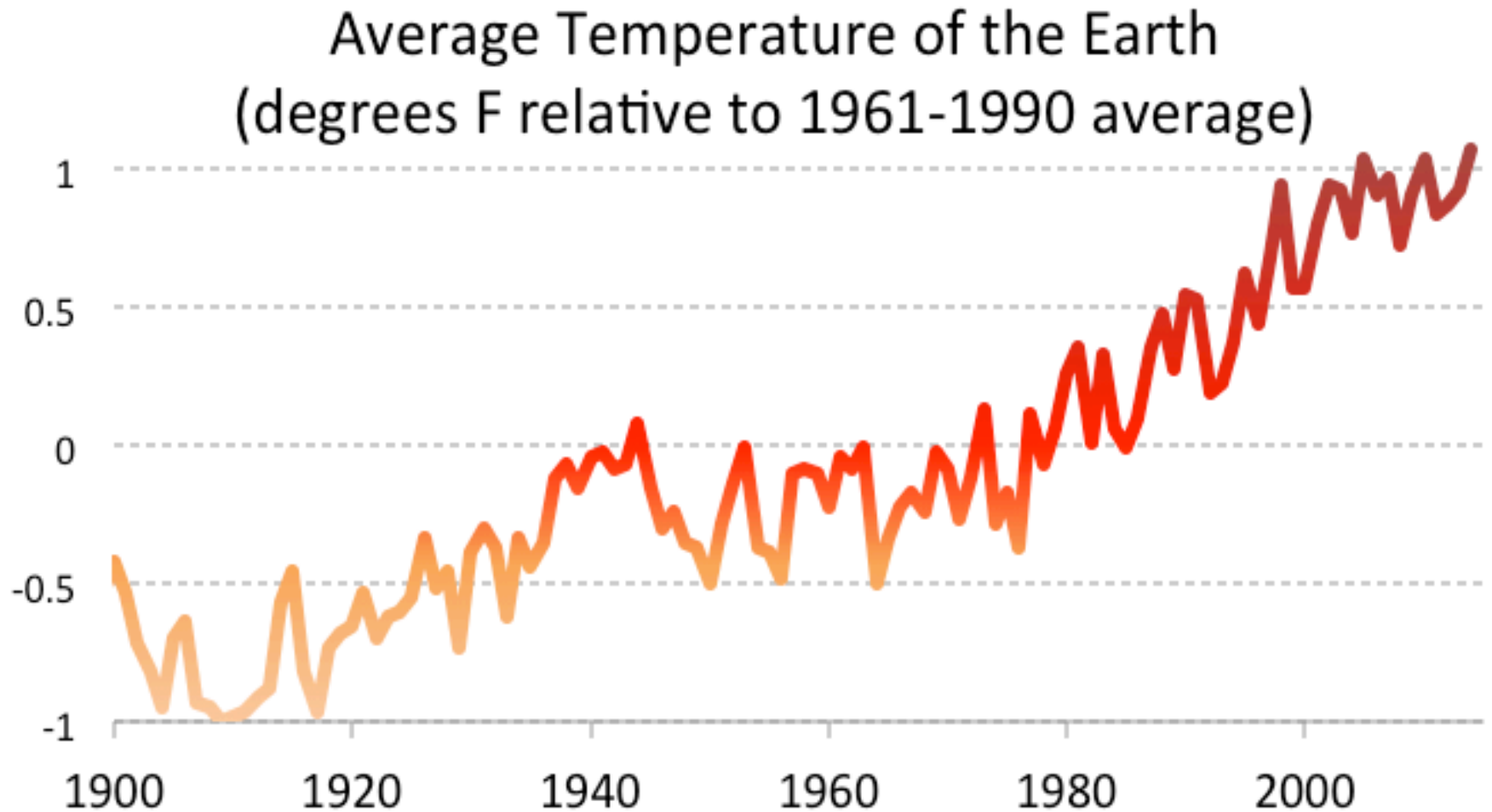
DOWNSCALING **introduces new information** into global climate model output to generate high-resolution climate projections

Where does this new information come from?

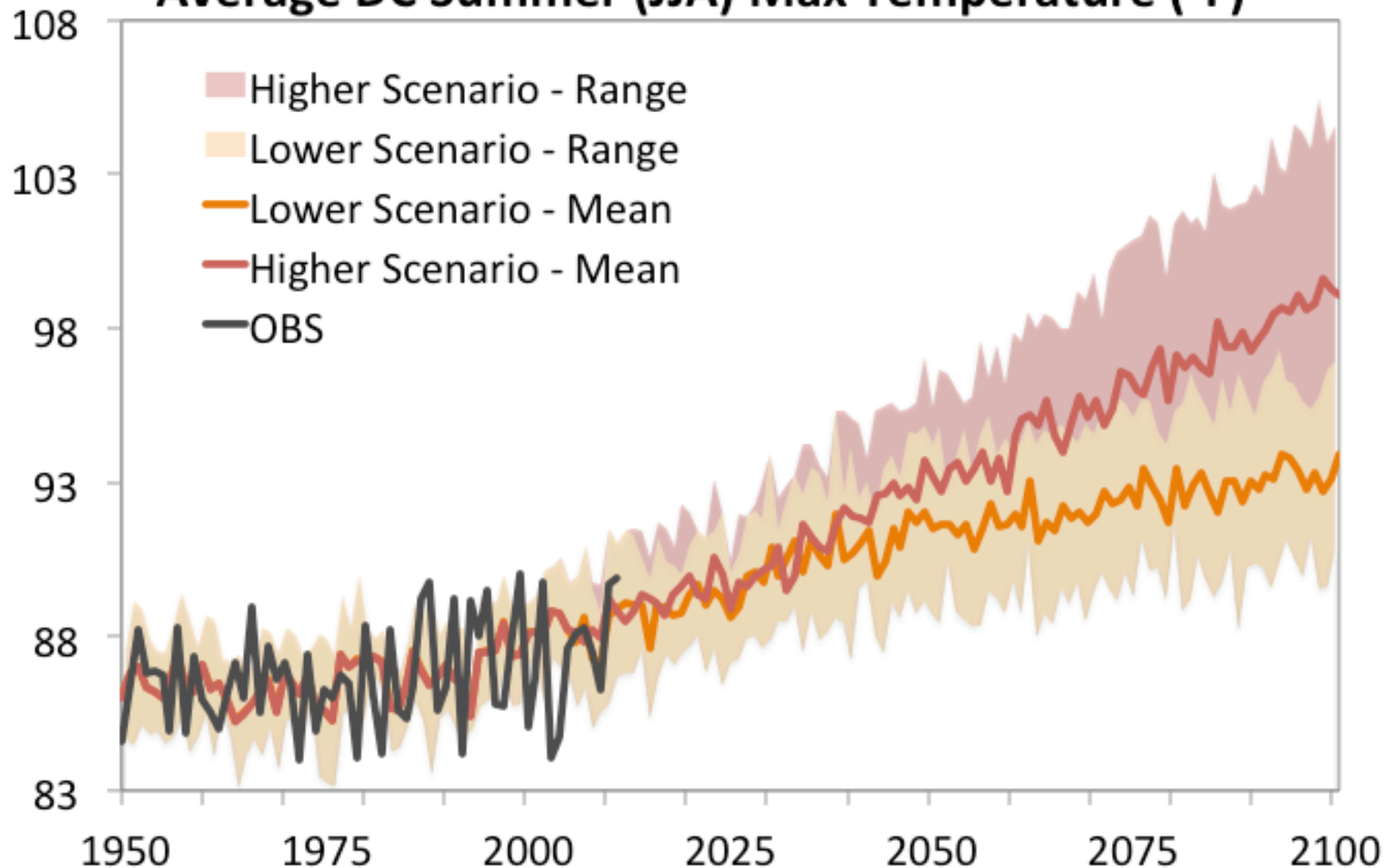
Observations (weather stations, weather balloons, satellites, radar)

Higher-resolution modeling of physical processes

What does downscaling do?

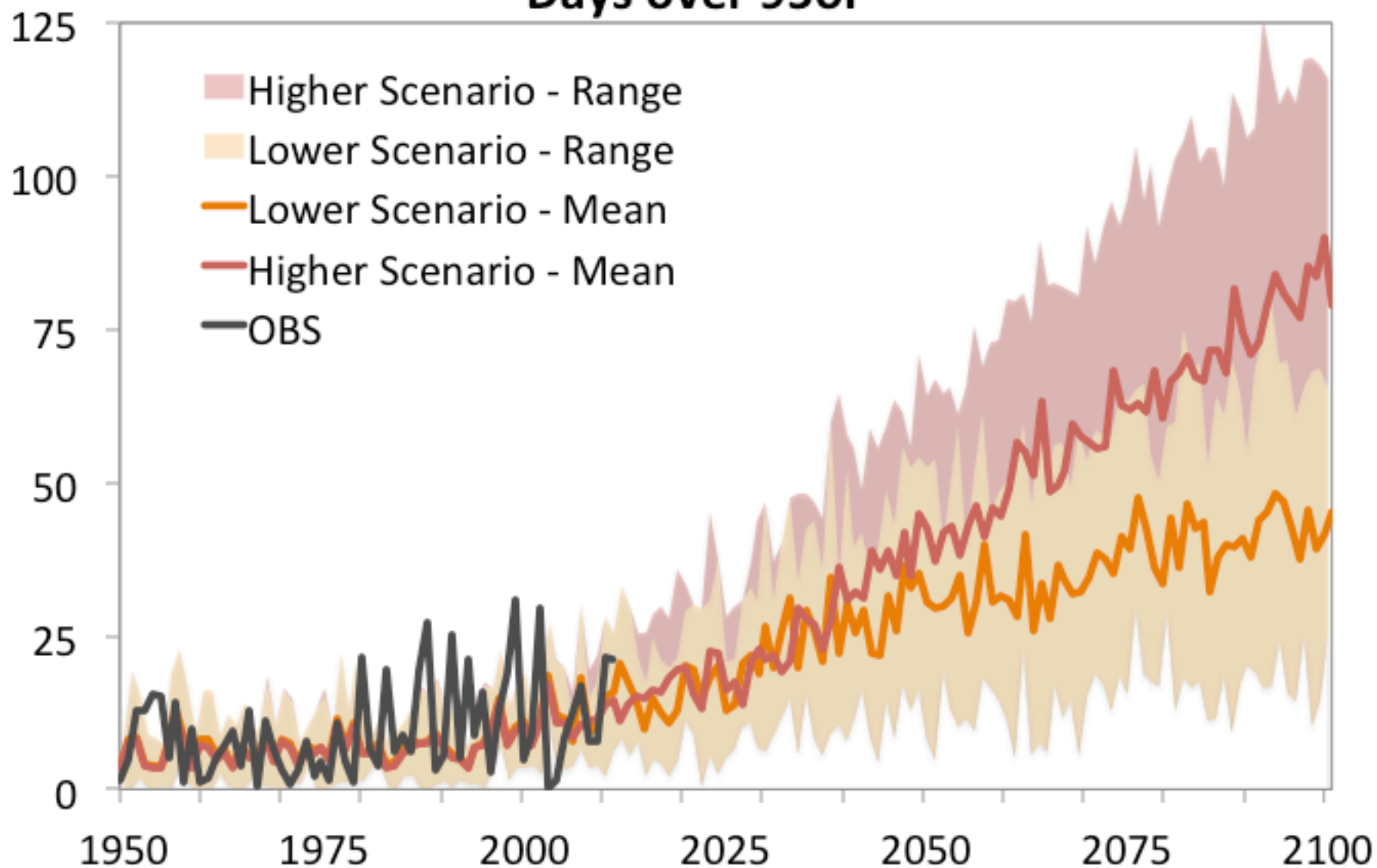


Average DC Summer (JJA) Max Temperature (°F)

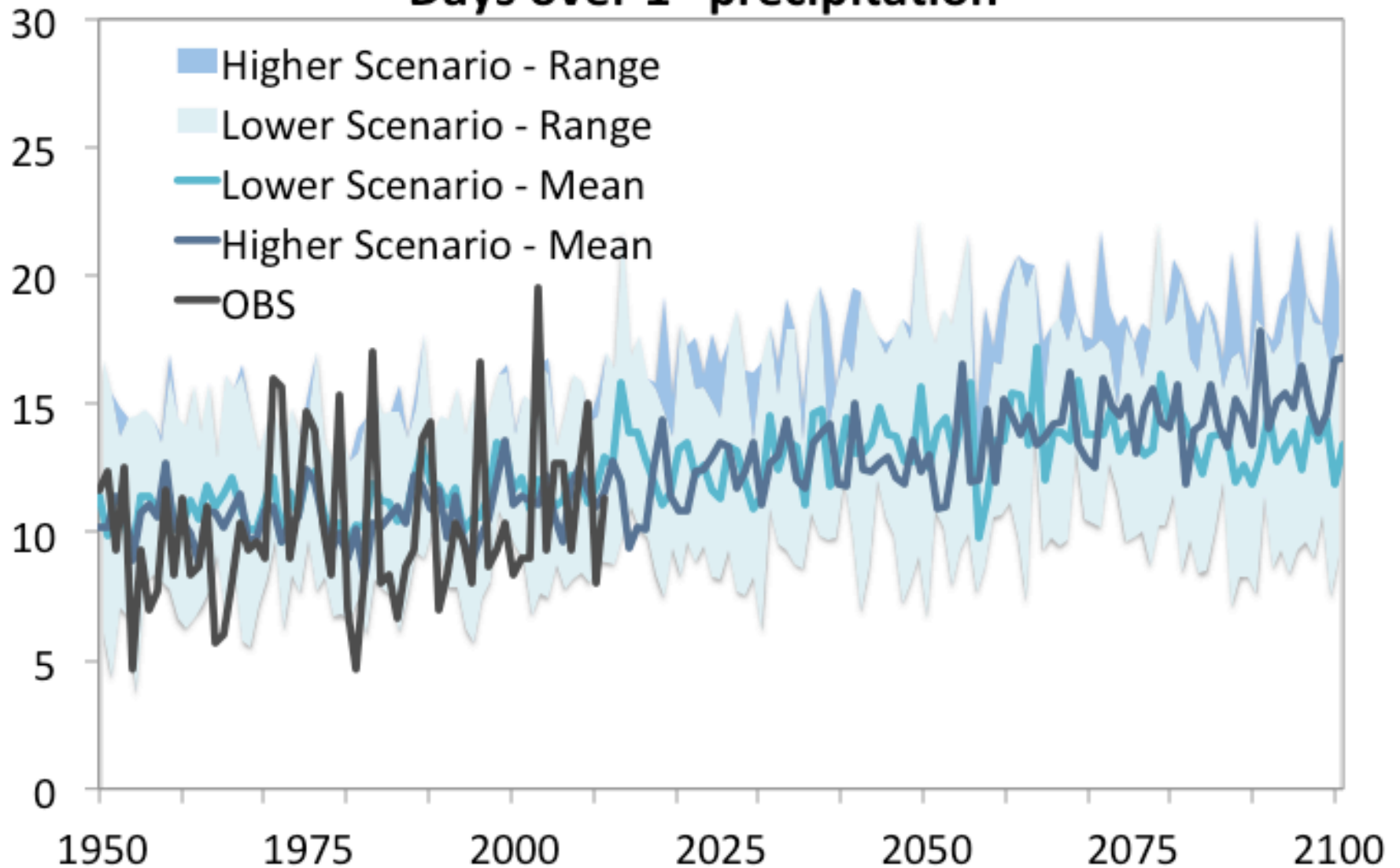


Average of 3 Washington DC weather stations

Days over 95oF

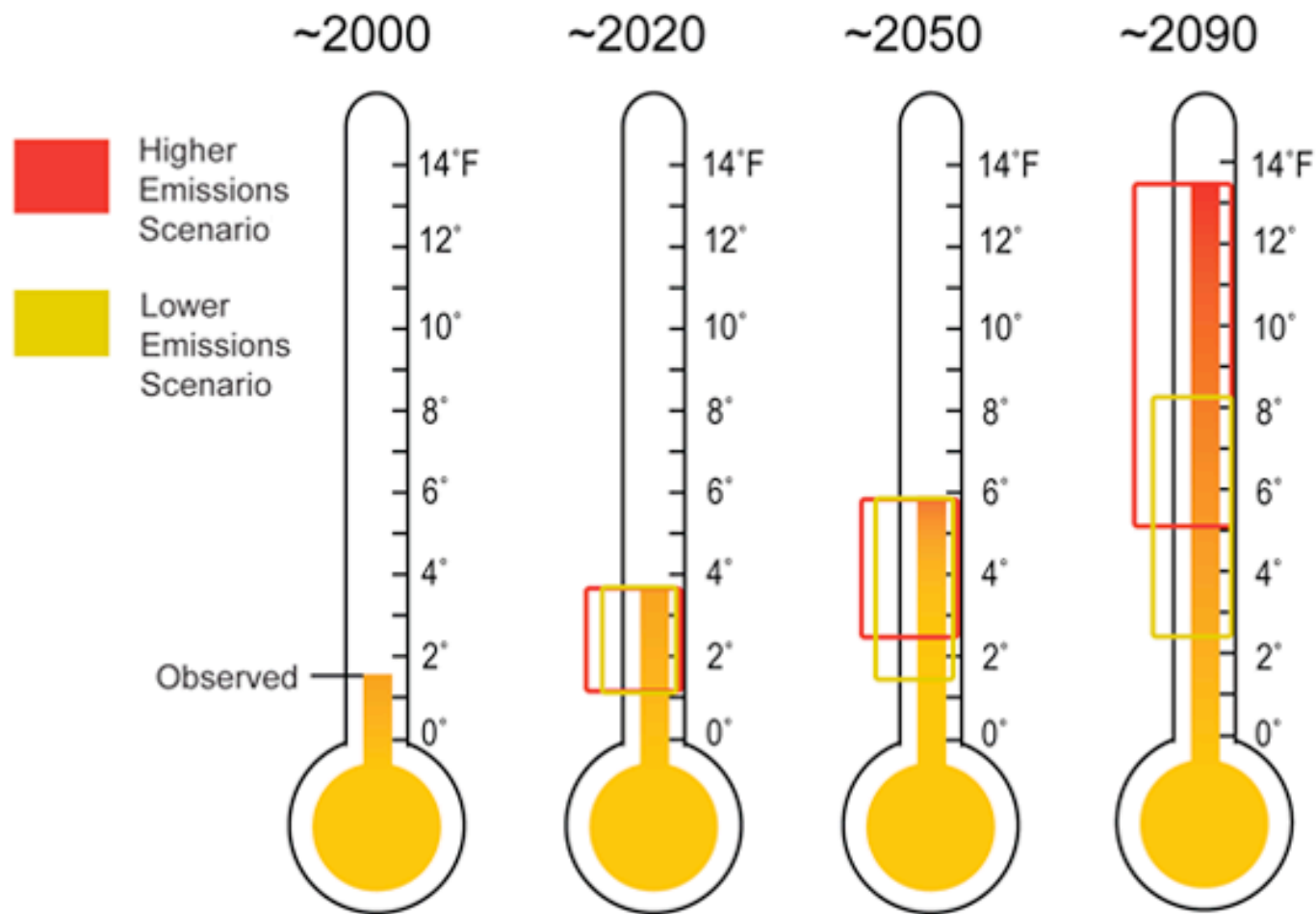


Days over 1" precipitation



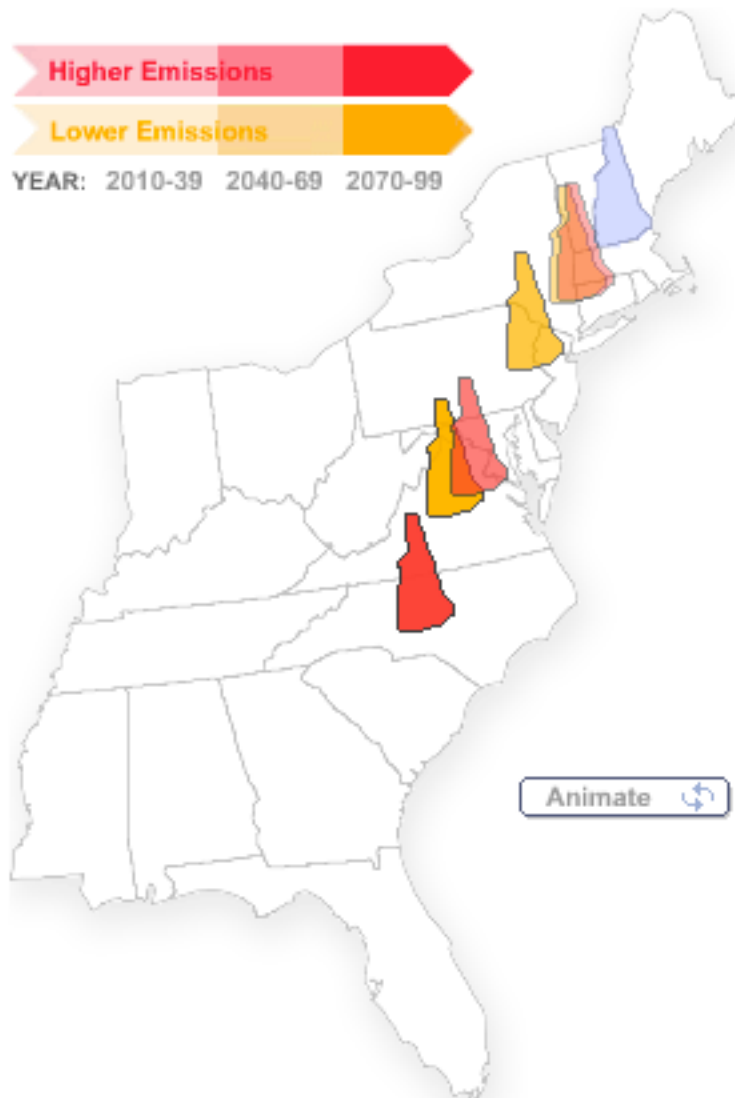
Average of 3 Washington DC weather stations

Temperature increases in California



Source: 2009 U.S. National Climate Assessment

GLOBAL TEMPERATURE -> LOCAL CHANGE



Summer in New Hampshire could feel like the typical summer in North Carolina by the end of the century unless we take action to reduce heat-trapping emissions today.

Lower-Emissions

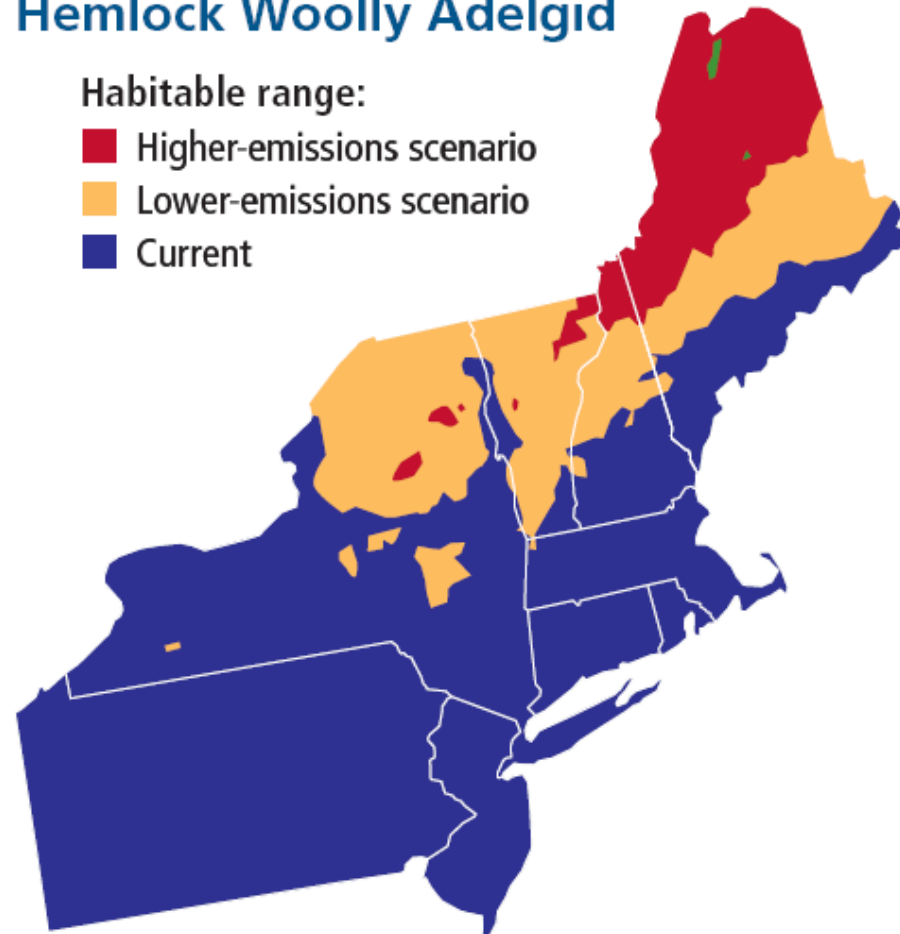
Scenarios: a shift away from fossil fuels in favor of clean energy technologies, causing heat-trapping emissions to decline by mid-century

Higher-Emissions

Scenarios: continued heavy reliance on fossil fuels, causing heat-trapping emissions to rise rapidly over the century

GLOBAL TEMPERATURE -> LOCAL IMPACTS

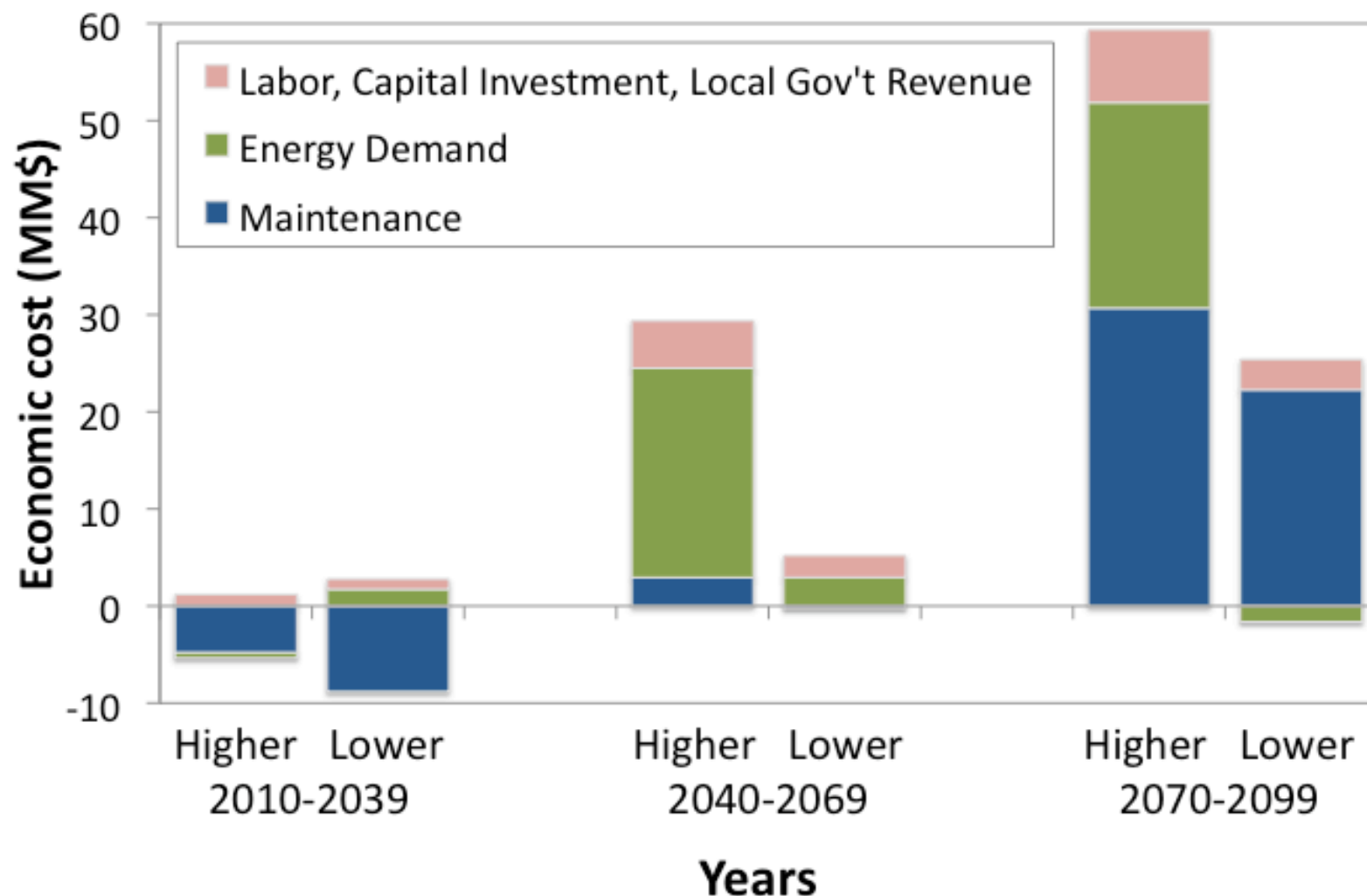
FIGURE 8: Late-Century Range of the Hemlock Woolly Adelgid



Projected northward expansion of the Hemlock Woolly Adelgid.

Currently limited by cold winter temperatures.

GLOBAL TEMPERATURE -> LOCAL IMPACTS



SUMMARY

As climate is changing, **science** can help us **define the outcomes of our choices** and **prepare for a different future**

Key to informing mitigation is connecting impacts with human choices. Even qualitative information (direction of trend) or awareness of vulnerabilities can be useful.

Key to informing adaptation is integrating climate preparedness into existing planning frameworks and mechanisms, not treating it like something new.

SUMMARY

As climate is changing, science can help us define the outcomes of our choices and prepare for a different future.

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Key to informing mitigation is connecting impacts with human choices. Even qualitative information (direction of trend) or awareness of vulnerabilities can be useful.

Key to informing **adaptation** is **integrating climate preparedness into existing planning frameworks** and mechanisms, not treating it like something new.

The more **mitigation** we do,
the less **adaptation** will be
required,
and the less **suffering** there
will be.

John Holdren

President's Science Advisor; Harvard University

SUMMARY

As climate is changing, science can help us define the outcomes of our choices and prepare for a different future

Key to informing **mitigation** is connecting impacts with human choices. Even qualitative information (direction of trend) or awareness of vulnerabilities can be useful.

Key to informing **adaptation** is integrating climate preparedness into existing planning frameworks and mechanisms, not treating it like something new.

Both of these are key to limiting suffering.

We CAN mitigate





Fossil Fuels Just Lost the Race Against Renewables

The race for renewable energy has passed a turning point. The world is now adding more capacity for renewable power each year than coal, natural gas, and oil combined. And there's no going back.





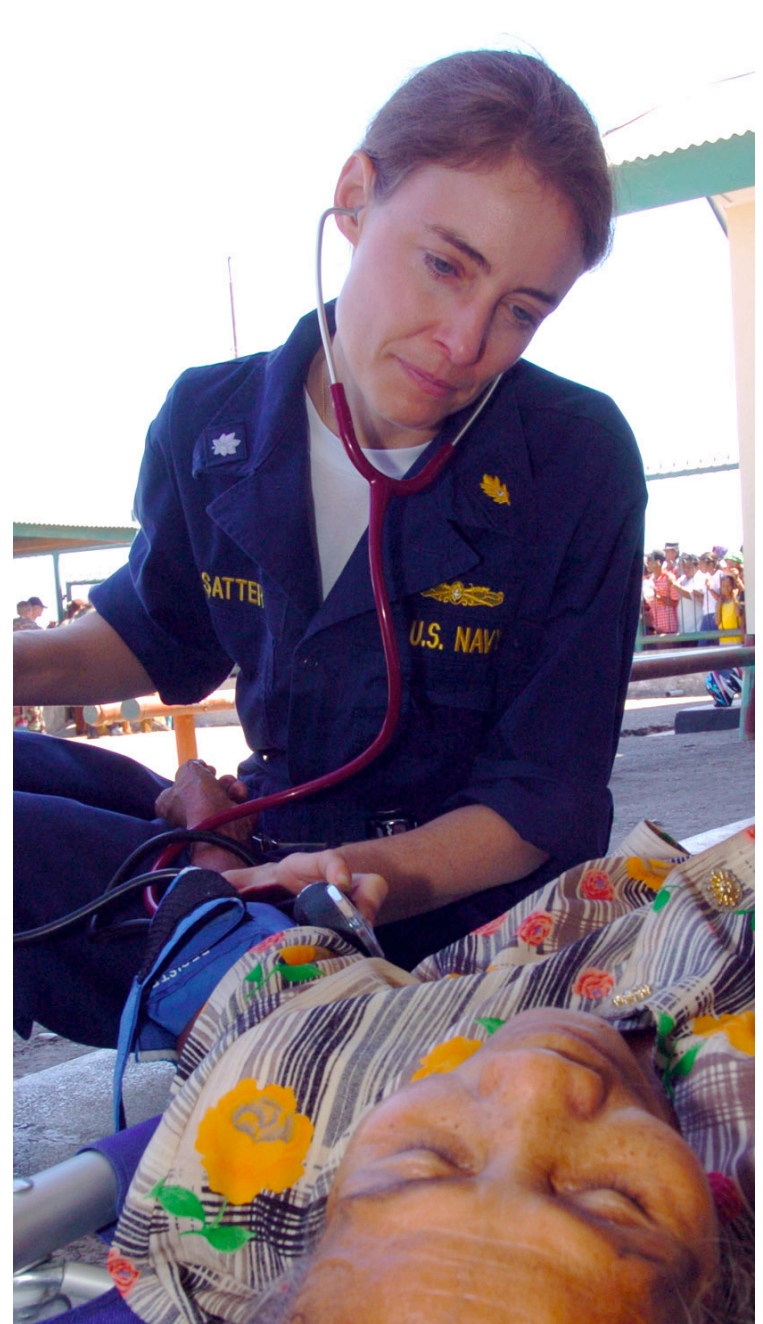
We CAN adapt

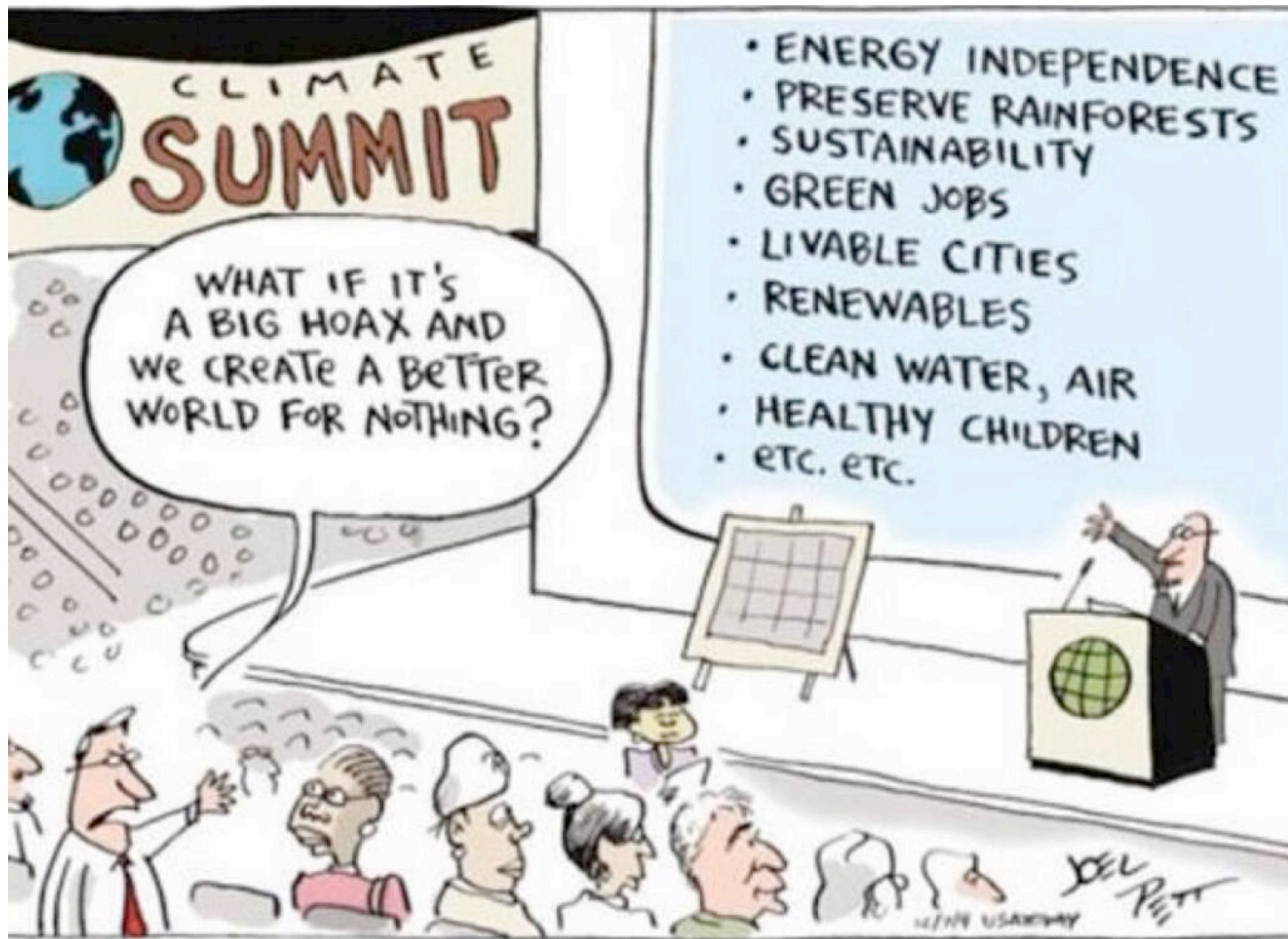


We CAN adapt

A photograph of modern floating houses on a body of water. The houses are multi-story, with large windows and balconies. One house in the foreground has a prominent red-orange facade, while others have light-colored wood or metal siding. The houses are built on a floating platform, and their reflections are visible in the water. A small boat with a blue cover is docked near the red house. The sky is clear and blue.

We CAN adapt





THANK YOU!

www.katharinehayhoe.com

@KHayhoe