



Climate
Up Close.

Our team



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Postdoctoral
Research Fellow
UCSD

Support:



Emma Ignaszewski
Communications strategy



Our tours

Nebraska
tour 2025

Chicago
tour 2023

Central
PA tour
2019

New
Jersey
tour 2022

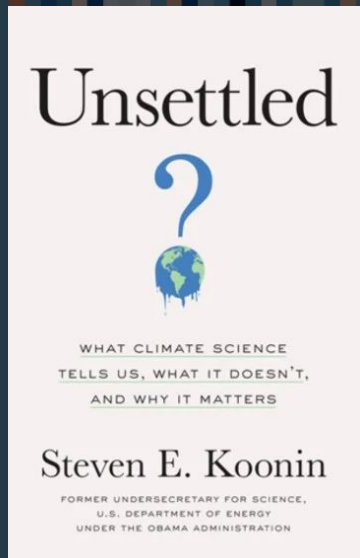
NH tour
2024

Philly
area tour
2020

North
Carolina
tour
2026

Florida
tour 2022

“Heat waves in the U.S. are now no more common than they were in 1900.”



—From *Unsettled* by Steven Koonin, Physicist and former Undersecretary for Science at U.S. Department of Energy

A satellite image of a hurricane, showing a large, swirling cloud system with a distinct eye. The image is in grayscale, with the clouds appearing in shades of gray against a darker background. The hurricane is centered in the upper half of the frame, with its eye clearly visible. The surrounding clouds are dense and swirling, indicating the powerful nature of the storm.

“The hurricane ‘machine’ is climate change. ... As temperatures rise, more hurricanes grow.”

—Rep. Alexandria Ocasio-Cortez after Hurricane Helene (2024)



“We have to cut the emissions that are warming the planet and heading us inexorably toward several tipping points beyond which there is no reverse.”

—John Kerry (2023)

The Landscape of Climate Knowledge

What's *settled*?

What's *uncertain*?

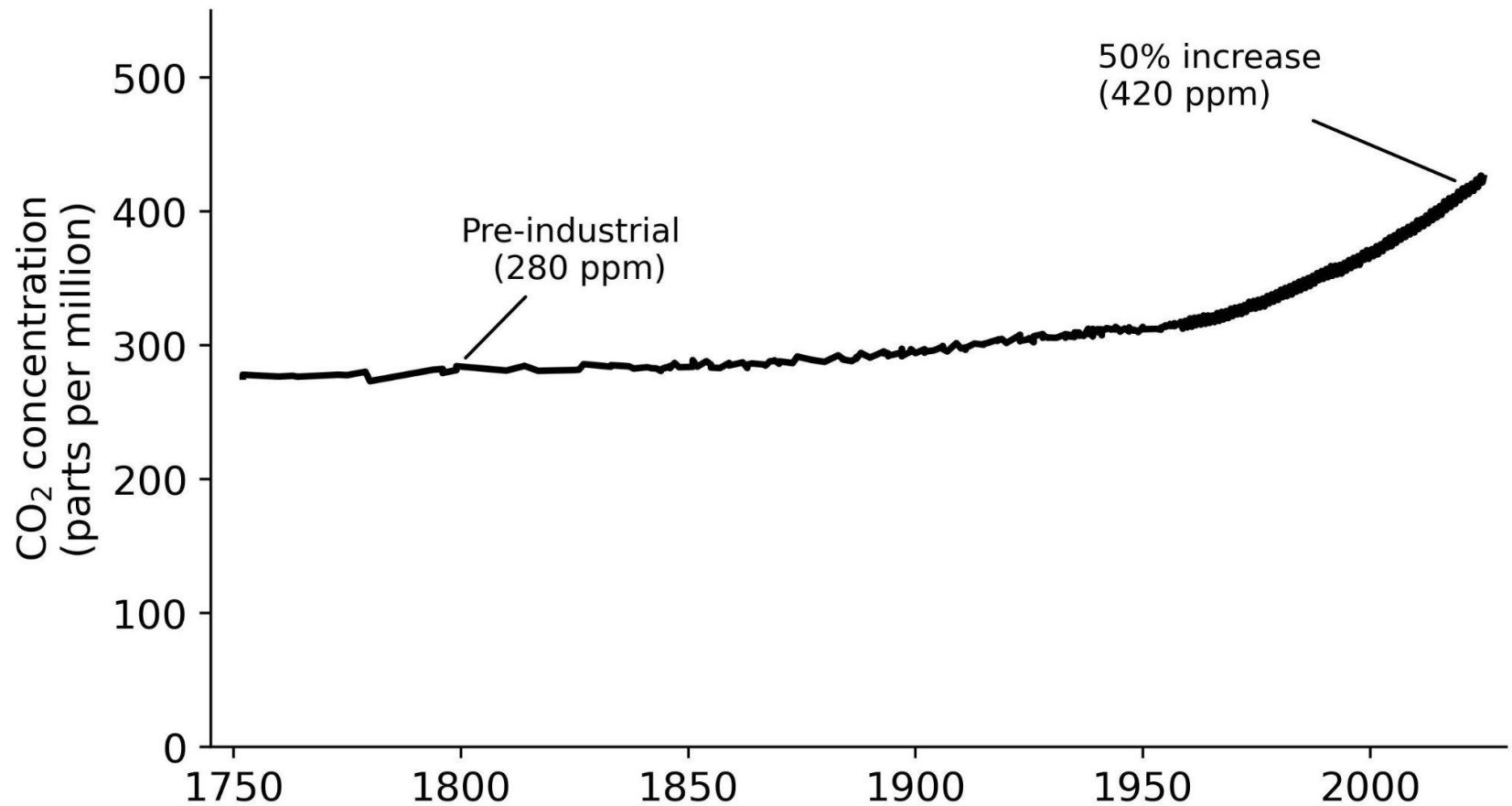


The Landscape of Climate Knowledge

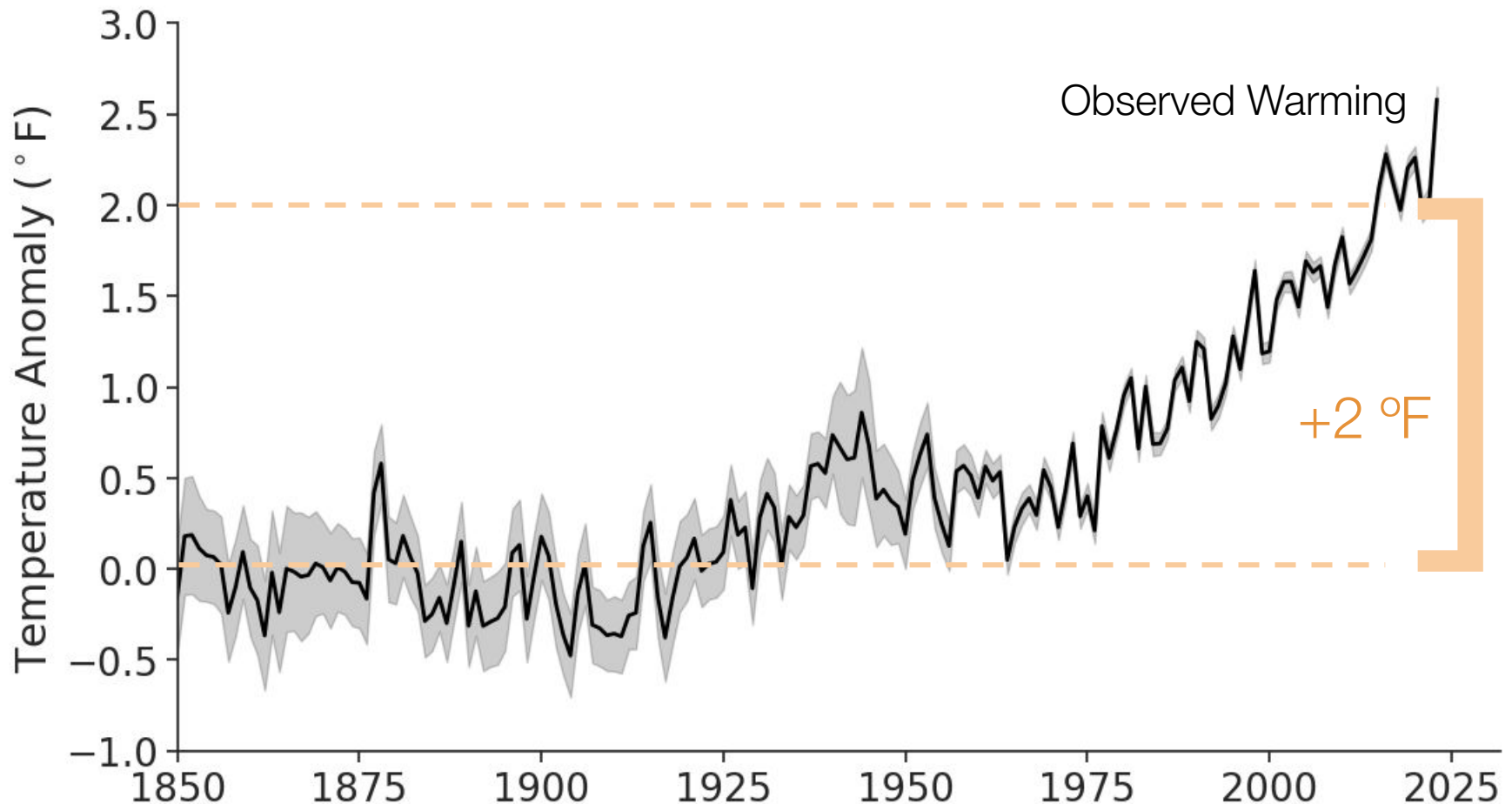
What's *settled*?

What's *uncertain*?

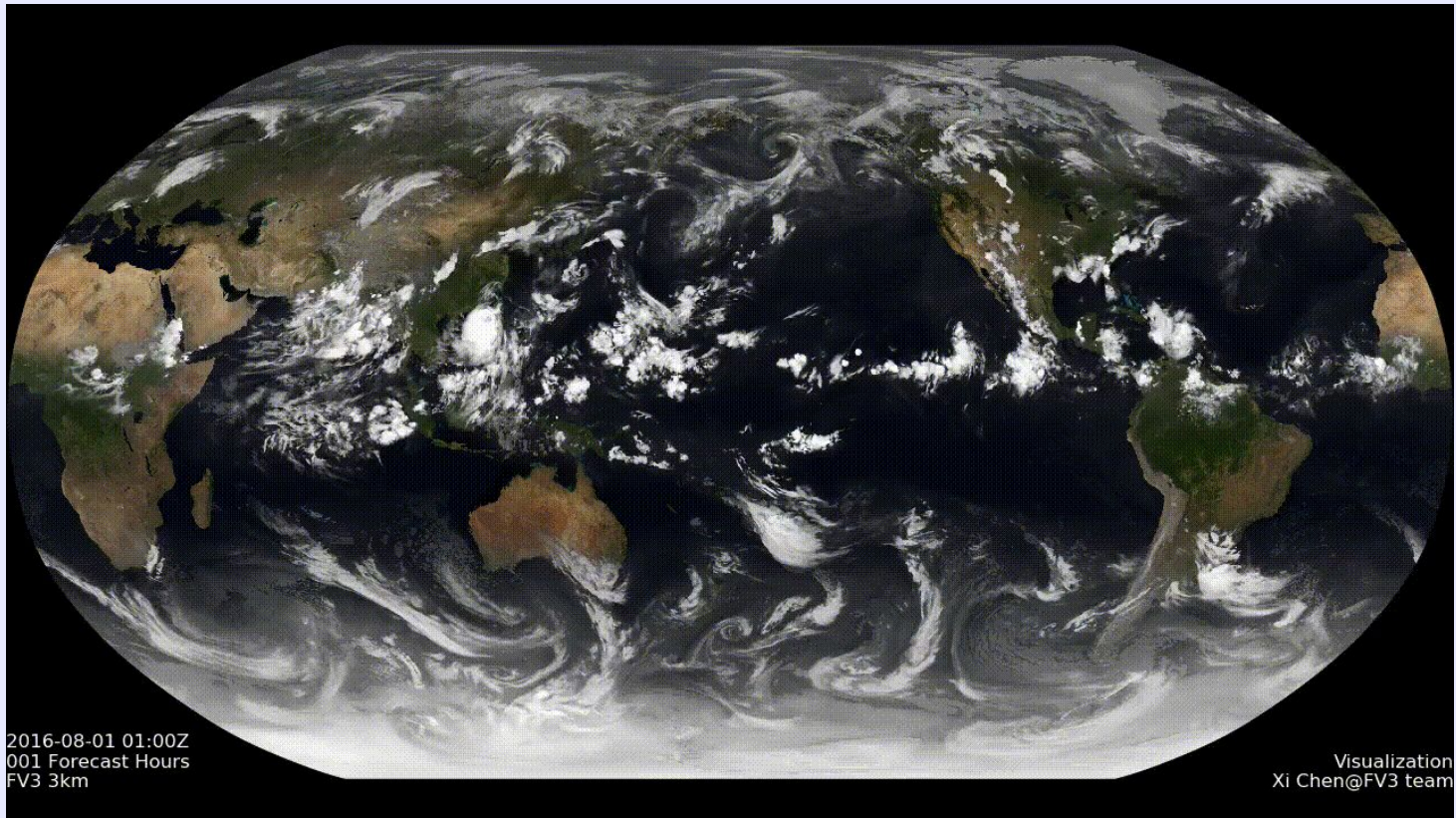
Atmospheric CO₂ concentrations are rising.



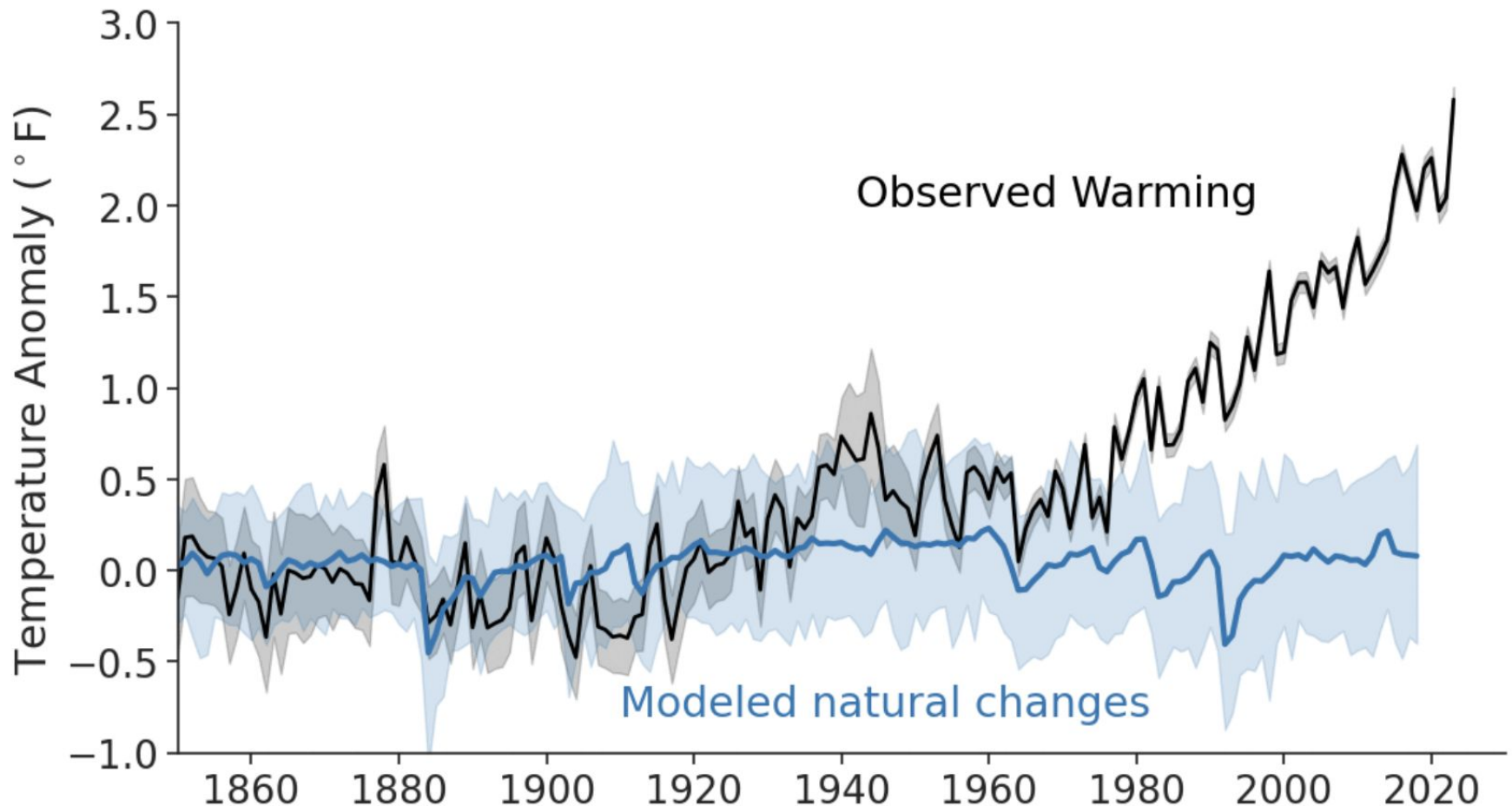
Global temperatures are rising.



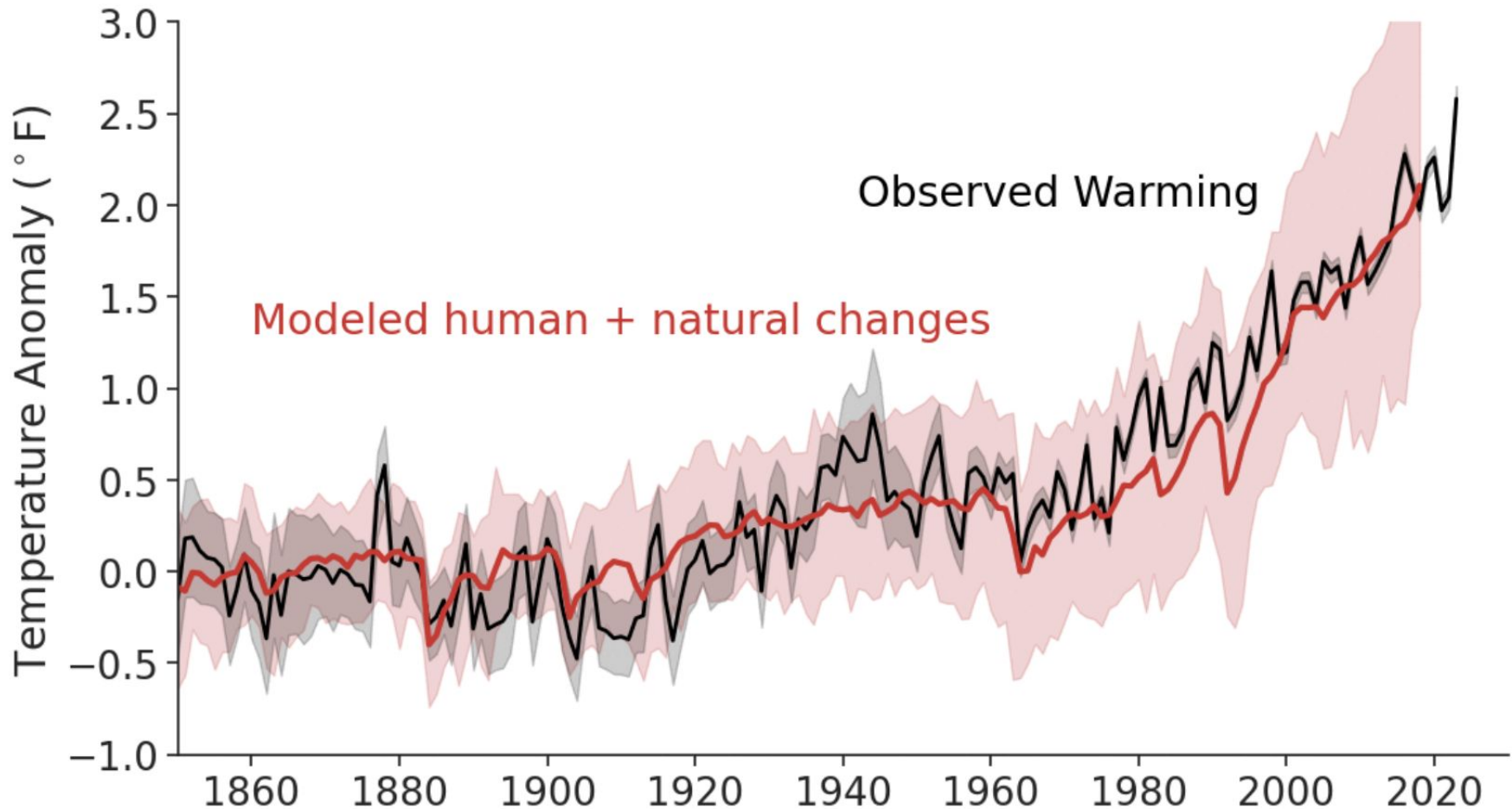
Climate models help us ask questions about the planet



Natural changes alone fail to account for the observed warming.

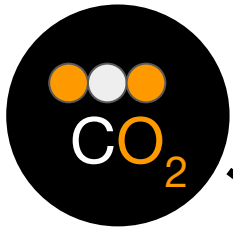


Adding in human changes,
we get a closer match.



The Landscape of Climate Knowledge

Uncertain



CO₂
Increase



Average
Temperature
Increase

Settled

Which impacts of
warming are *settled*?

...heat waves?

HAPPENING NOW

SEPTEMBER STARTS WITH A HEATWAVE

RALEIGH



95°
6:16

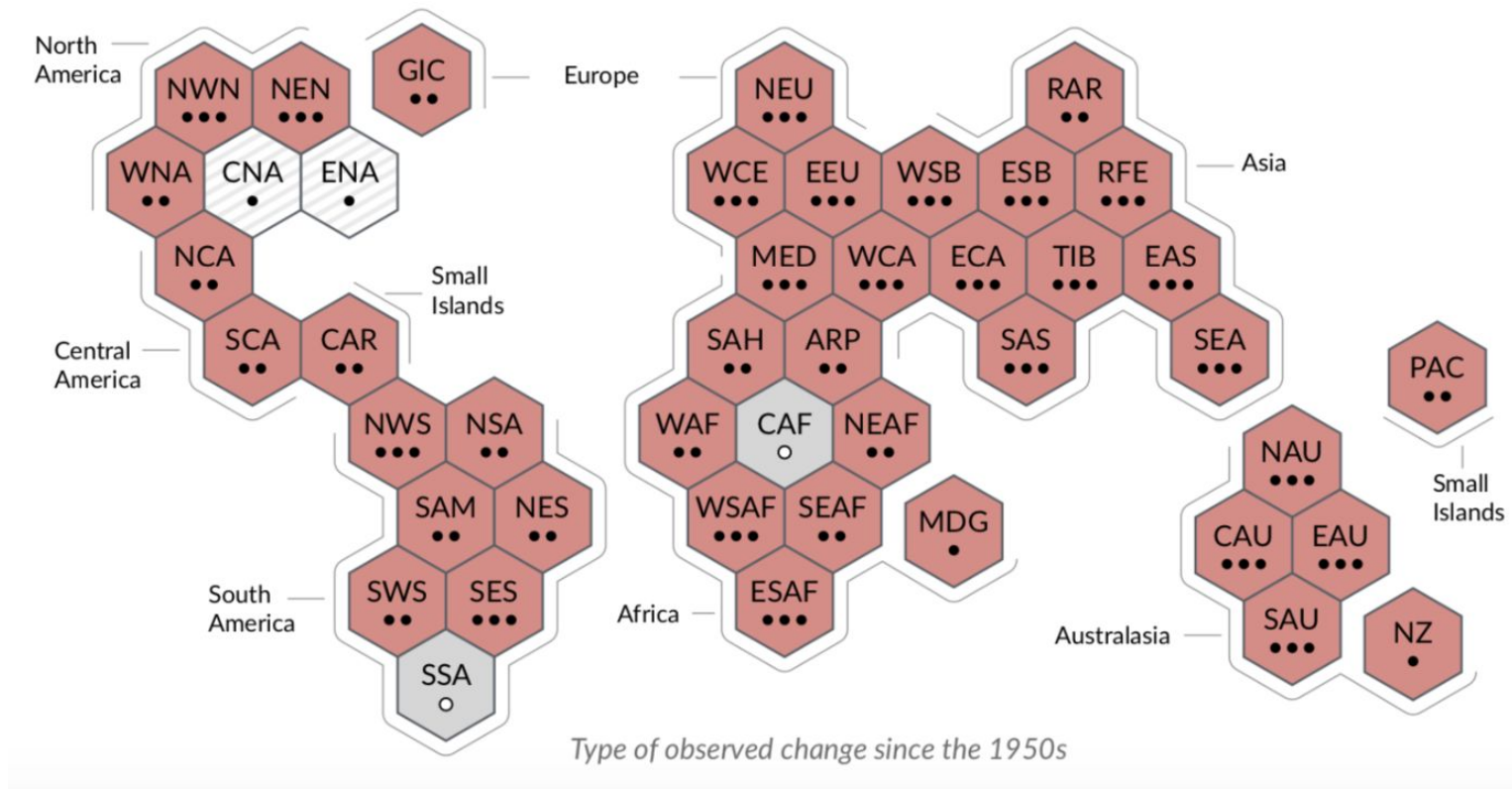
What does the science say?



The Intergovernmental **P**anel on **C**limate **C**hange (**IPCC**) is a group of scientists who come together every few years to form and communicate the scientific consensus on climate change.

See also the [North Carolina Climate Science Report \(2020\)](#)

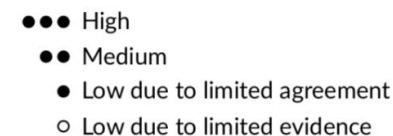
Observed changes in heat waves



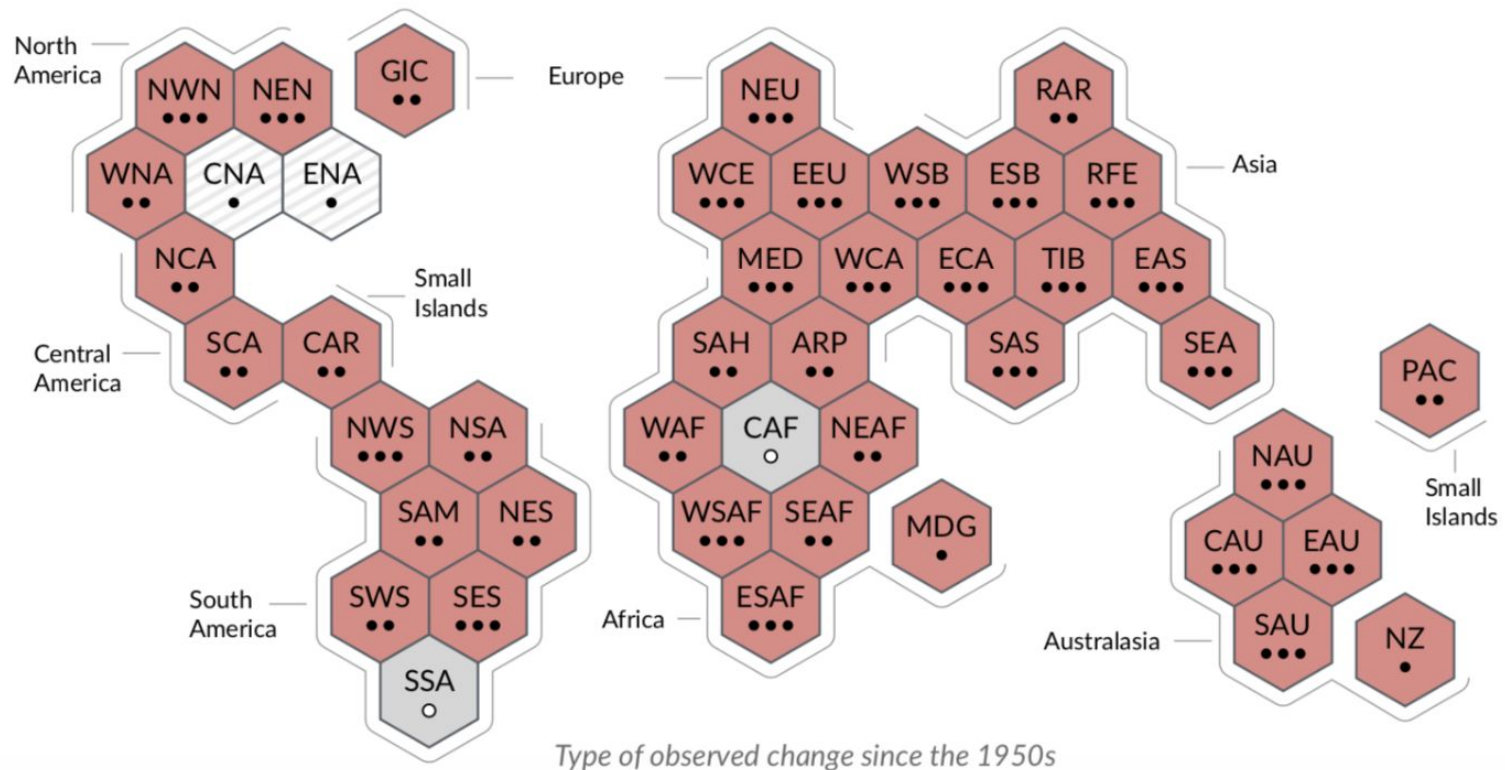
Type of observed change in hot extremes



Confidence in human contribution to the observed change

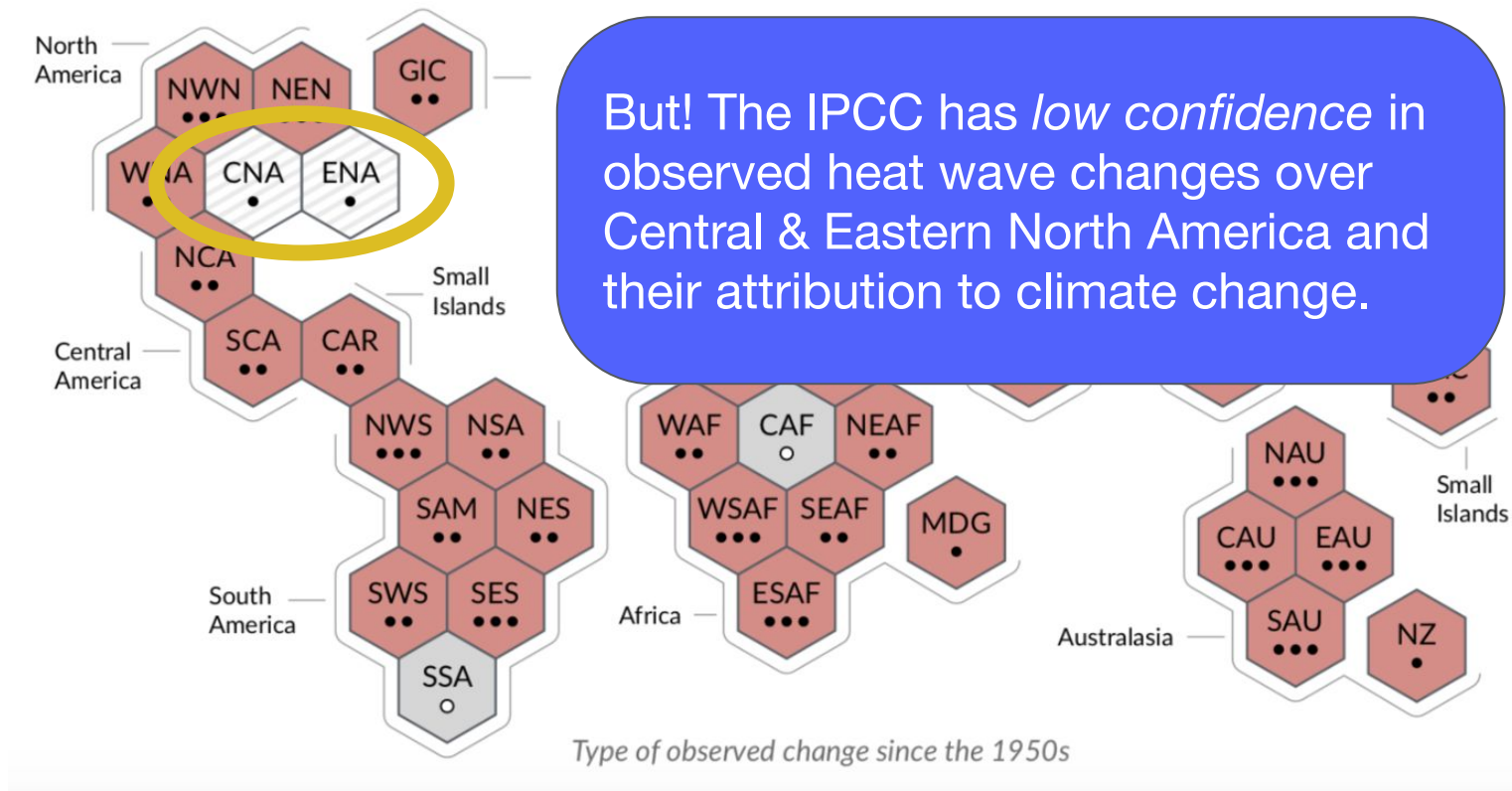


Observed changes in heat waves

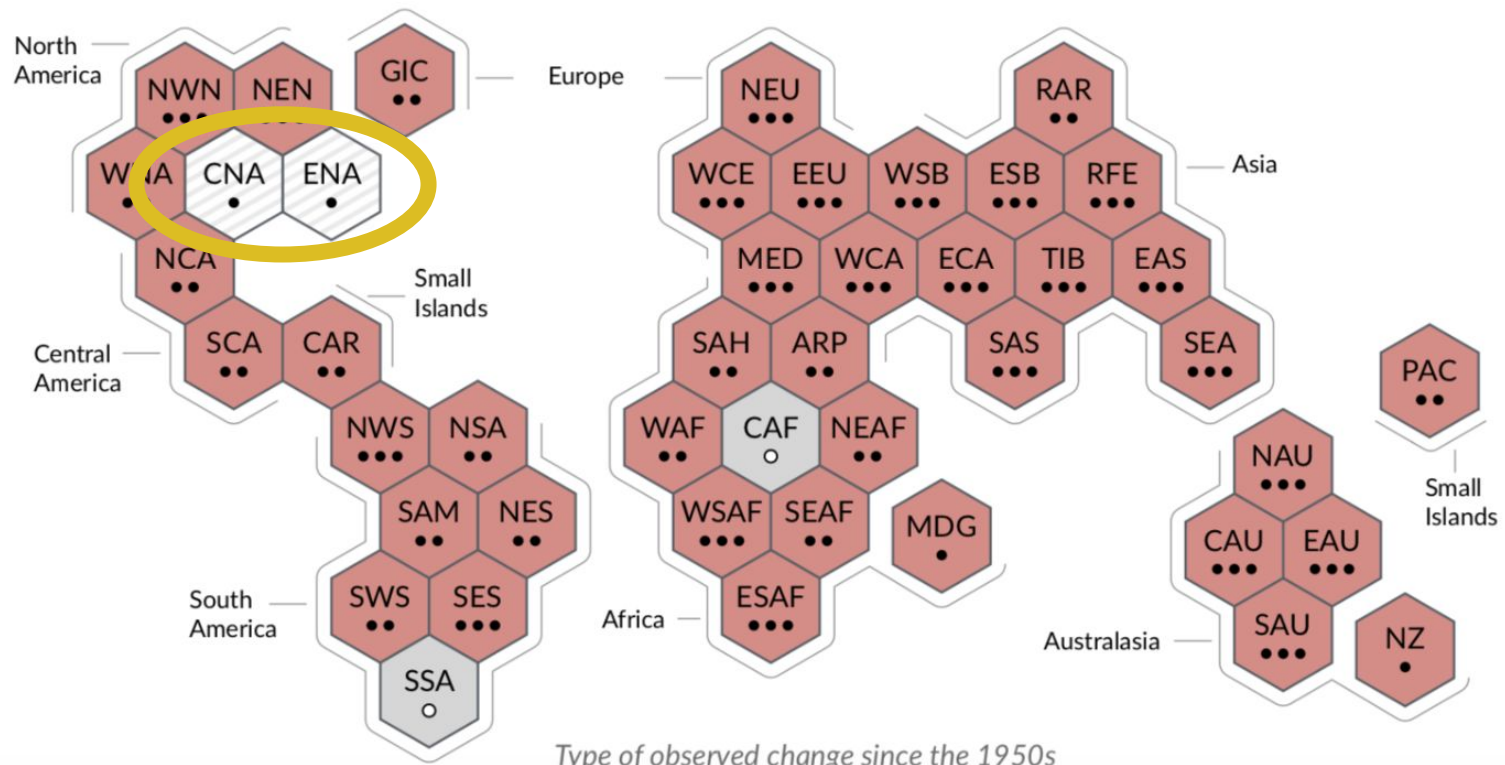


**In most places, heat waves
have become 3°F hotter.**

Observed changes in heat waves



Heat waves are intensifying *globally*.



Unsettled



WHAT CLIMATE SCIENCE
TELLS US, WHAT IT DOESN'T,
AND WHY IT MATTERS

Steven E. Koonin

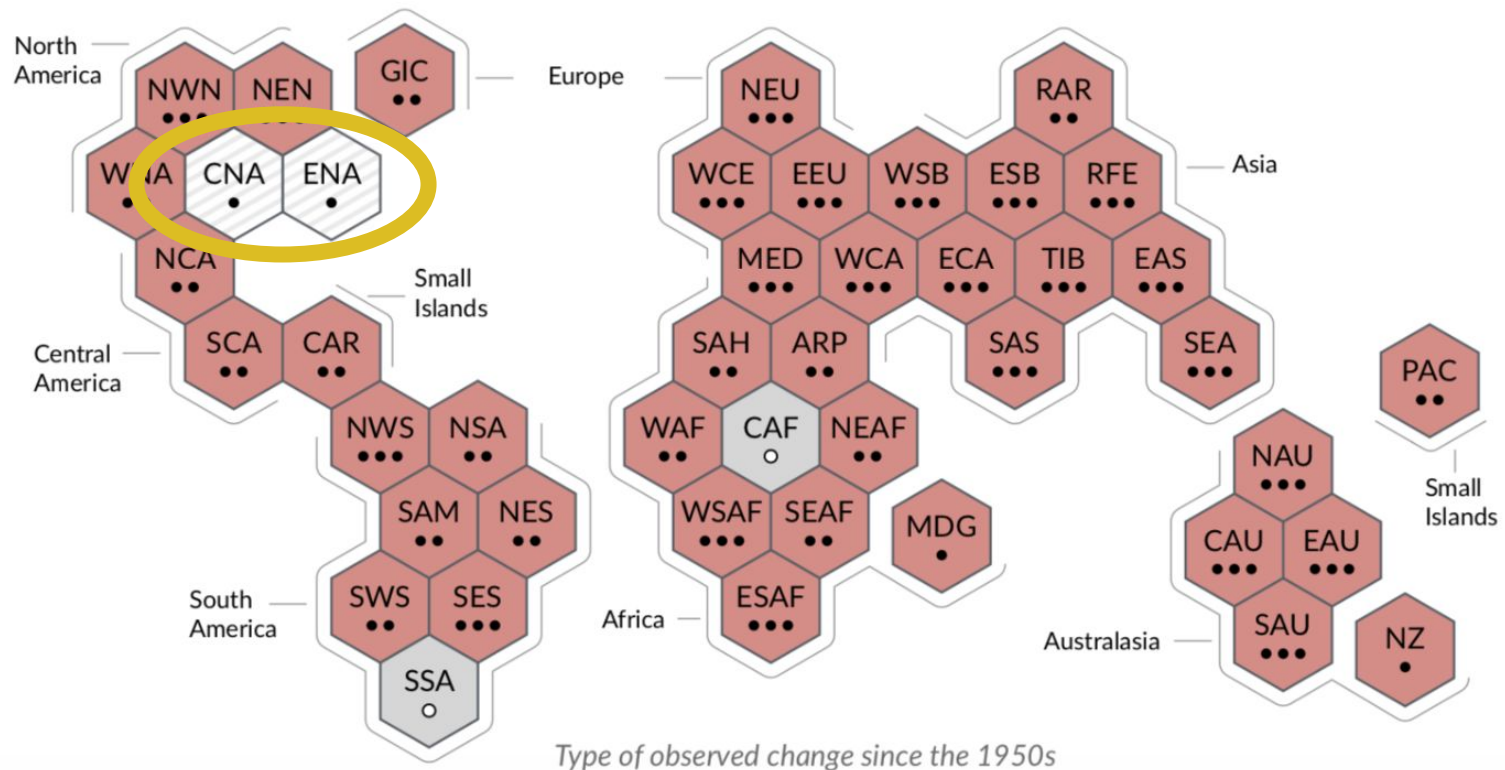
FORMER UNDERSECRETARY FOR SCIENCE,
U.S. DEPARTMENT OF ENERGY
UNDER THE OBAMA ADMINISTRATION

“Heat waves in the U.S. are now **no more common** than they were in 1900.”

—Steven E. Koonin, *Unsettled*

→ **Misleading, and hides the bigger picture!**

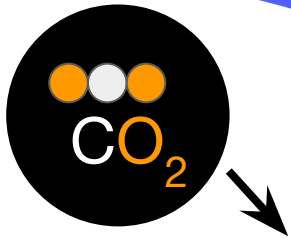
Observed changes in heat waves



Looking forward, the IPCC concludes that: If global warming reaches $\sim 4^{\circ}\text{F}$, it is **very likely** that ENA & CNA will see an increase in the intensity and frequency of hot extremes.

The Landscape of Climate Knowledge

Uncertain



CO₂
Increase



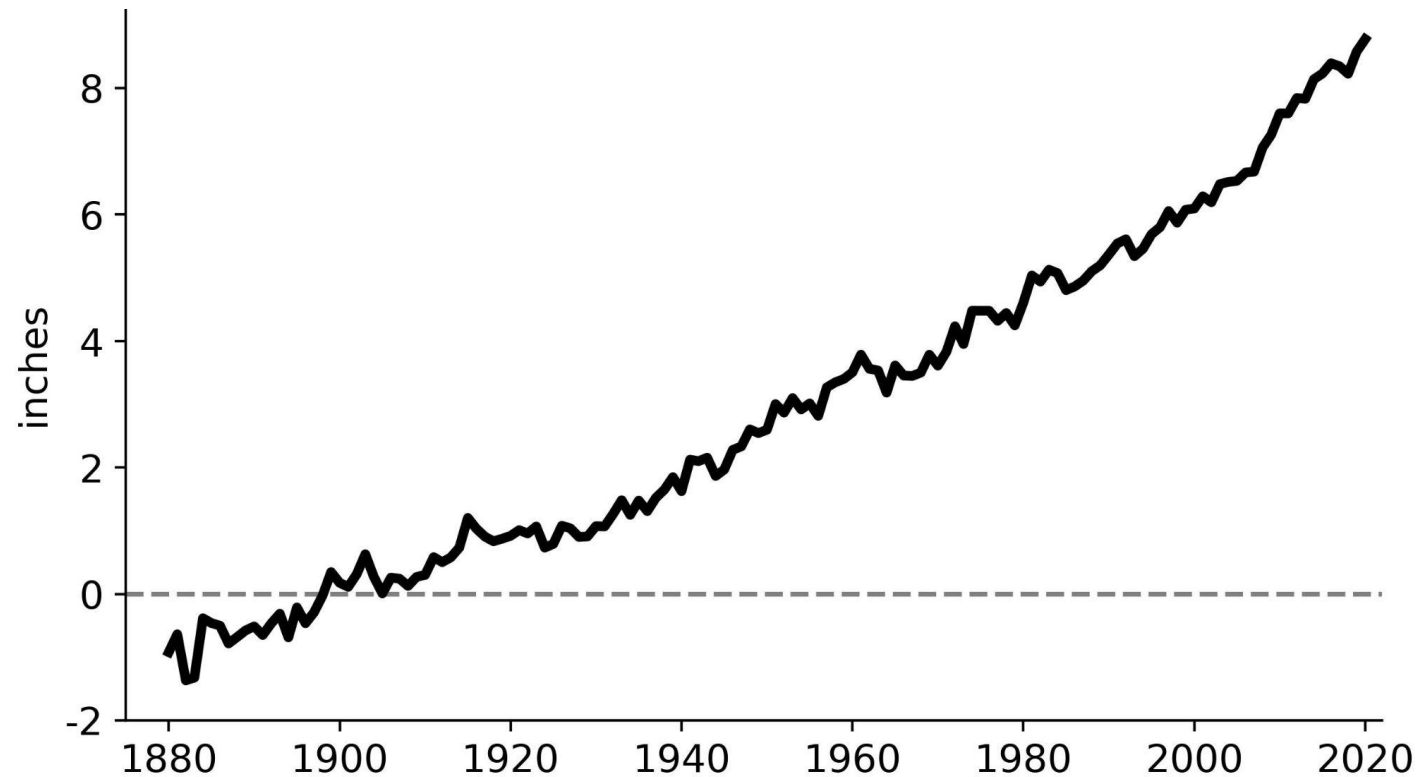
Average
Temperature
Increase

Settled



Heat
Waves*

Average sea level rise since 1900



Average sea level rise since 1900

8 inches
of sea level
rise to date



‘King tide’ flooding event
in Carolina Beach, 2023

Average sea level rise since 1900

8 inches

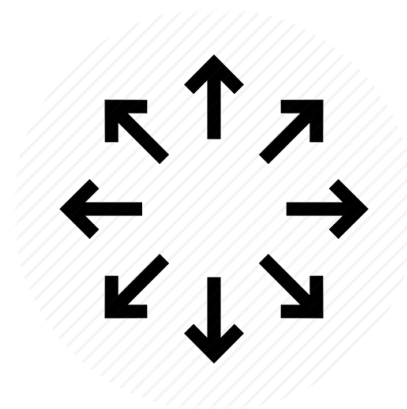
of sea level
rise to date

=



5 inches
from land ice
melting

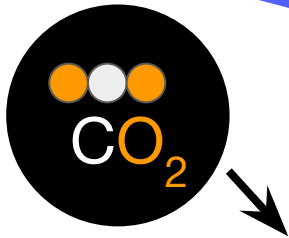
+



3 inches
from thermal
expansion

The Landscape of Climate Knowledge

Uncertain



CO₂
Increase



Average
Temperature
Increase

Settled



Heat
Waves*



Gradual Sea
Level Rise



Cirrostratus veil

ice crystals that make the halos

Upper tangent arc

merges with top of 22° halo

Lens flare

camera artifact, not weather

Sundog (parhelion)

with tail pointing away from sun

Sun

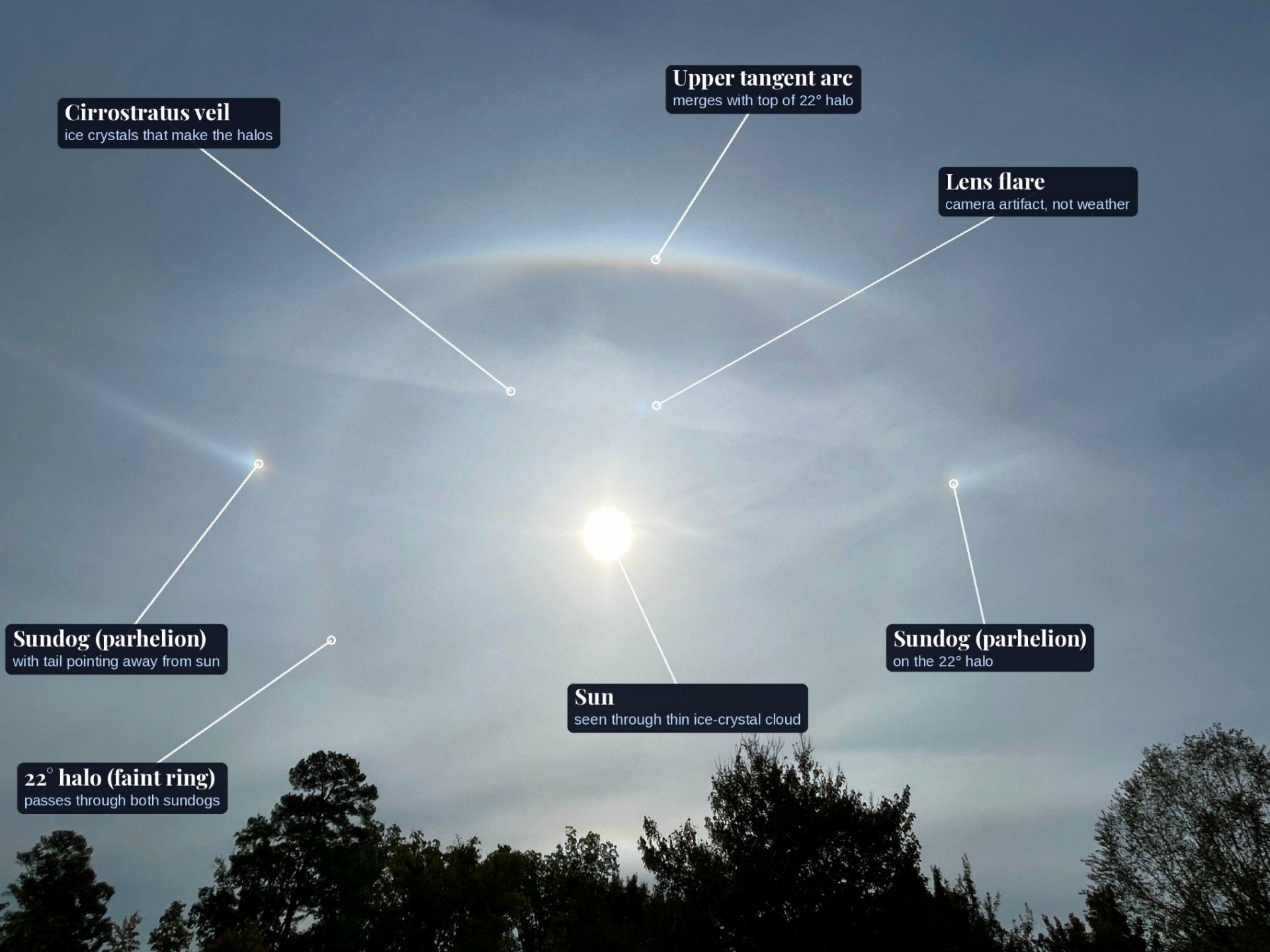
seen through thin ice-crystal cloud

Sundog (parhelion)

on the 22° halo

22° halo (faint ring)

passes through both sundogs





“Snowhenge”

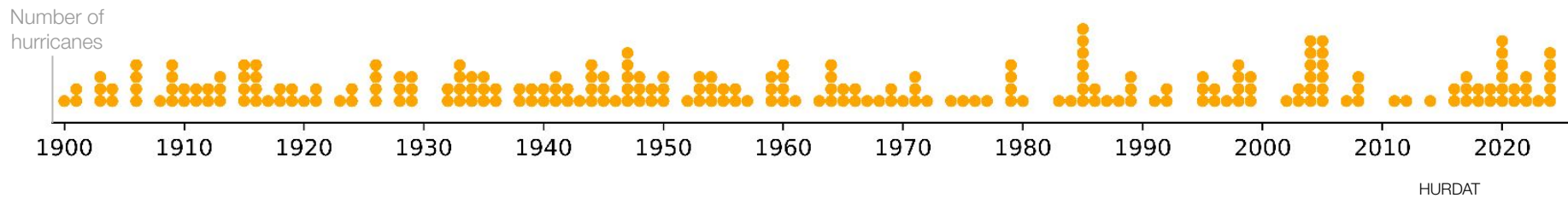


“The hurricane ‘machine’ is climate change. ... As temperatures rise, more hurricanes grow.”

—Rep. Alexandria Ocasio-Cortez, after Hurricanes Helene and Milton (2024)

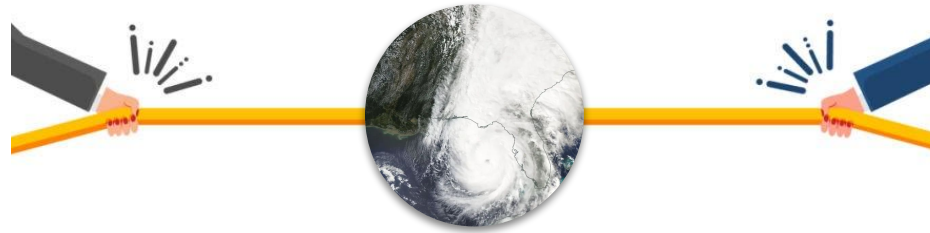
Have warmer oceans caused more hurricanes?

Landfalling hurricanes in the United States



There is **no trend** in the number of landfalling US hurricanes

Will warmer oceans cause more Cat 4+ hurricanes?



←

**Fewer total
hurricanes**

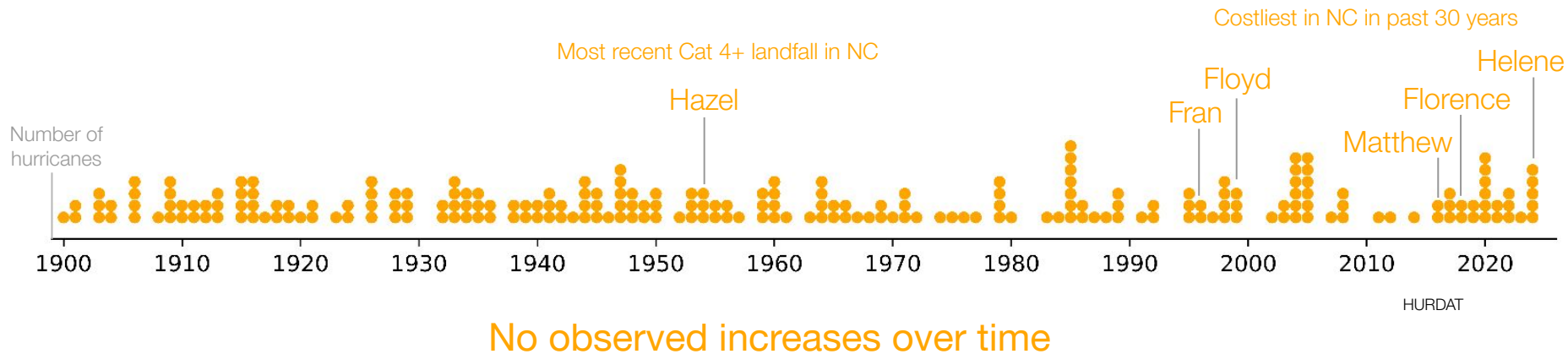
→

**A given hurricane
will be stronger**

The future number of Cat 4+ hurricanes is uncertain.

Most hurricane damage and fatalities in NC come from extreme rainfall.

Landfalling hurricanes in the United States

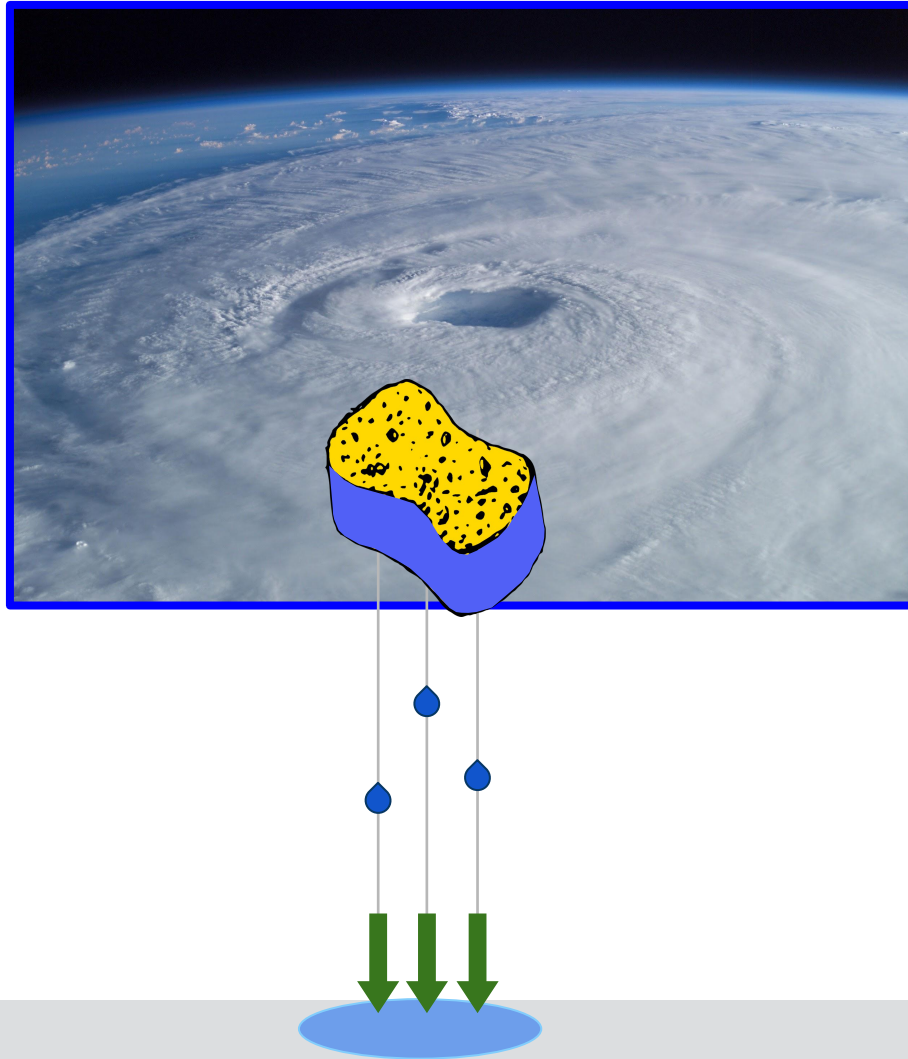


How does hurricane rainfall respond to global warming?

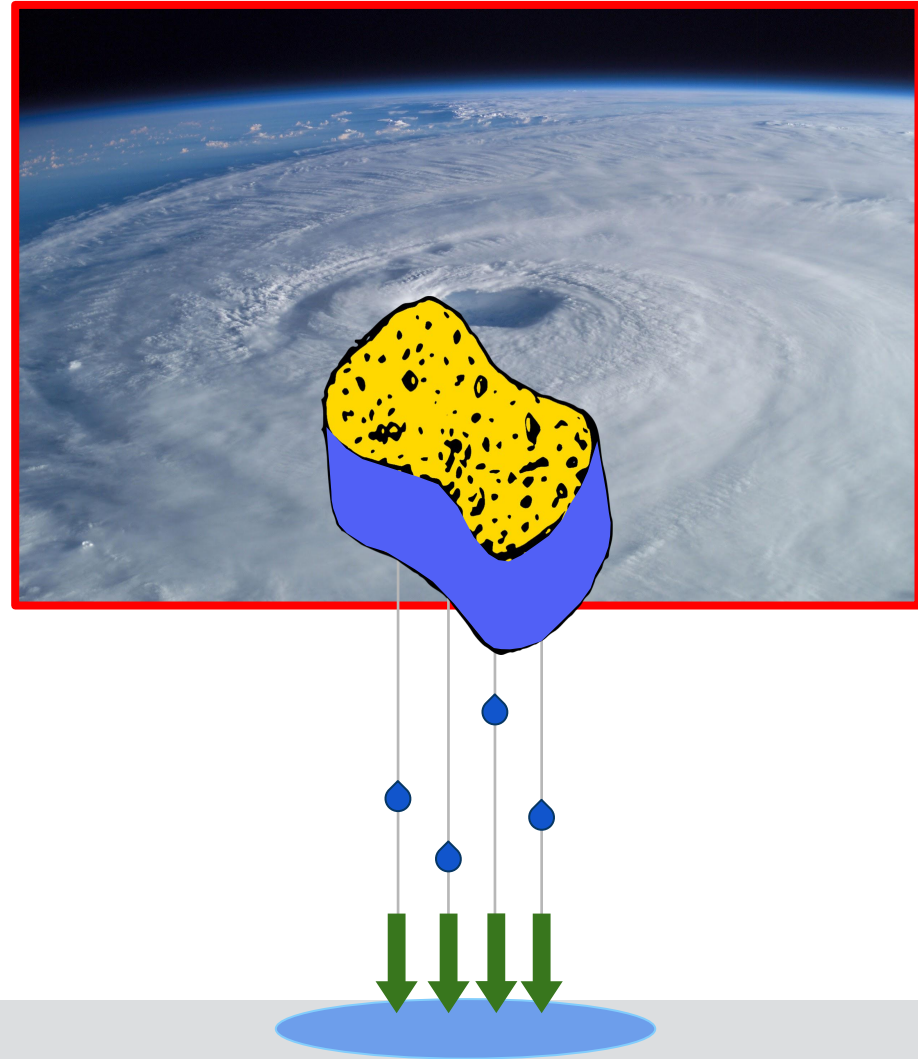
Hurricane rain rate increases about 4% per 1°F

(roughly 10% so far)

Cooler

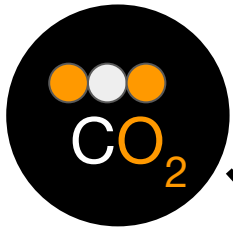


Warmer



The Landscape of Climate Knowledge

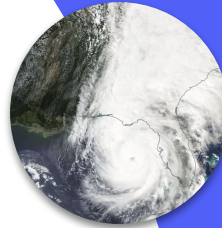
Uncertain



CO₂
Increase



Average
Temperature
Increase



Hurricanes



Heat
Waves*

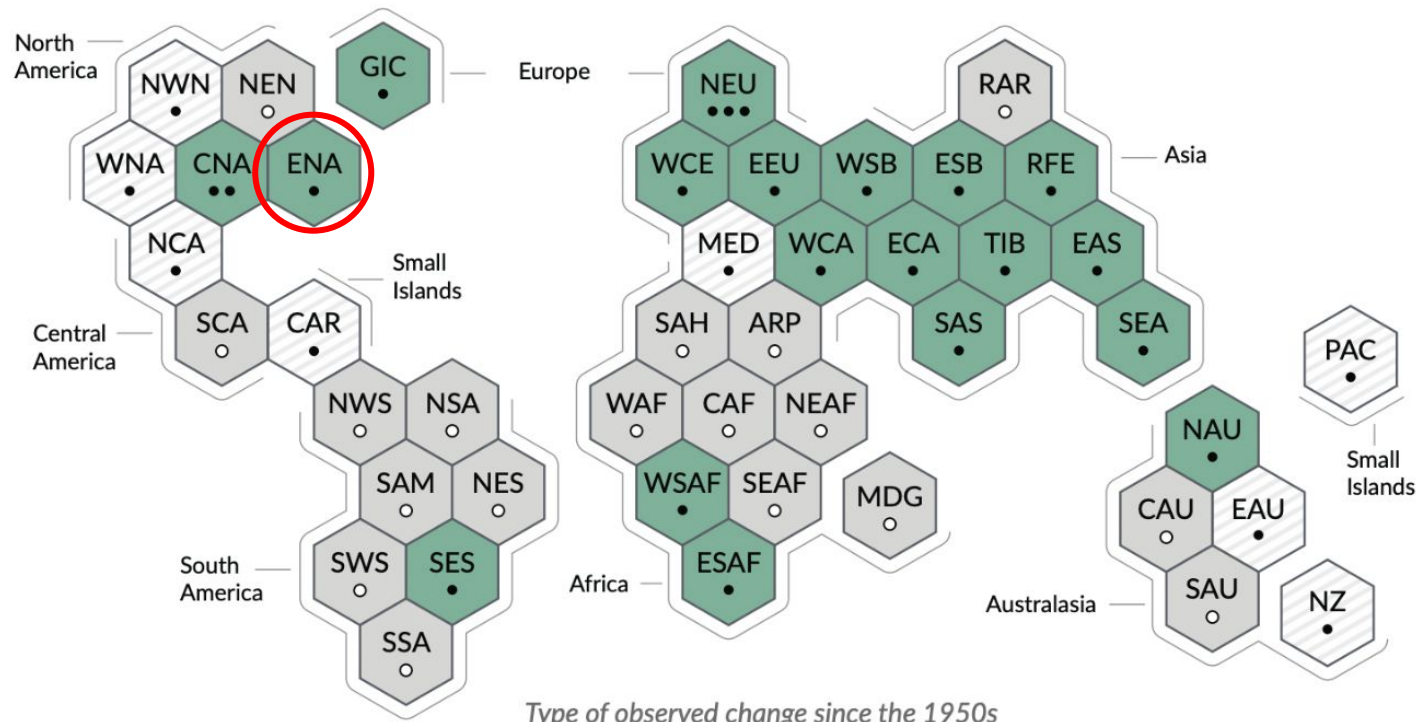


Gradual Sea
Level Rise

Settled

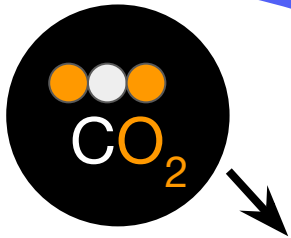
Theory and models: Heavy rain intensifies by 4% per °F.

Observations: Many locations still have limited data.



The Landscape of Climate Knowledge

Uncertain



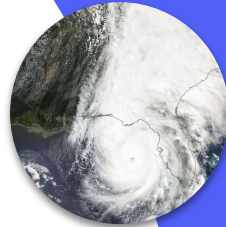
CO₂
Increase



Average
Temperature
Increase



Extreme
rainfall



Hurricanes



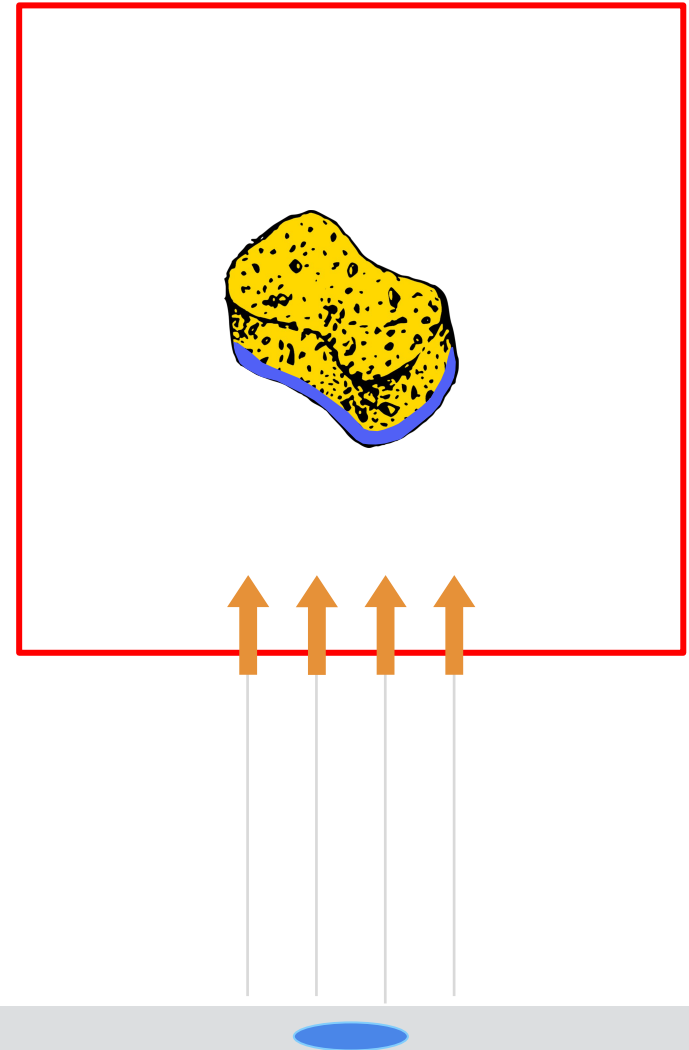
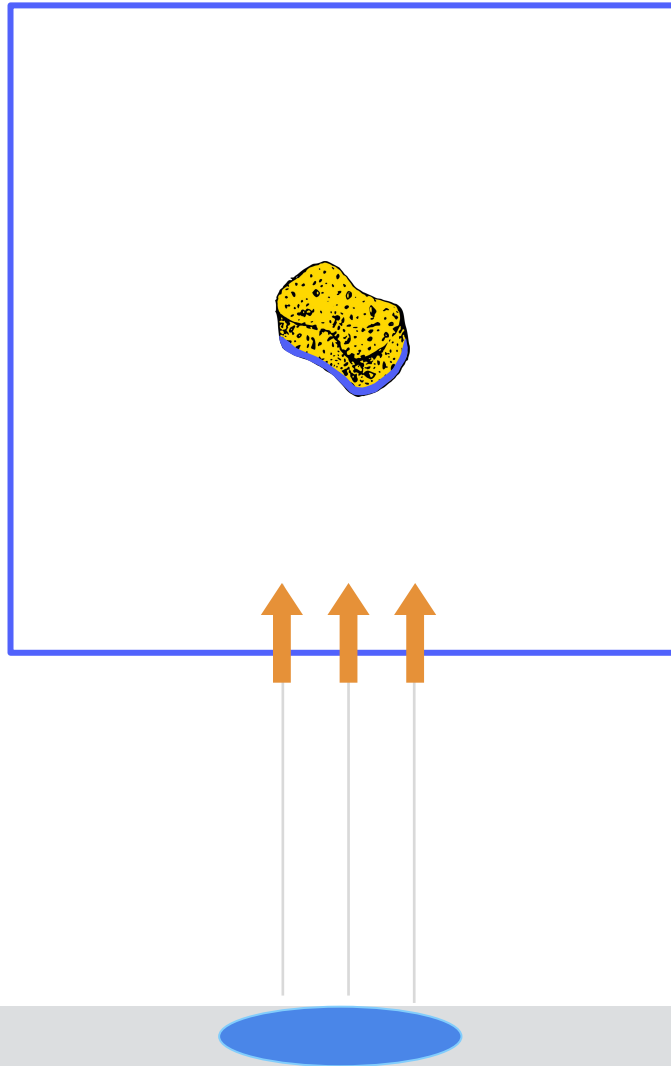
Heat
Waves*



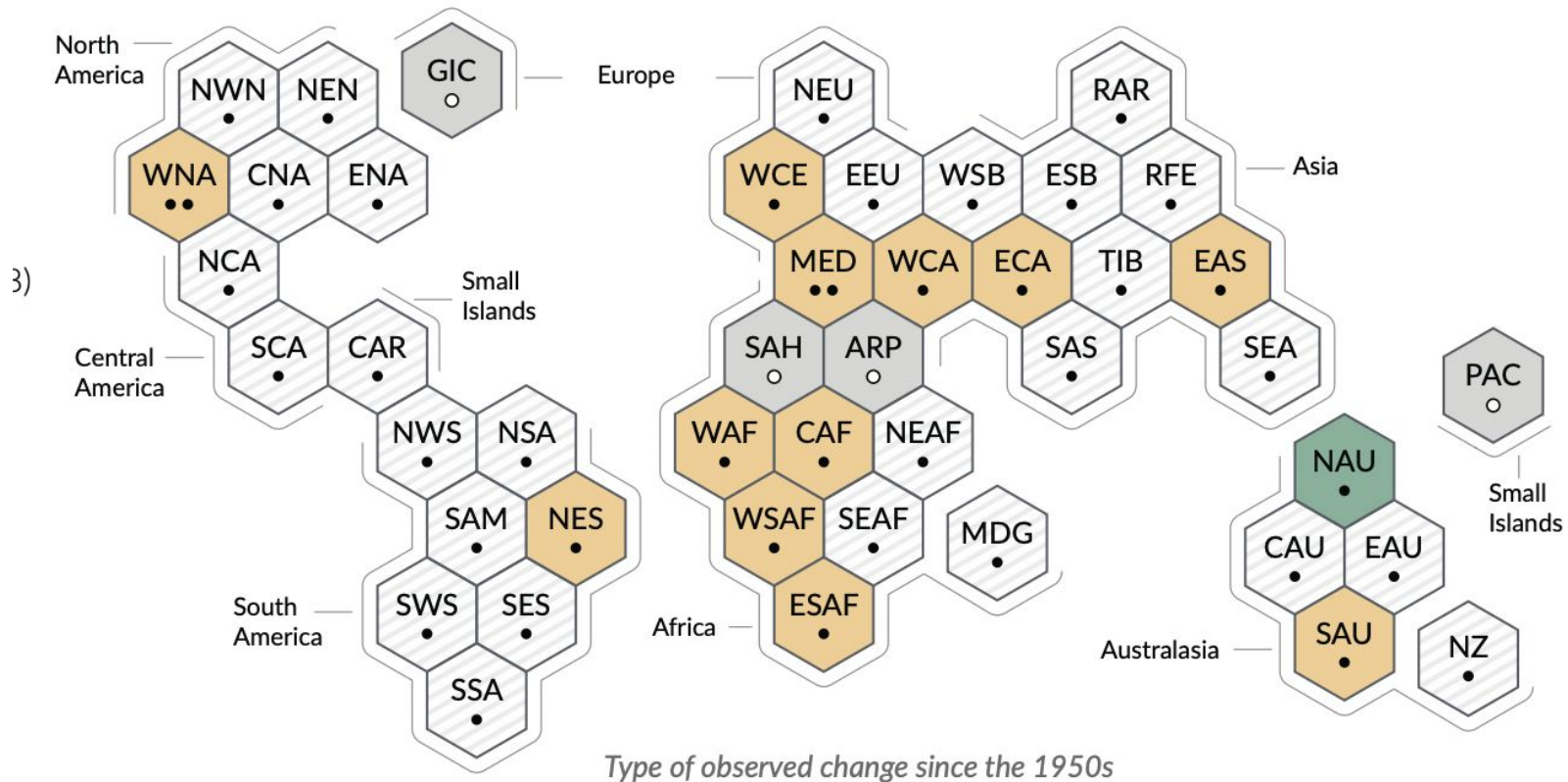
Gradual Sea
Level Rise

Settled

Extreme evaporation also intensifies with warming.

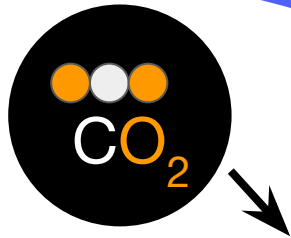


No significant drought trends in Eastern North America



The Landscape of Climate Knowledge

Uncertain



CO₂
Increase

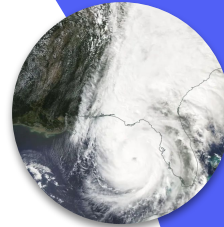
Settled



Average
Temperature
Increase



Extreme
rainfall



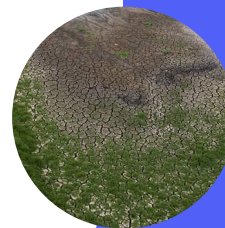
Hurricanes



Heat
Waves*



Gradual Sea
Level Rise



Droughts

Tipping points?

West Antarctic Ice Sheet collapse



“Poorly understood processes of instabilities, characterized by deep uncertainty”

Collapse of the AMOC

Atlantic Meridional
Overturning Circulation



“It is very likely that AMOC will decline in the 21st century, but there is low confidence in the model’s projected timing and magnitude.”

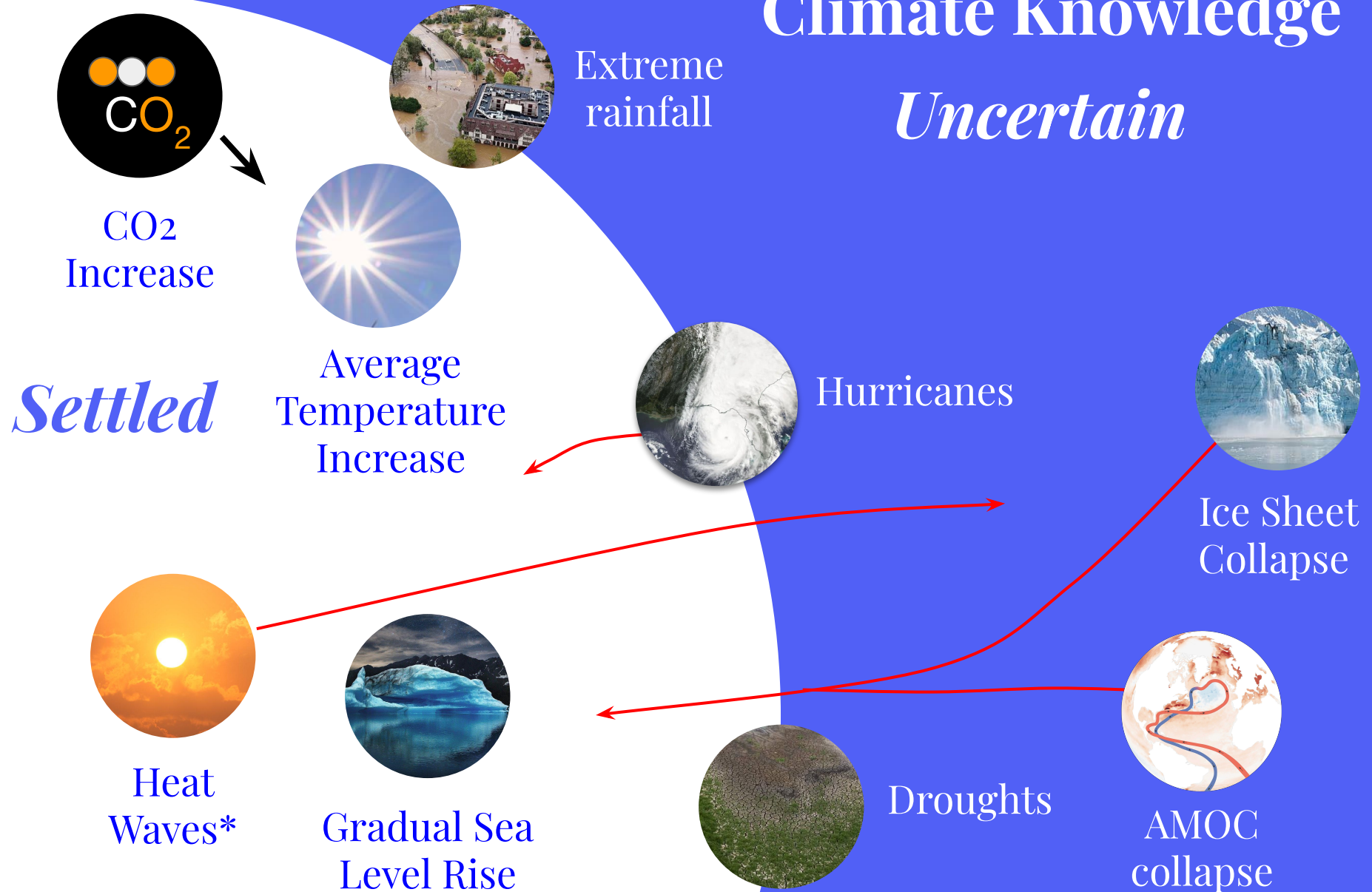


“We have to cut the emissions that are warming the planet and heading us **inexorably** toward several tipping points beyond which there is no reverse.”

—John Kerry (2023)

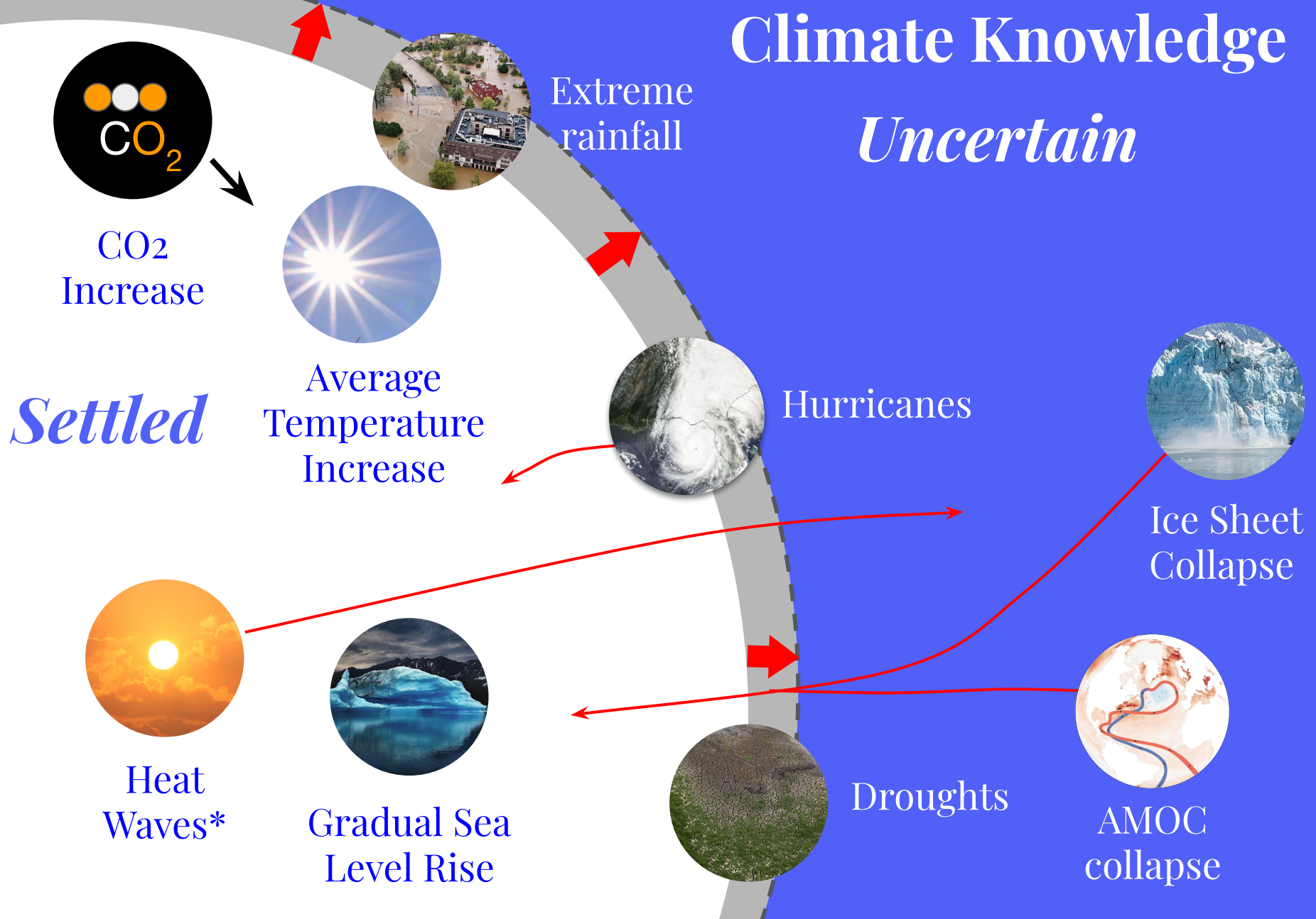
The Landscape of Climate Knowledge

Uncertain



The Landscape of Climate Knowledge

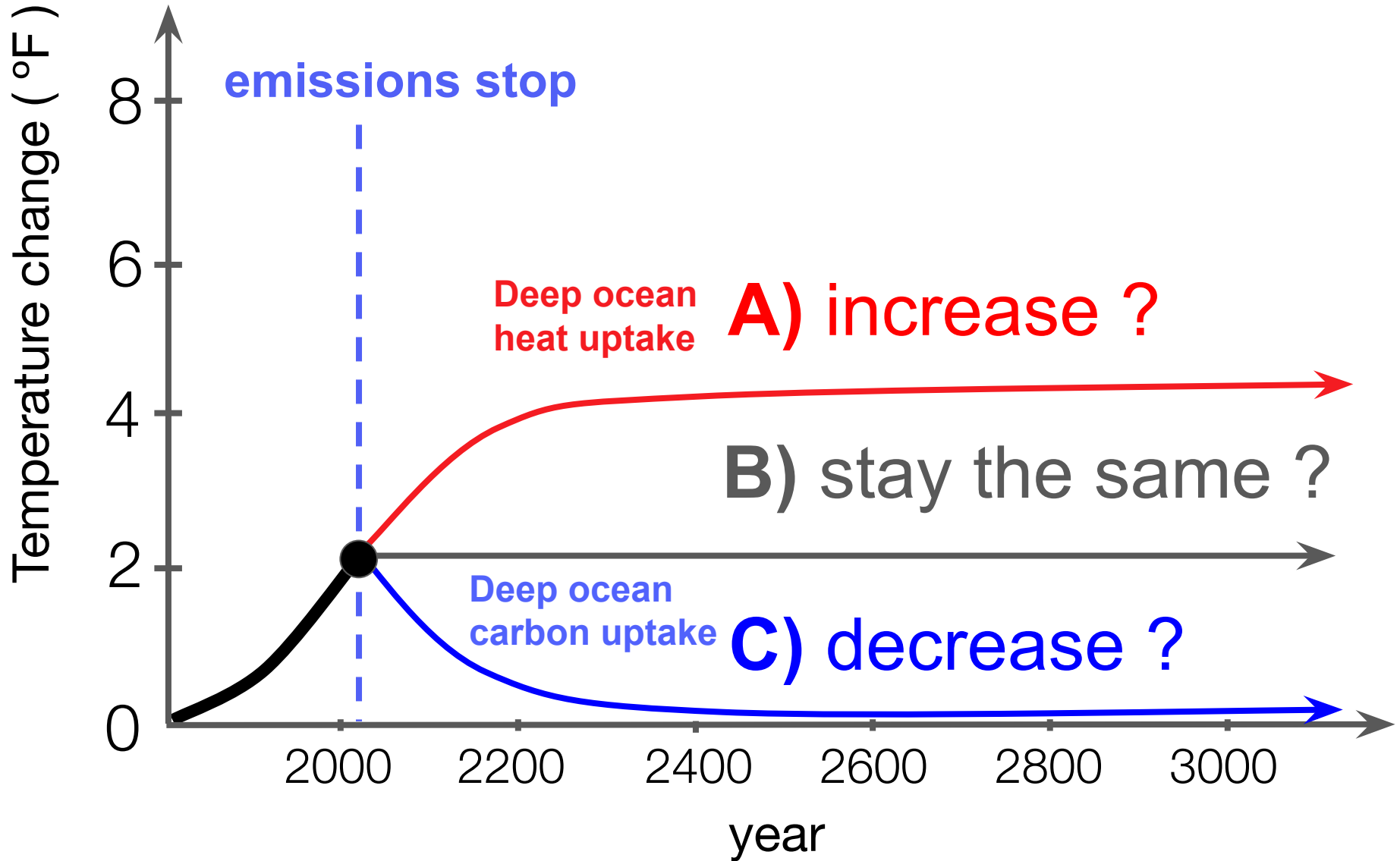
Uncertain

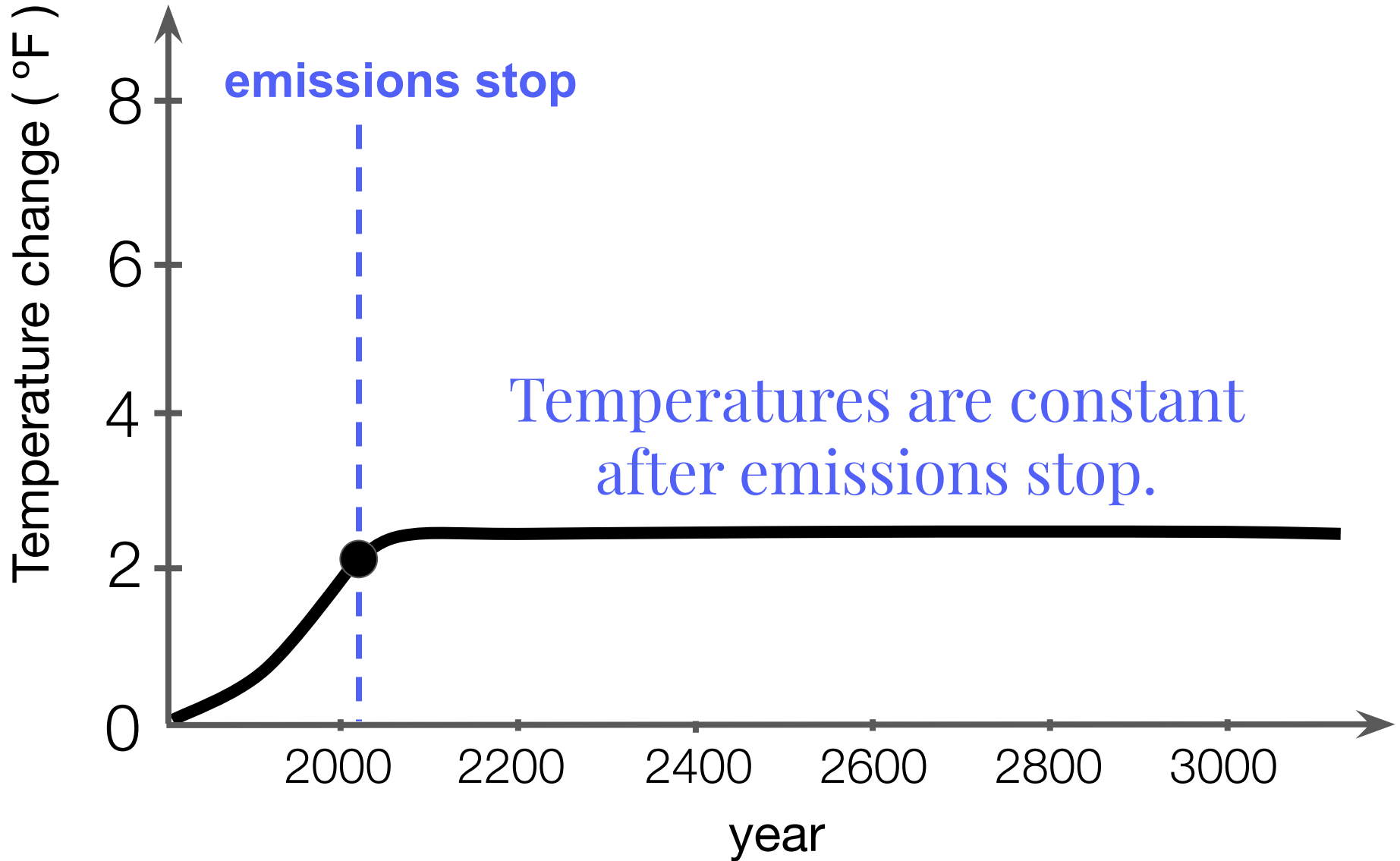


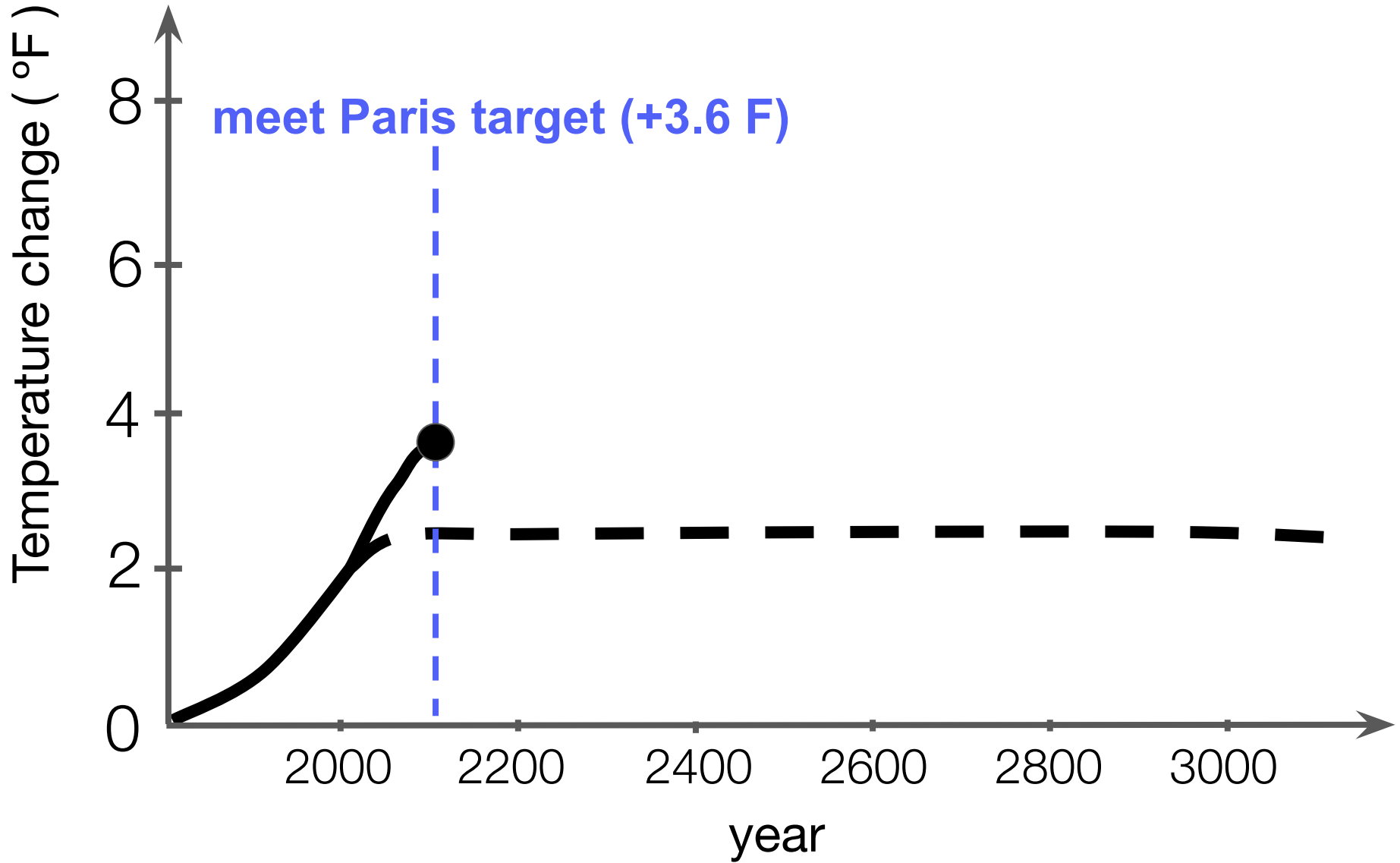
What does the
future hold?

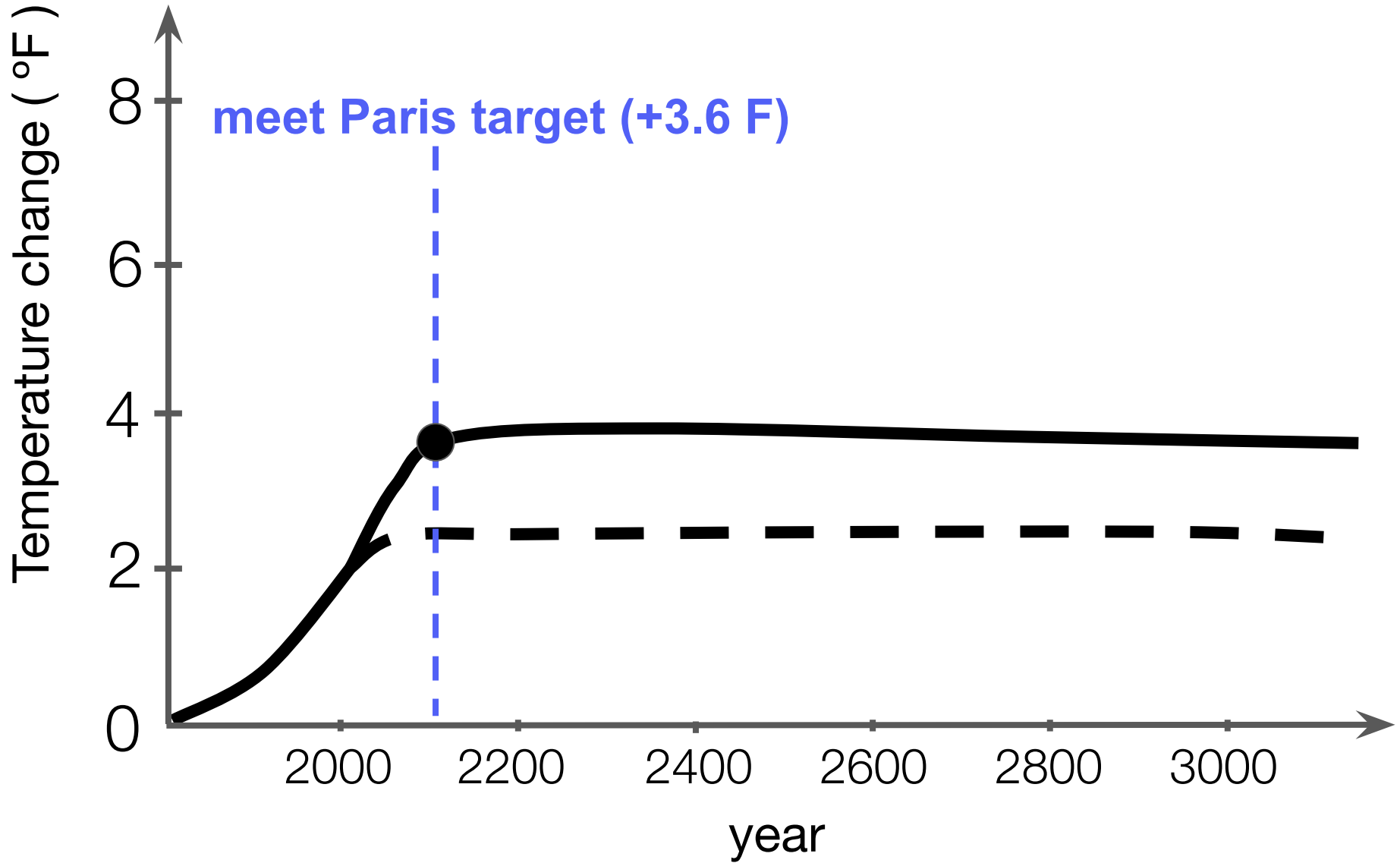


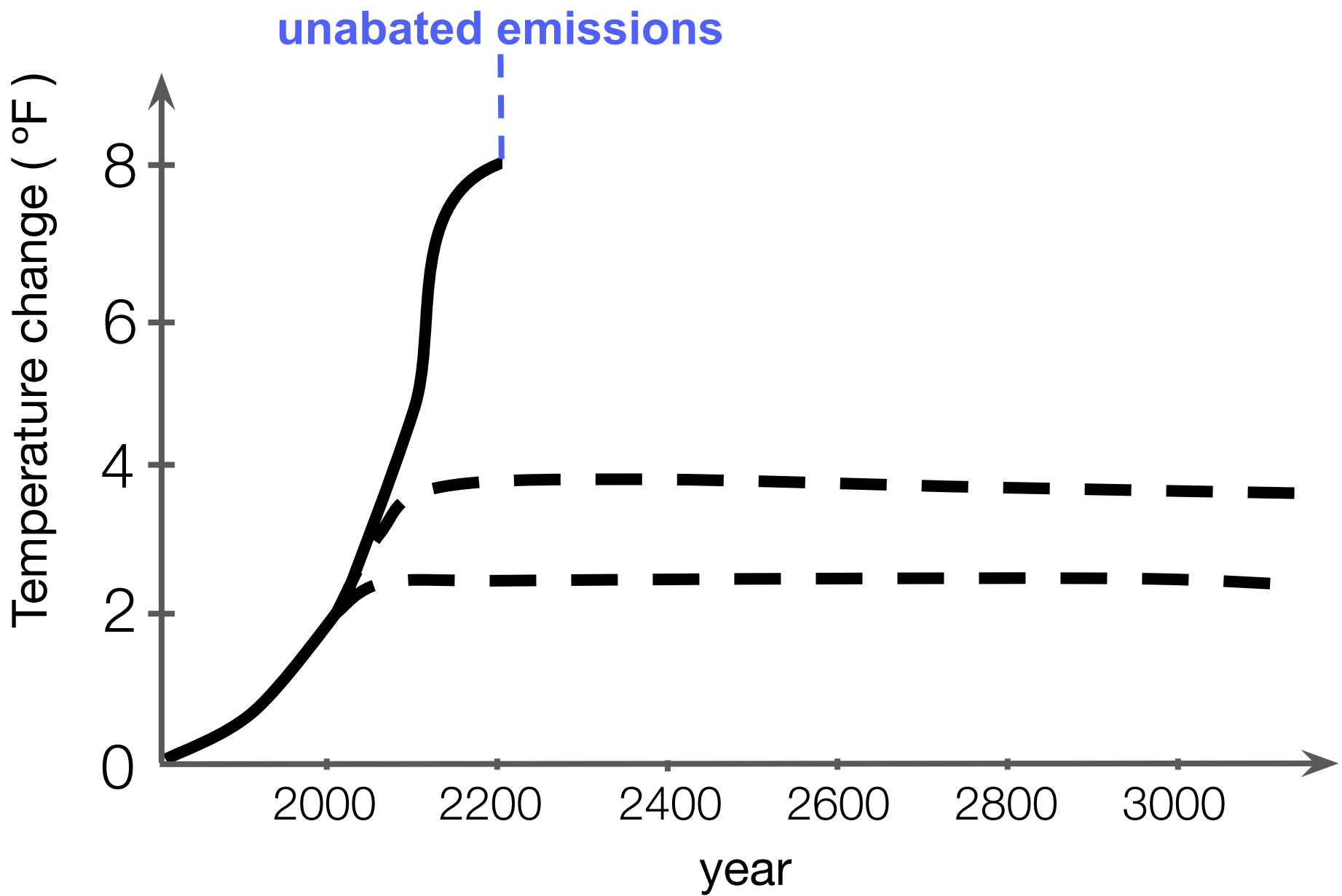
Q: If we stopped emitting CO₂ tomorrow, what would happen to global temperature?

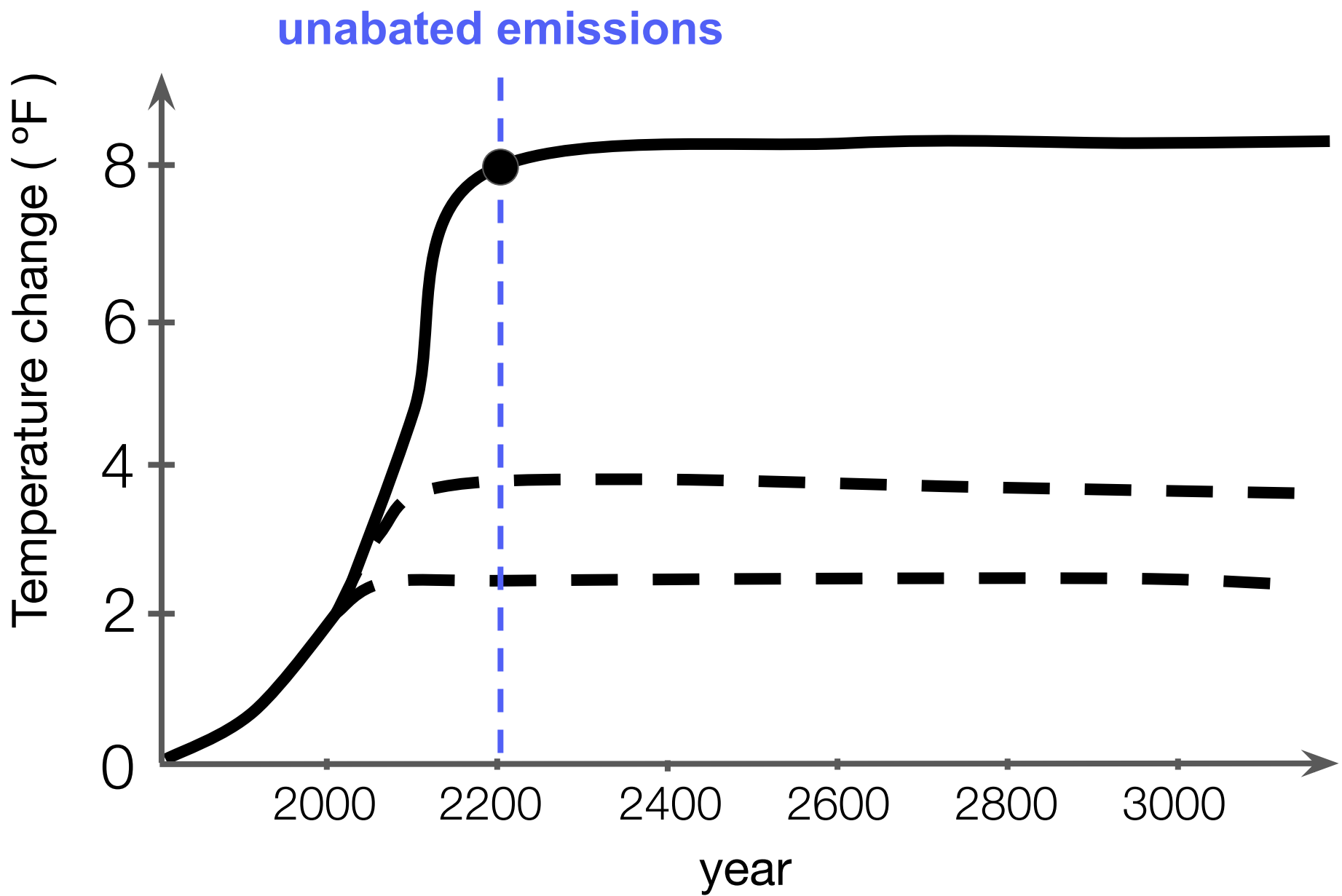


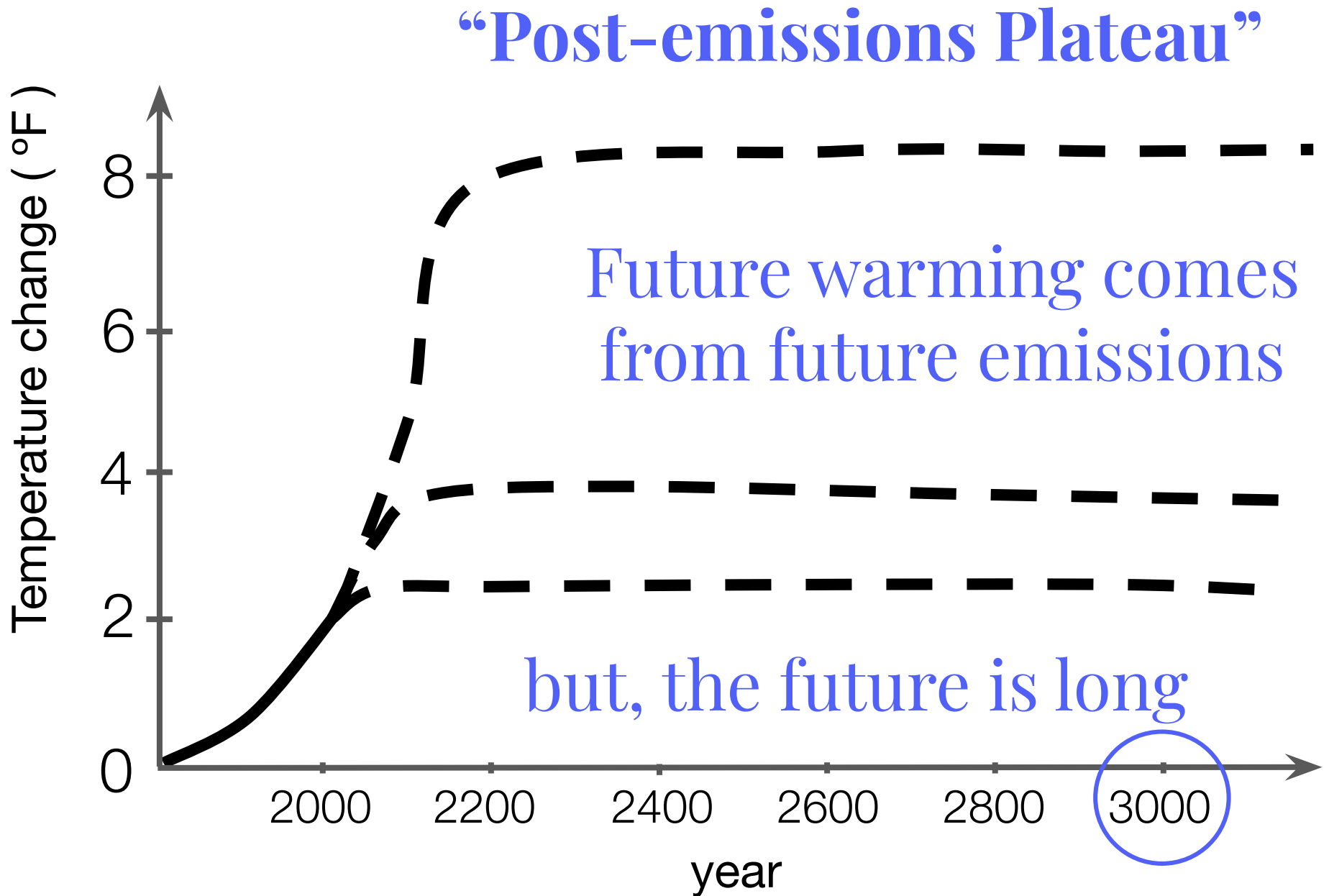






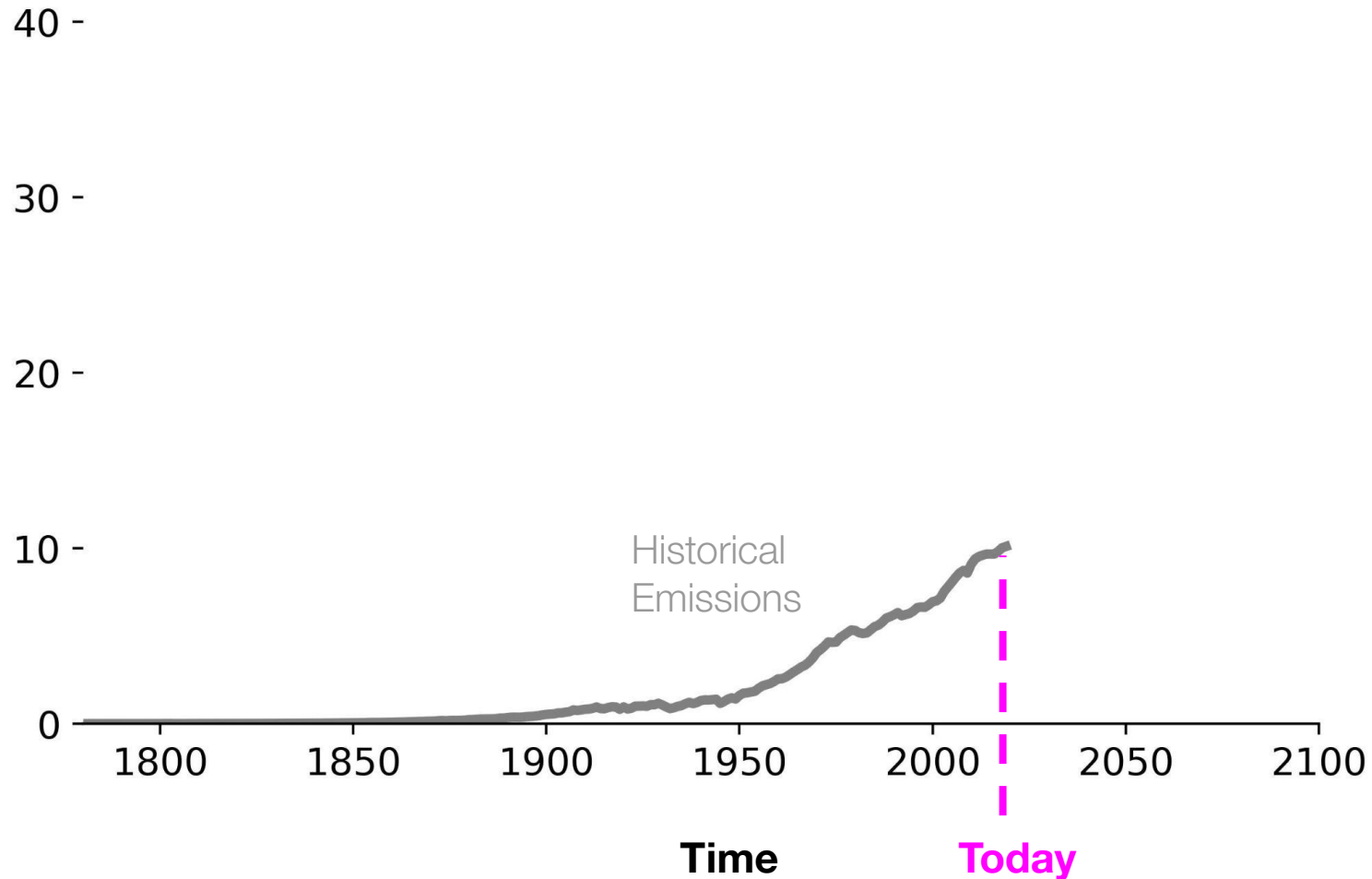






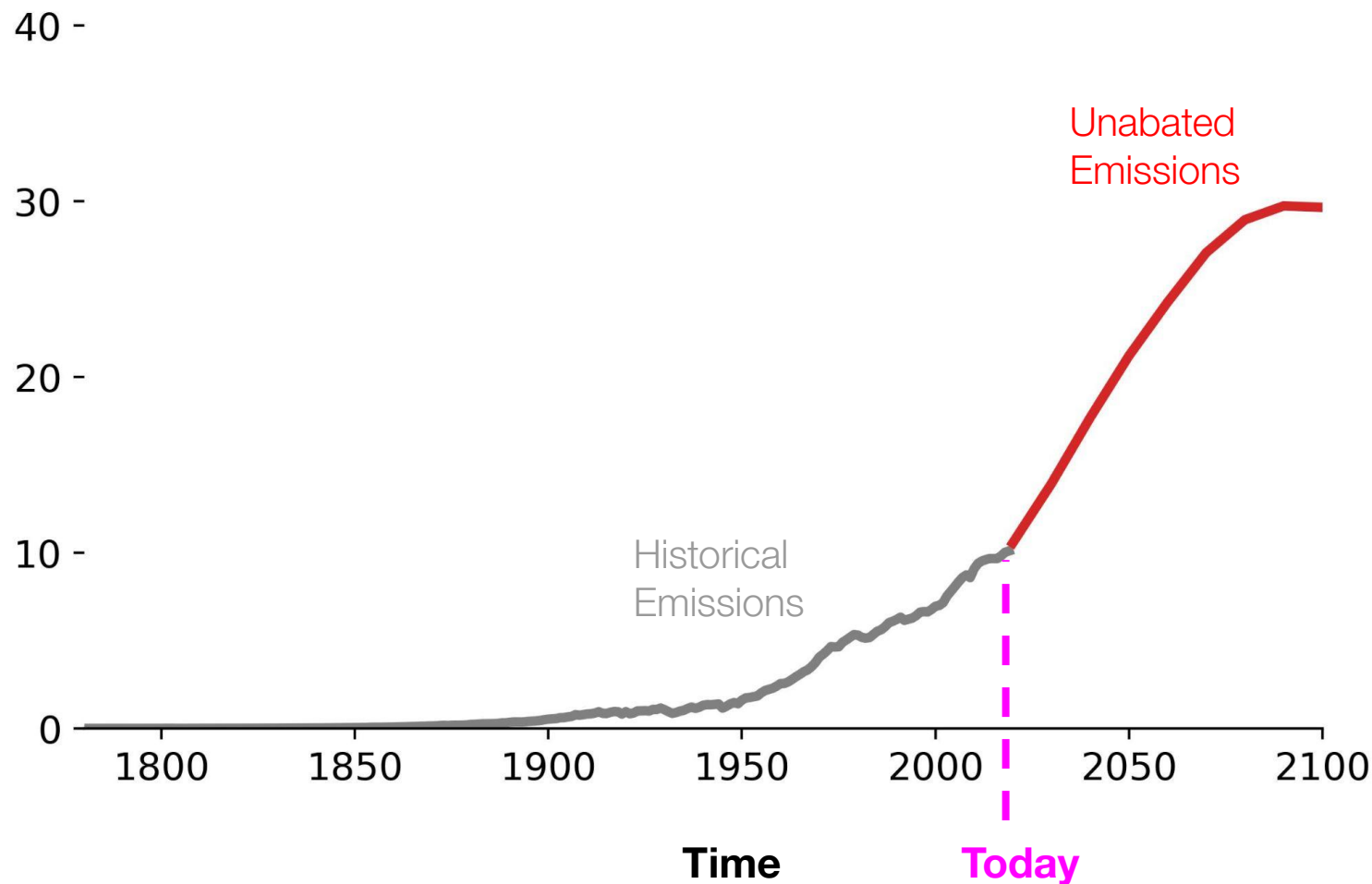
What do emissions scenarios look like?

**Annual Emissions
(gigatons carbon/year)**



What do emissions scenarios look like?

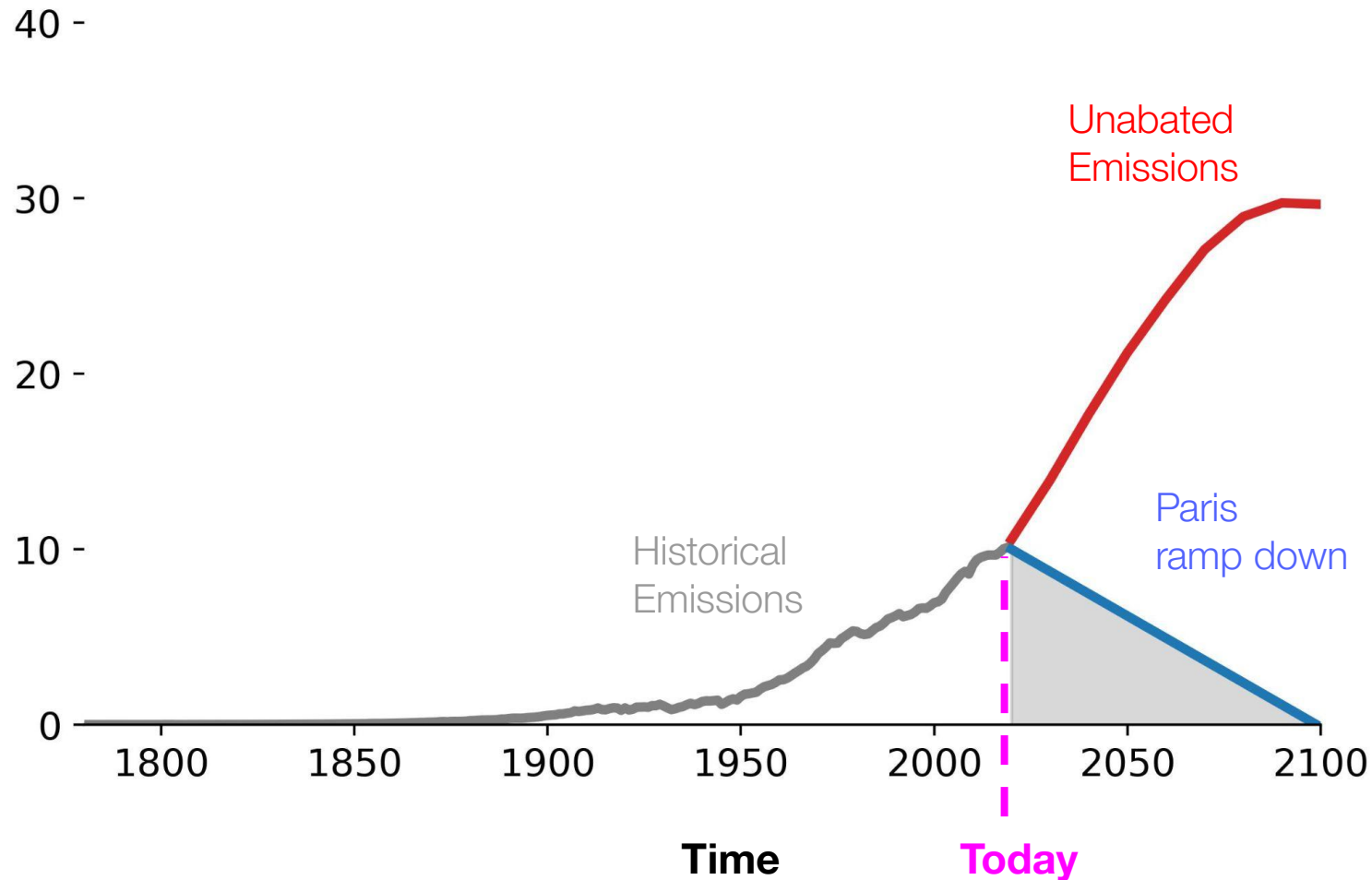
Annual Emissions (gigatons carbon/year)



Source: Future unabated emissions are [SSP5-8.5](#).
Global temperature estimate at 2100 for SSP5-8.5 is from Table 4.2 of IPCCAR6WGI Ch. 4

What do emissions scenarios look like?

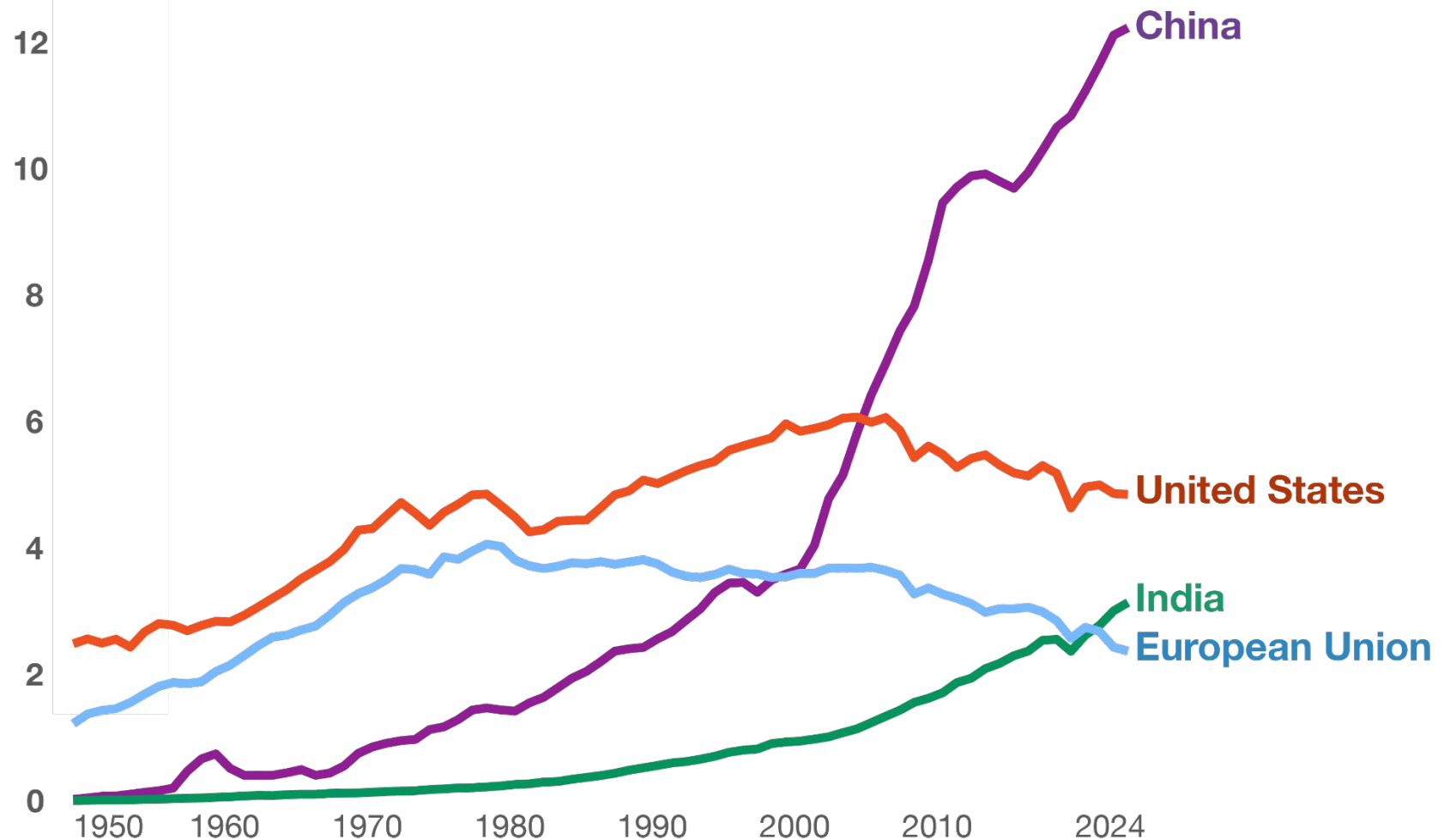
Annual Emissions (gigatons carbon/year)



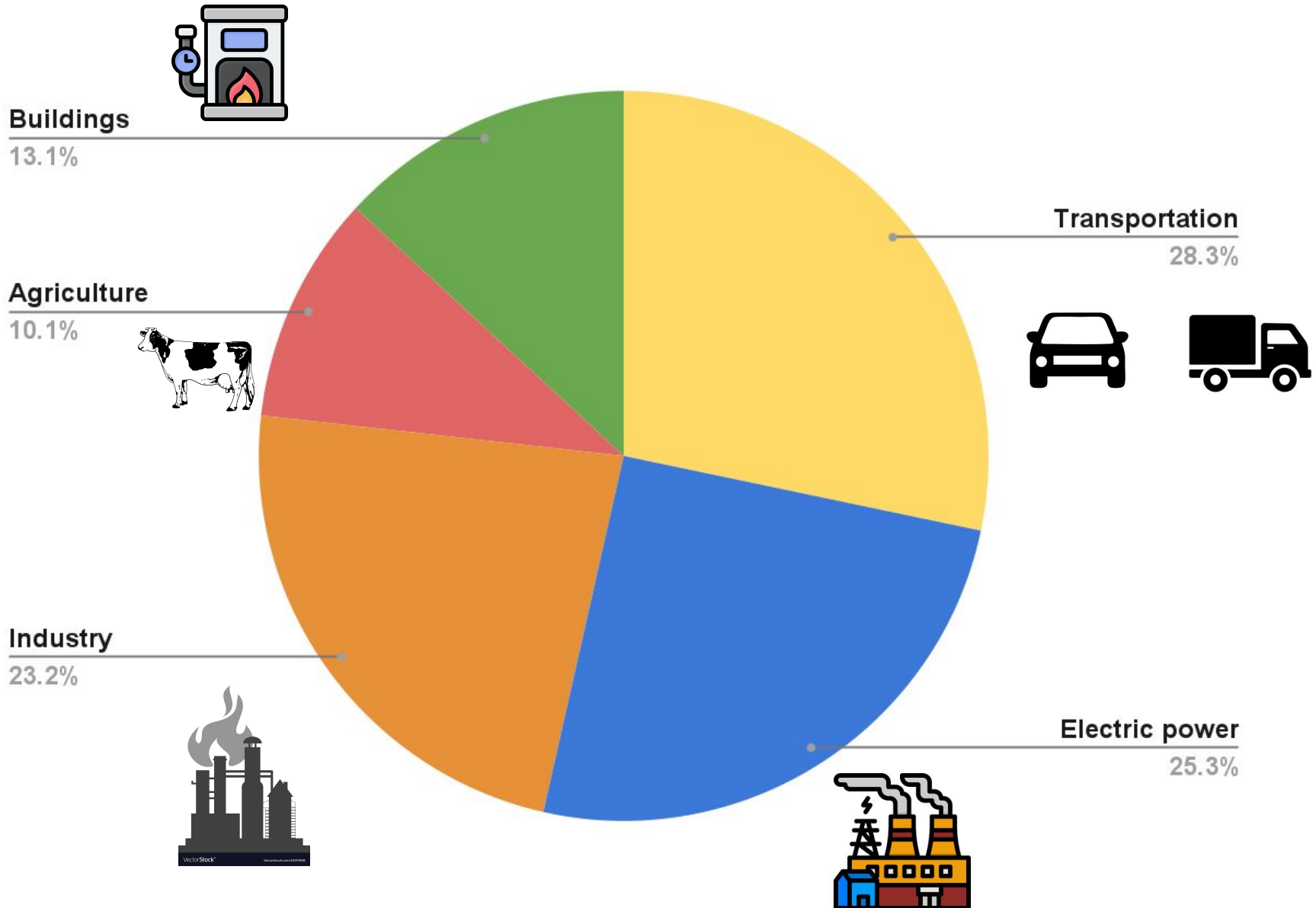
Source: Future unabated emissions are [SSP5-8.5](#).
Global temperature estimate at 2100 for SSP5-8.5 is from Table 4.2 of IPCCAR6WGI Ch. 4

Emissions around the world

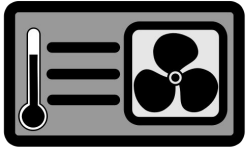
**Annual Emissions
(gigatons carbon/year)**



U.S. CO₂-eq emissions



U.S. CO₂-eq emissions



16% of households

Buildings

13.1%

Agriculture

10.1%

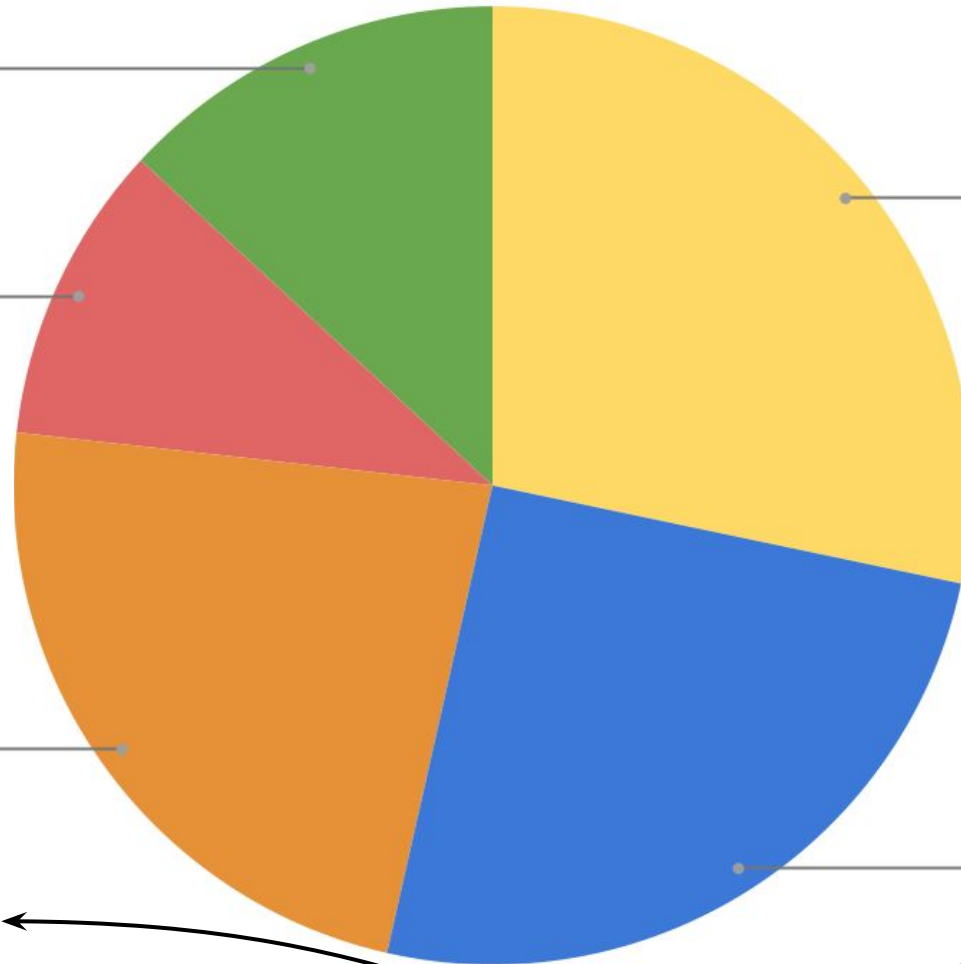
~ 1% of
meat sales



Industry

23.2%

<1% of
industrial
heat



Transportation

28.3%

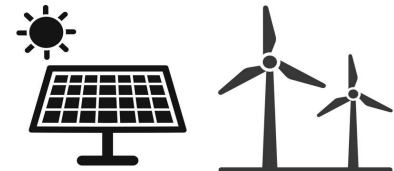


2% of fleet
7% of sales

Electric power

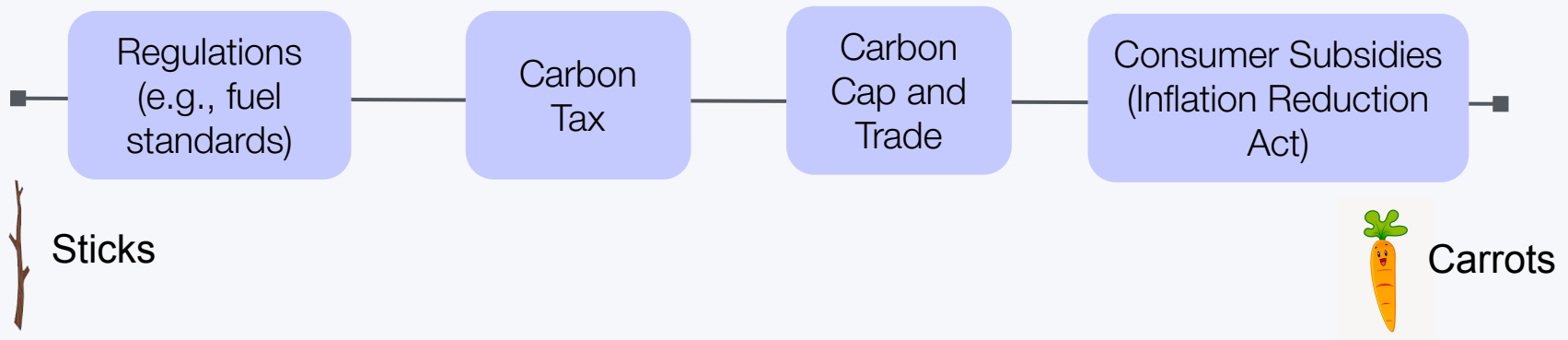
25.3%

17% of grid

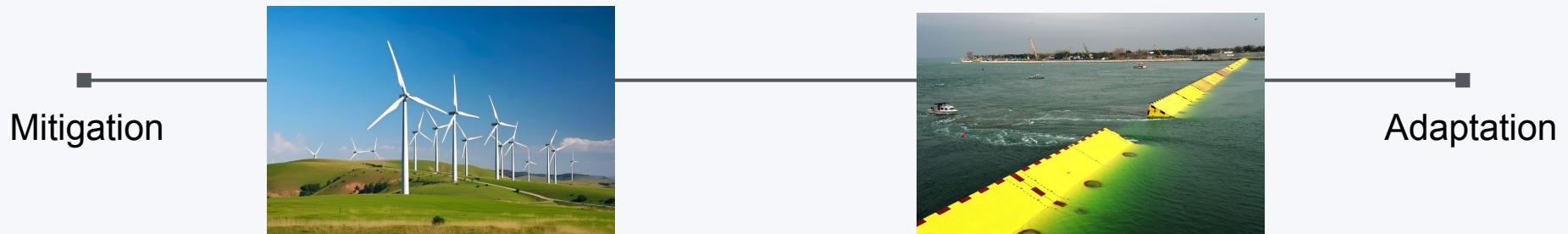


Policy choices depend on science *and* values

Mitigation policy: carrots vs. sticks?

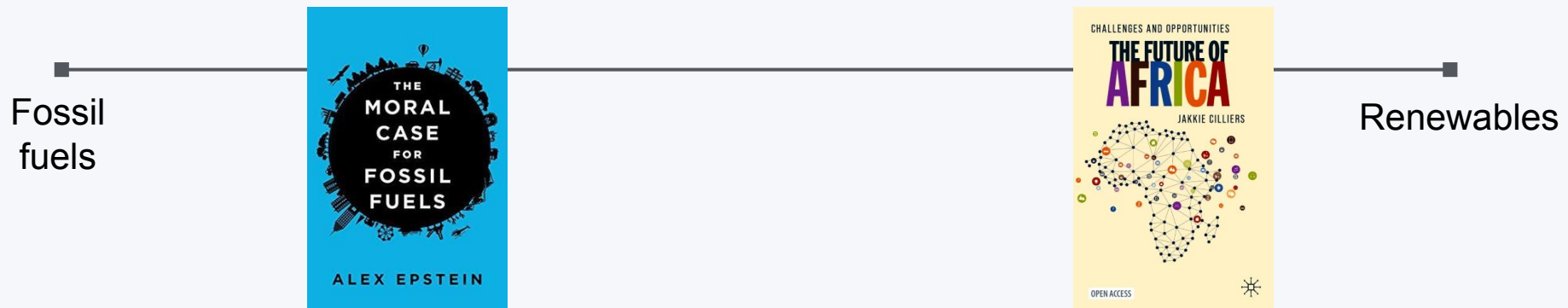


How should we balance mitigation and adaptation?



Policy choices depend on science *and* values

Should emerging economies rely on fossil fuels or renewables?



Should we “geoengineer” to offset global warming?





See us in North Carolina! Learn more at www.climateupclose.org

Friday **10/9** 1:30 pm Erwin Mill | Hosted by OLLI at Duke
Bay A, Room 103, 2024 W Main St, Durham, NC 27705

7:15 pm Eno River Unitarian Universalist Fellowship
Commons Room, 4907 Garrett Rd, Durham, NC 27707

Saturday **10/10** 10 am Church of Reconciliation | Hosted by the League of Women Voters
110 N. Elliott Rd, Chapel Hill, NC 27514

2 pm North Carolina Museum of Natural Sciences
11 W Jones St, Raleigh, NC 27601

Sunday **10/11** 11:30 am Raleigh Friends Meeting
625 Tower St, Raleigh, NC 27607

2 pm Barnes Welcome Center | Hosted by Sarah P. Duke Gardens
420 Anderson St, Durham, NC 27705

Monday **10/12** 6:30 pm Durham County Main Library
300 N. Roxboro St, Durham, NC 27701

Help us build conversations that
meet people where they are on
climate science.

We are a 100% volunteer
organization.



All donations go towards covering the travel expenses of Climate Up Close scientists on the road. We will provide you with an expense report, so you can see exactly how your donation enabled our outreach efforts.

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to the sign-in
sheet to receive
the slide deck!

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organization. Your
donation is tax
deductible.

Climate
Up Close.

Q&A

Climate Up Close. | Q&A

Question Parking Lot: Erwin Mill

- You spoke about being unsettled about West Antarctic Ice Sheet, AMOC. What is currently happening?
- How do you see AI impacting the climate crisis?
- From what I've read, historical models has predicted pretty accurately. Is there a range of consensus future models?
- Is there additional information about the Younger Dryas - changing the density of the seawater - is that minor vs. major?
- What do we know about the economics of alts between fossil fuels and renewables?
- I don't believe the answer is B - why wouldn't temperatures go back down if you cut emissions back down to pre-industrial?
- How much do we understand about the other environmental impacts of alternatives - EV battery impact, for example.
- Are wildfires included in drought - how unsettled?
- Are there any tipping points in field which have actually been reached?
- Where is the planet at this time relative to the historical rhythm of ice ages?
- Do electric cars produce emissions even though powered by electric power?
- Thoughts on nuclear energy?
- Climate has always changed, what if we had a volcanic eruption or meteorite tomorrow?
- What do you think about Carbon sequestration by injecting in basalt rock?

Follow-up questions? Reach us at climateuc@gmail.com

Climate Up Close. | Q&A

Question Parking Lot: Eno River Unitarian Universalist Fellowship / ERUFF

1. Electric car: It costs me 3 cents per mile vs. 11 cents for gas.
2. Tipping point: Permafrost melting and methane release - could you address?
3. When you talked about the ocean, you didn't mention ocean acidification, biological effects - major effects on ocean life, world's food supply, and things we haven't thought about - please address.
4. We don't know much about the ocean, least studied part of our world.
5. I understood oceans to be quite saturated with carbon now - were we hearing otherwise?
6. How warming temperatures and changing growing regions or migration of habitat area for wildlife and people?
7. Post-emissions plateau: Is what you're proposing coincident with Hansen's analyses, or different?
8. What is the mechanism by which the number of hurricanes is expected to decrease with warming?
9. You've been artful at explaining science. With all this intelligentsia of you 4 and correlation of science to values - did you go to public school or not?
10. On different geoengineering ideas - could you rate which one(s) would have the most possibility of having an effect, including one you didn't mention around putting iron in ocean?
11. I've heard 1/3 of humanity gets freshwater from glacial melt; glaciers are disappearing. That looks like a threat to 1/3 of humans in 20-30 years.
12. I subscribe to Union of Concerned Scientists newsletters - they seem political, may see some positions as settled that you consider unsettled - what's your opinion of them and are they stepping out of bounds?
13. The overturn of the ocean as it sinks on European coast and comes up - CO2 saturation low, then comes up over 200 years. Still absorbing now, but what happens when comes to surface, will start releasing?
14. Even with plateau, if avg temperature already getting warm enough, we're going to have less and less water?
15. In addition to increased funding, what is needed to improve models so more insight into uncertain areas?
16. Moral question: You talked about emissions being higher in China than in U.S.; you did not talk about per capita emissions, which to me is moral question. We talk about EV as a panacea, but depends on power stations and what vehicles are using for power. And to what extent they're impacting low income or minority communities.

Follow-up questions? Reach us at climateuc@gmail.com

Climate Up Close. | Q&A

Question Parking Lot: Church of Reconciliation

1. Do you have a recommended reading list?
2. You didn't discuss tornadoes - how related to that is climate change?
3. It's my understanding in NC we've been in drought since last August - can you comment on what's happening in our state?
4. Can you comment on coral reefs and potential conversion of forests to savannahs?
5. In the models you run, do you account for catastrophic occurrences like Krakatoa or other events that change the extremes?
6. Comment: You mentioned we're early days in some of these innovations, but around the world, new car % sold around the world is more like 30-40% now; the U.S. look gives us a distorted perspective.
7. You showed a graph of temperature steady until early 60s - what caused the change?
8. Is there any data that has shown relationship between CO2 emissions and policy that has been enacted?
9. Who are the major competing policy influences / influencers are on these questions?
10. Can you prioritize some of the actions you've mentioned?
11. What is your hope for presenting to a group like this - what are you trying to get us to think about?
12. Even if we all drove electric cars, if we hopped in a jet plane a few times a year, that nullifies all that. Thoughts?
13. How much more funding do you have to continue your work over the next few years?
14. What is the confidence level on the flattening of temperatures as emissions stop?
15. Cement - making it from calcium carbonate introduces a large amount of carbon to the atmosphere.

Follow-up questions? Reach us at climateuc@gmail.com

Climate Up Close. | Q&A

Question Parking Lot: North Carolina Museum of Natural Sciences

1. Based on what's being done today in government and policies being passed, what will world look like in 2100?
2. One thing that alarms me the most is overdevelopment of data centers, especially given that we don't know the consequences. Problem of over-using fossil fuels for the electricity needed, as well as water use. I see us as putting us close to a tipping point.
3. What are the positive things coming out of AI towards solutions?
4. Are you using quantum computing - every AI model that comes in - differences are substantial. What do you think of those technology advancements - corrections to our understanding?
5. The economics are changing rapidly re: induction stoves, solar panels, EVs. Are you building changes in costs, etc., into models? On the regulatory side: You are all researchers, not policy—in Europe there have been regulations, some of which have been implemented—how are you incorporating into your results? Curious to see impact you've already assessed.
6. Did climate scientists learn anything about climate science from the effects of Covid when so much of the economy shut down?
7. Curious about volcano eruptions, earthquakes, wildfires—didn't see them on the landscape?
8. What does a day in the life of a climate scientist look like, from a science perspective?
9. In the next 10 years, what are you excited to study, and hoping you'll find? If things don't change, what are you optimistic about?
10. What's the difference between AMOC collapse and AMOC decline?
11. The presentation put forward the idea that many things are settled. If the science is settled, why haven't we fixed it?

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Climate Up Close. | Q&A

Question Parking Lot: Raleigh Friends Meeting

1. CH₄ not mentioned as a tipping point - have they fallen out of fashion?
2. EVs mentioned as a solution, but electricity also bad—can you talk about that?
3. What should we take away and how should we feel—hopeful, not hopeful?
4. As seas rise on the East Coast, the land is sinking. Thoughts?
5. Are we saying that mean ocean levels are observably 8” higher than 30 years ago? I don’t see that when I go to the coast.
6. Graphs go back to 1600s but ice cores go back further. El Nino discovered only a few decades ago. Probably long cycles we haven’t recognized, making it accelerate with our emissions. Thoughts?
7. When you have a situation that suggests theory should say one thing but we don’t have the observations, how do you use science to understand the difference?
8. Your pie chart: transportation was the biggest slice. Is it know what % of that is aviation?
9. How wet bulb temperatures are involved/used in measuring/understanding heat wave?
10. Do homeowners’ usage of native grasses, etc., have an impact on climate change or help overall?

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Climate Up Close. | Q&A

Question Parking Lot: Sarah P. Duke Gardens

1. Does the increase in energy in the world affect what is happening geologically (besides Greenland getting higher)? Volcanoes, earthquakes, mini Ice Ages?
2. Could one volcanic eruption emit as much as humanity's emissions in a year? And what are the odds of that?
3. These other forms of energy, such as nuclear, also involve the need to take care of excessive energy, such as waste heat—how much is that affecting global warming?
4. Do current AI models change or influence the models you're looking at, any surprises pointing you in new directions?
5. Is it better to think locally instead of globally - fires in Canada/Australia, heat waves in France - is that where real concerns are?
6. Wildfires in the US - is that linked to climate change?
7. You referred to temperature often - not clear if referring to air temperature over land vs. sea surface temperature?
8. Is carbon capture a realistic solution to help with this or is that too far off?
9. What was causing the 3" out of the 8" in sea level rise?
10. One of your slides referenced the NC climate report from 2020 - wondering about its credibility?
11. In addition to your website, what are credible resources these days?
12. Curious about Nadir's personal experience as a federal employee—what changes have you seen, how have there been impacts on your work?
13. Your tour: Since 2019, has it been the 5 of you? What changes have you seen in the science in that time? How has your presentation changed over the last 7 years? Who are you presenting to—I'm guessing you largely get friendly audiences, curious about opportunities to reach different audiences, skeptical audiences? Do you keep data on audiences?
14. My understanding is that climate models start with initial conditions, maybe some randomization, and then mapping physics forward in time. What is prevalence of that vs. a more distributional model - in thermodynamics, the inputs are the statistics. And way back in time, have been different set points of where the whole earth system is. How does that contribute to our understanding of where our climate is right now. Even different spatial structures of the continents. Tipping points were very specific.
15. My wife rolls her eyes at me when needing to dump compost out, put plastic bottle in recycling vs. garbage. Do those actions make a difference?

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Climate Up Close. | Q&A

Question Parking Lot: Durham County Main Library

1. You said CO2 was a 50% increase, my math says more than 50%?
2. How do you talk to people who say: this is just my opinion; my opinion is this. I had a recent conversation with someone about a medical issue and all that mattered to them was their opinion.
3. Have you seen any models that increase war and how that impacts emissions?
4. Is carbon capture scammy? What's your opinion?
5. What's one thing you would want everyone to know if you could magically zap one statement into everyone's brain?
6. You talked about heat waves; what about warming winters? Canada - severe weather and cold, how it impacts pine needles?
7. You talked about Antarctic ice, no mention about Alaskan glacial melt - what about Alaska glaciers?
8. If you had to pick one thing to do to be impactful, what would that one thing be (personal action)?
9. If you were to counsel an upcoming graduate student to take on the topic that would make the most difference, what type of research would you counsel them to do?

Follow-up questions? Reach us at climateuc@gmail.com



Climate
Up Close.

Extra slides

Tipping points: Ocean current collapse

Fate of the Atlantic Meridional Ocean Circulation (AMOC):

- “Observed changes are too short for evaluation of long-term trend”
- “Very likely that AMOC will decline in 21st century, but low confidence in ... timing and magnitude”
- “An abrupt collapse before 2100 ... will not occur” (medium confidence)
- Impacts? Relative to global warming signal? Differentiate w.r.t. Gulf Stream



 **CLIVAR**
Climate and Ocean Variability,
Predictability and Change

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[Home](#) » [Workshop - Collapse of the Atlantic Ocean circulation: Can it? Has it? Will it?](#)

Workshop - Collapse of the Atlantic Ocean circulation: Can it?

Submitted by Joana on Fri, 2026-03-13 06:54

Monday, June 1, 2026 to Wednesday, June 3, 2026
Event City: London
United Kingdom

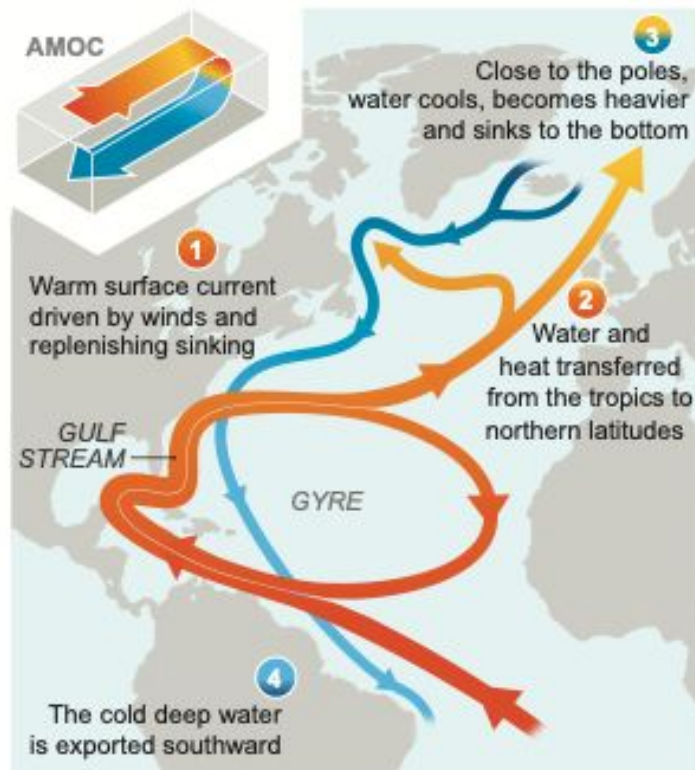
Tipping points: Ocean current collapse

FAQ 9.3: Will the Gulf Stream shut down?

The Gulf Stream, a warm current, is expected to weaken but not cease. This slowdown will affect regional weather and sea level.

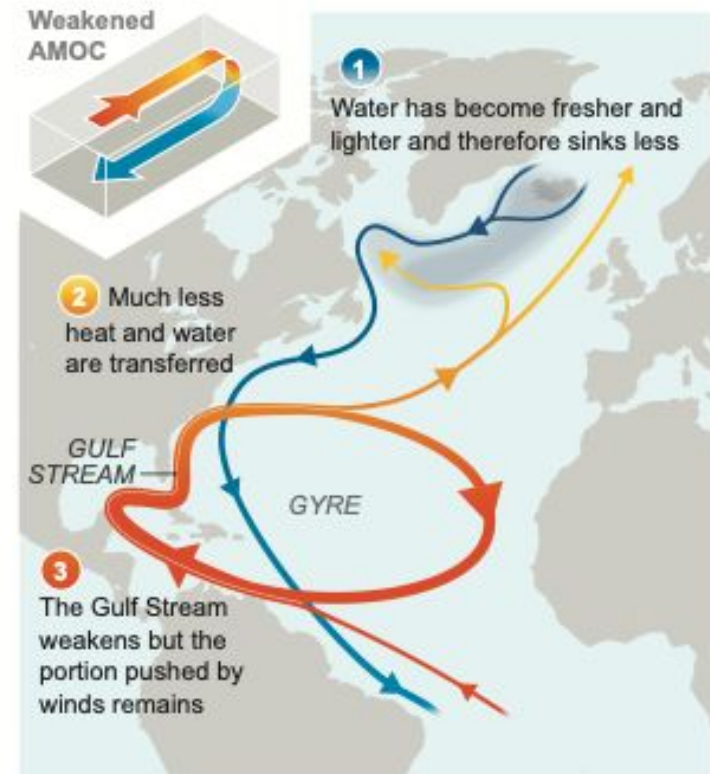
Today

The Gulf Stream is part of both the horizontal, subtropical gyre and the vertical, Atlantic Meridional Overturning Circulation (AMOC)



In a warmer world

Climate change weakens the AMOC, which slows the Gulf Stream down



“The gyre contribution to the Gulf Stream is 2 to 10 times larger than the AMOC contribution.”

Causes of ecological decline



#1: Habitat destruction (30%)



#2: Hunting/fishing (23%)



#3: Global warming (14%)



#4: Pollution (14%)

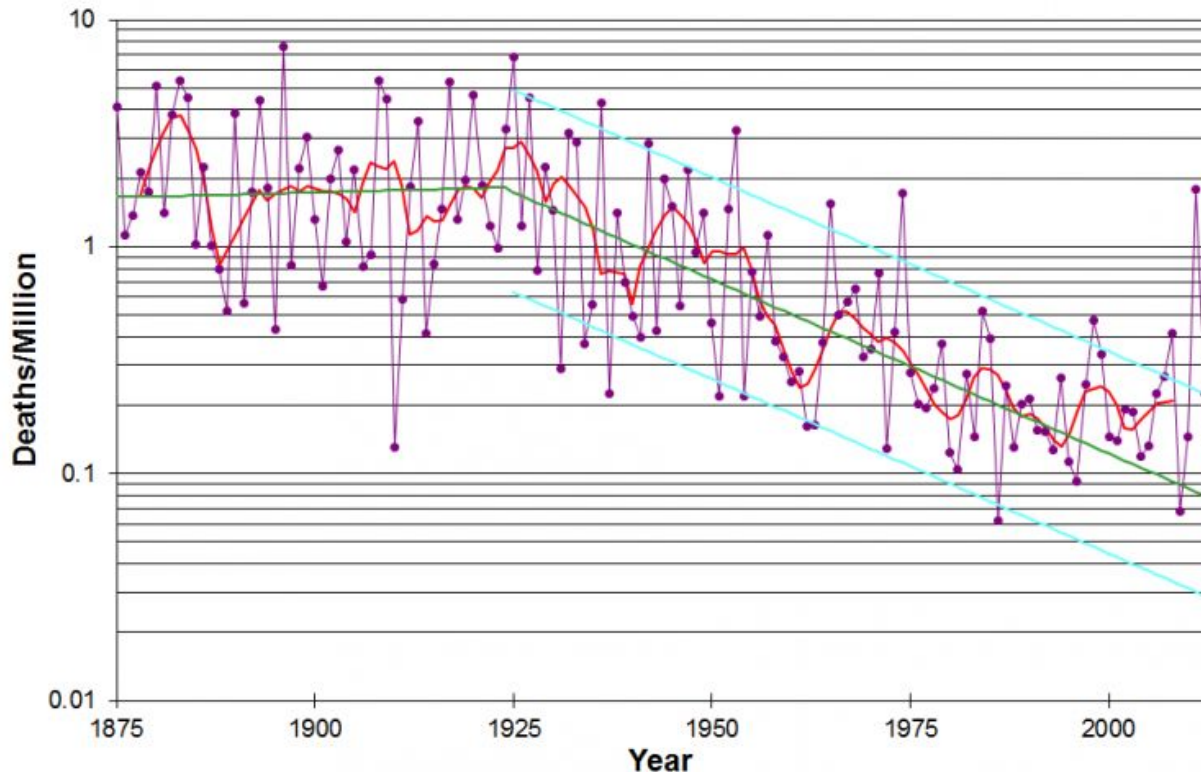


#5: Invasive species (11%)

Sixth Extinction

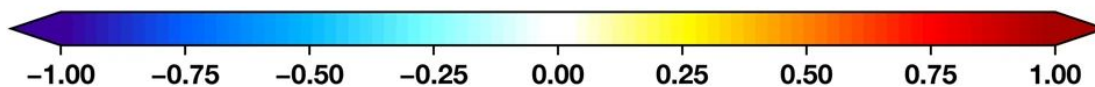
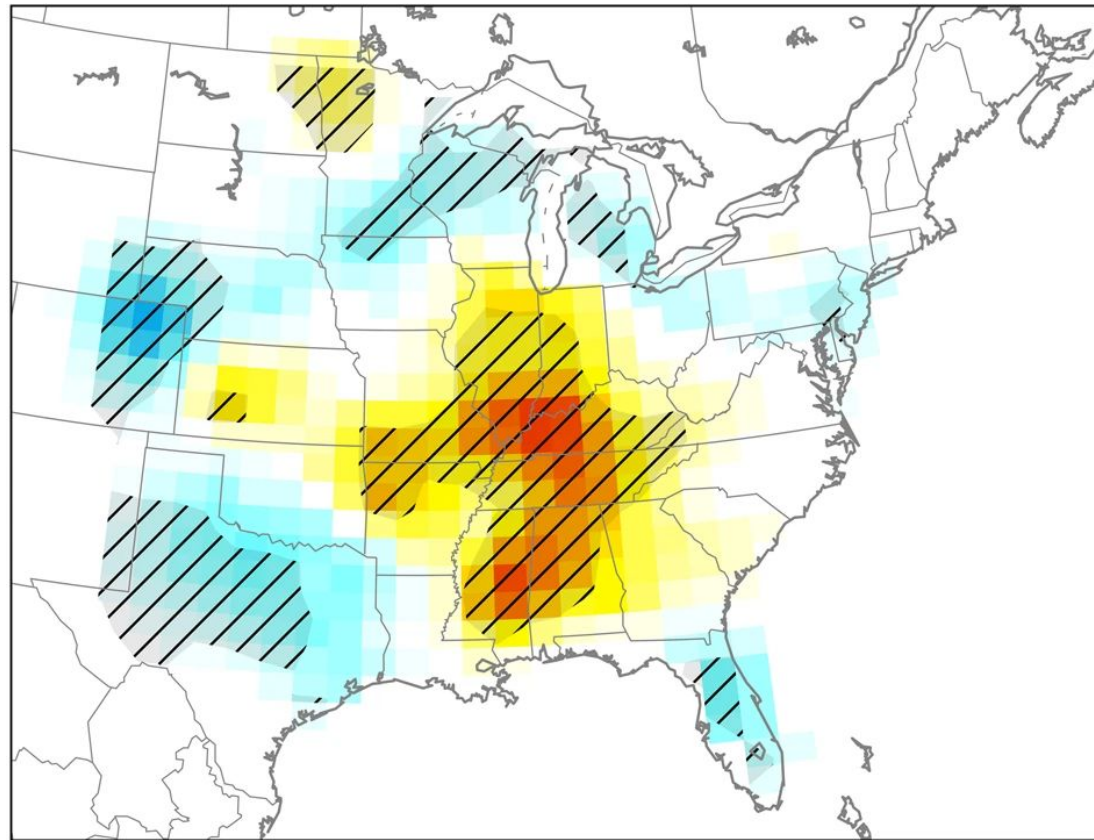


Tornado-related deaths are declining *rapidly*



- Better warnings
 - Doppler radar network, NEXRAD, better models and assimilation of obs etc
- Better *communication* of warnings
- Greater public awareness

Tornadoes have shifted East over past decades



Trend in annual
tornado count/10

Tornadoes **have** shifted towards the East over last 40 years
However, the links to climate change is unclear (c.f. NCA4/AR6 Ch. 11)

Local environmental change
is not the same as global climate change.



Tipping points?

West Antarctic Ice Sheet collapse



“Poorly understood processes of instabilities, characterized by deep uncertainty” (IPCC)

Permafrost “carbon bomb”



“Not enough to lead to a ‘runaway warming’ situation”. 1–7% effect. (IPCC)

Hurricane Helene (September 2024)

**3-day rainfall at
Mount Mitchell**

24.41"

If 10% less: 22"

Flooding in Asheville

Photo: The Urban News