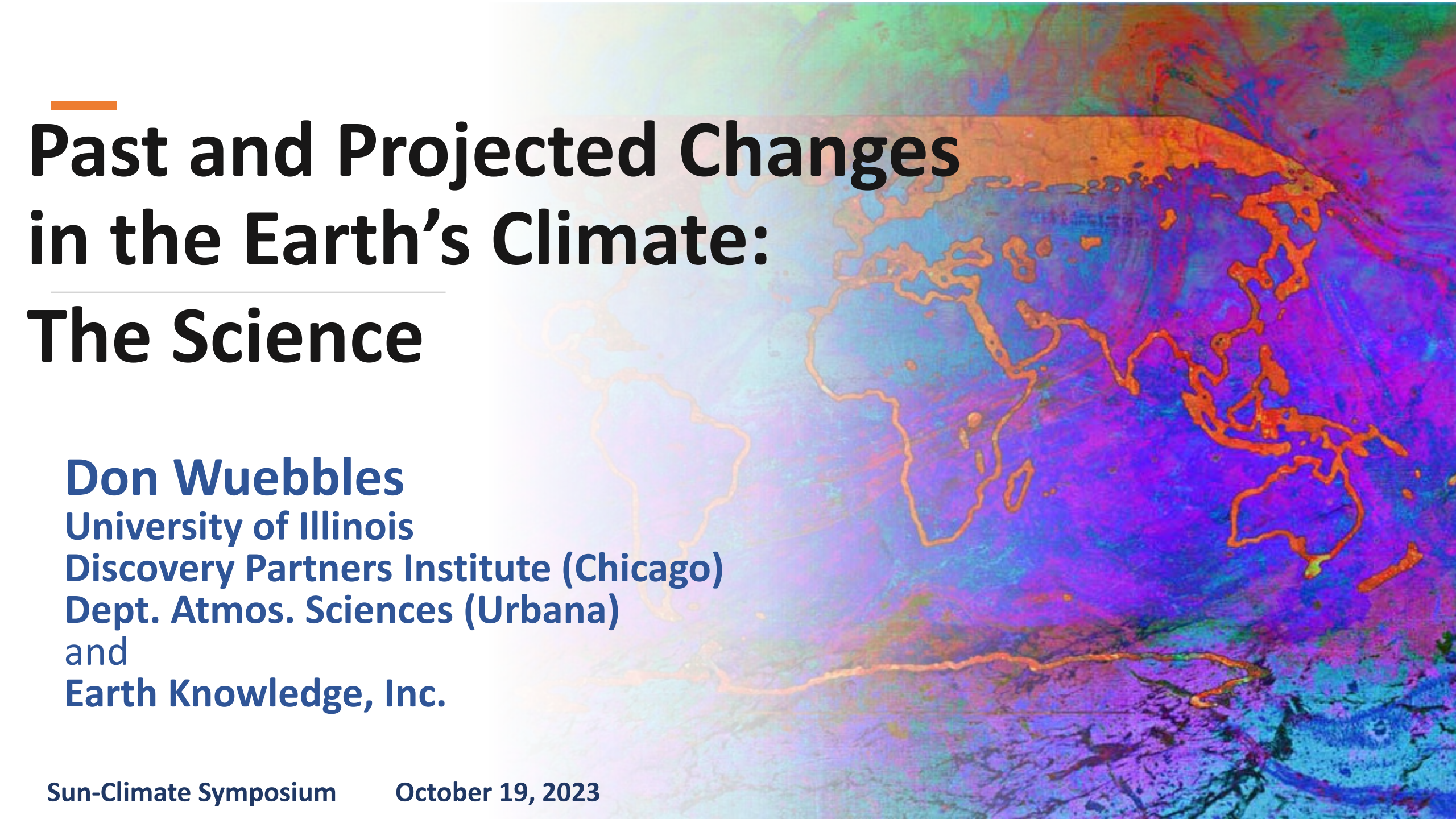
# Past and Projected Changes in the Earth's Climate:

# The Science

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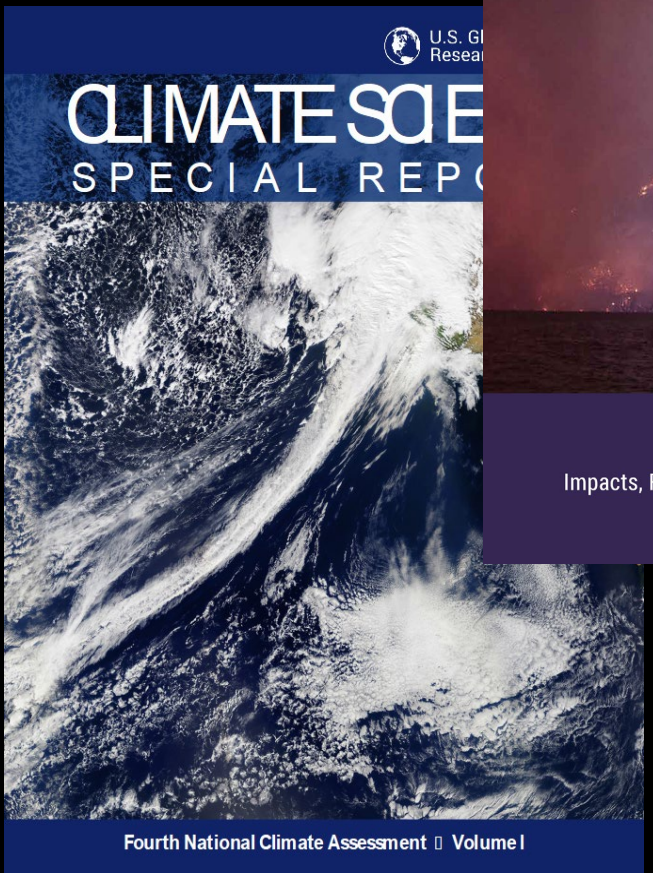
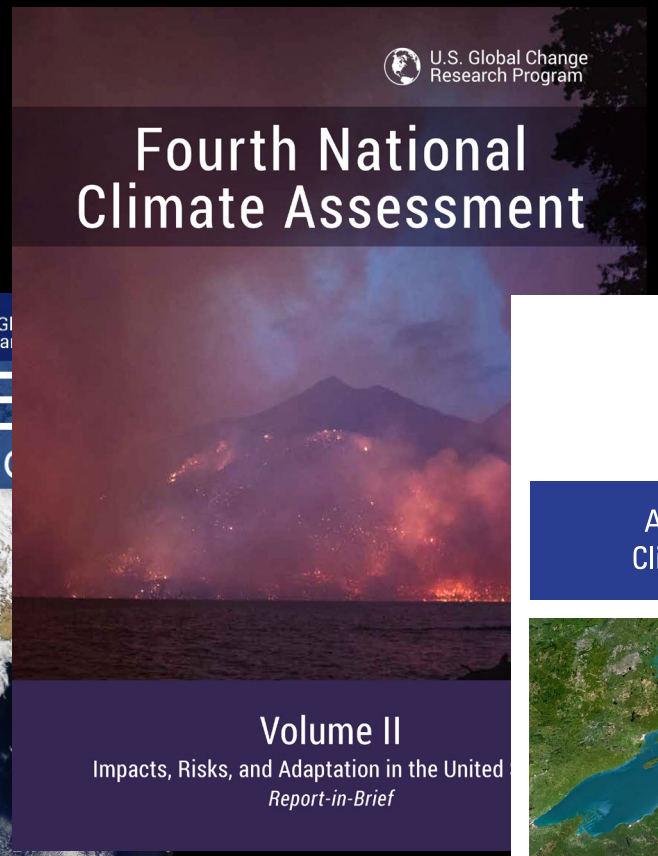
University of Illinois
Discovery Partners Institute (Chicago)
Dept. Atmos. Sciences (Urbana)
and
Earth Knowledge, Inc.


Sun-Climate Symposium October 19, 2023

# Scientists are Regularly Asked to Assess the Science of the Changing Climate and its Societal Impacts

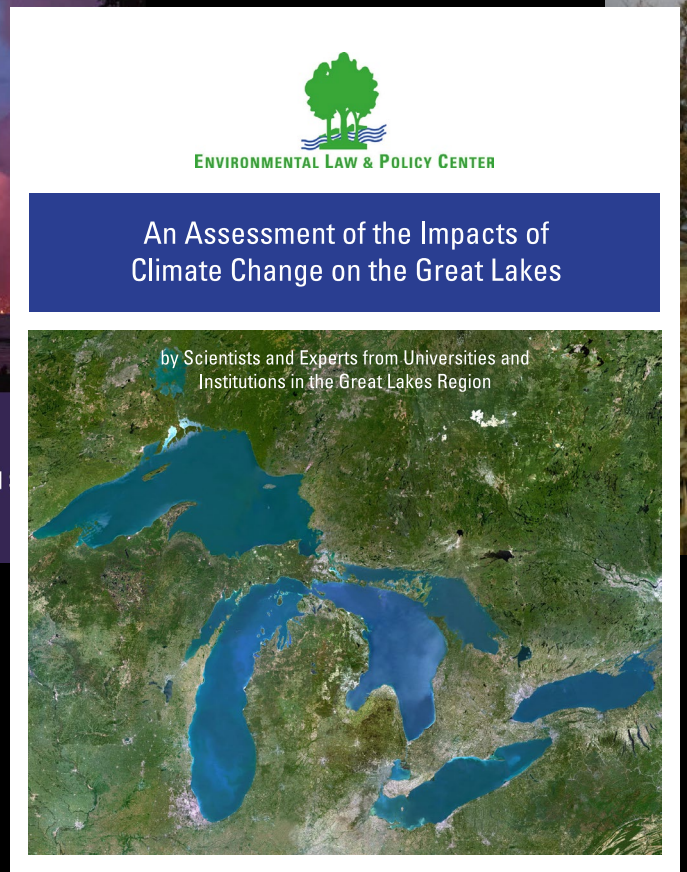
2017



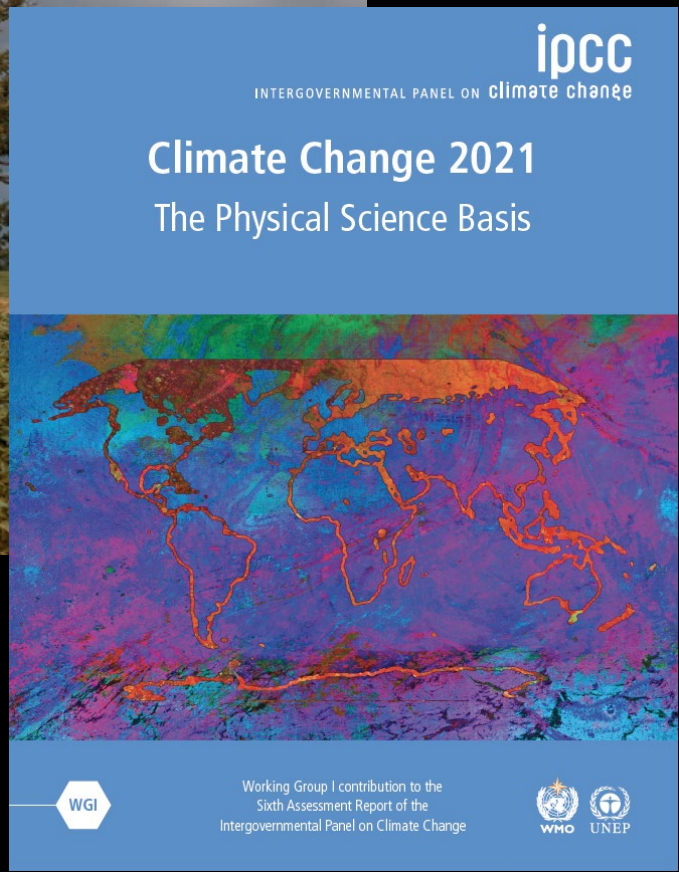

2018

2019




2021

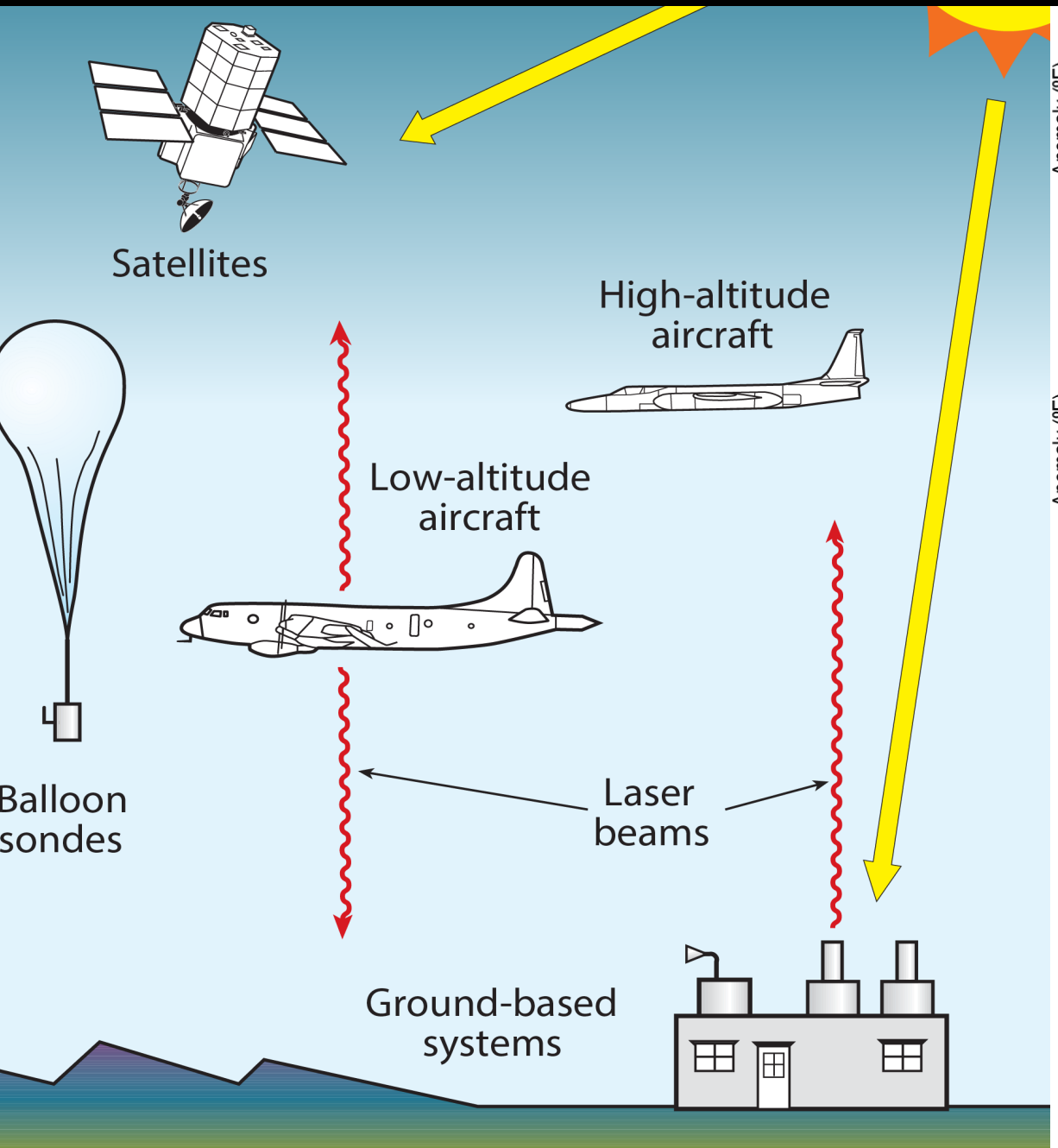

2021

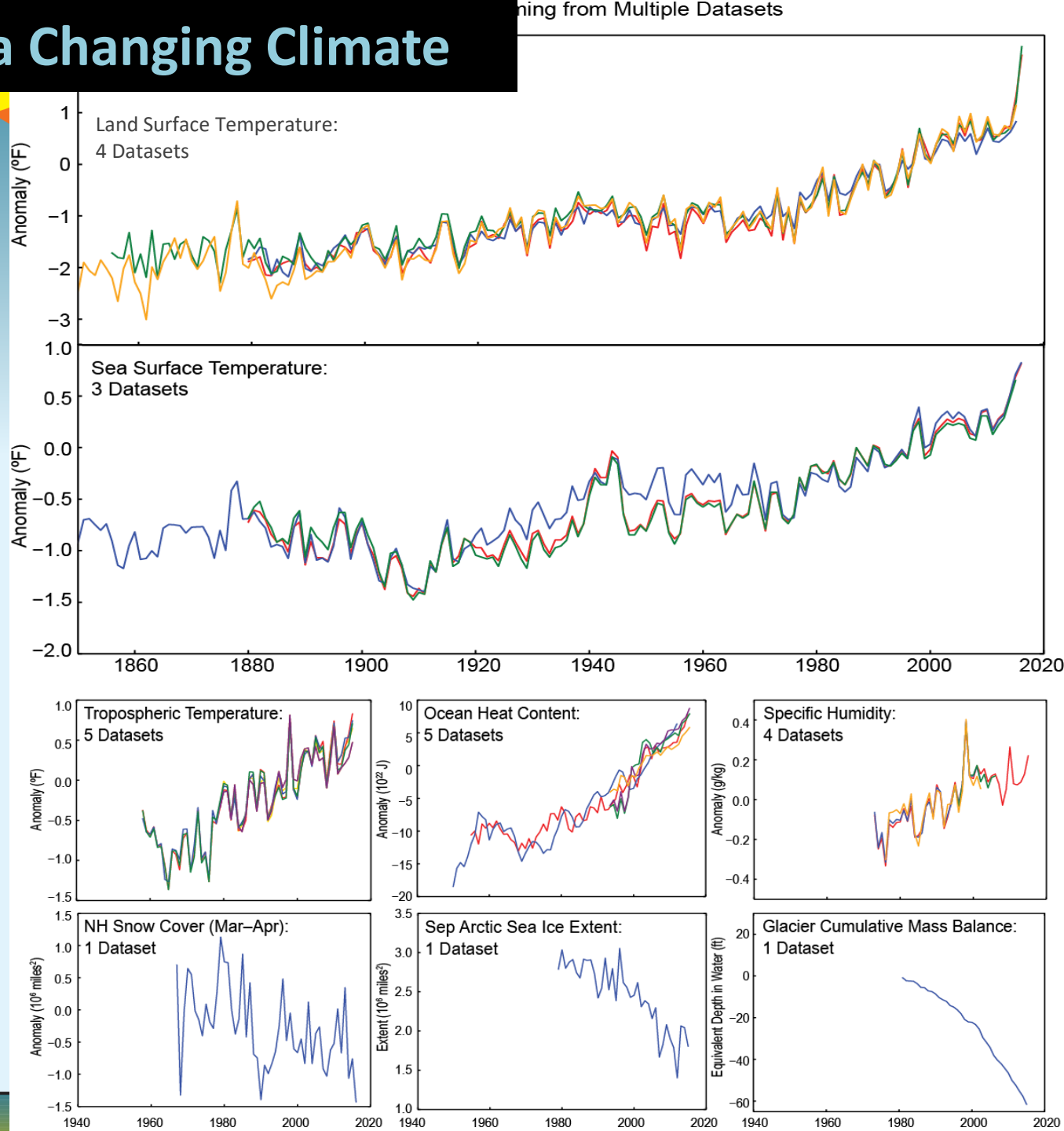


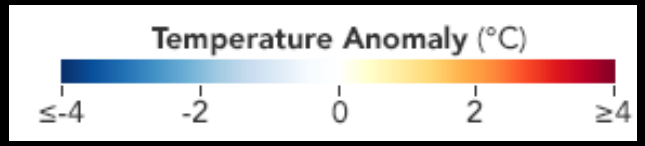
# The Science of Climate Change: The Bottom Line

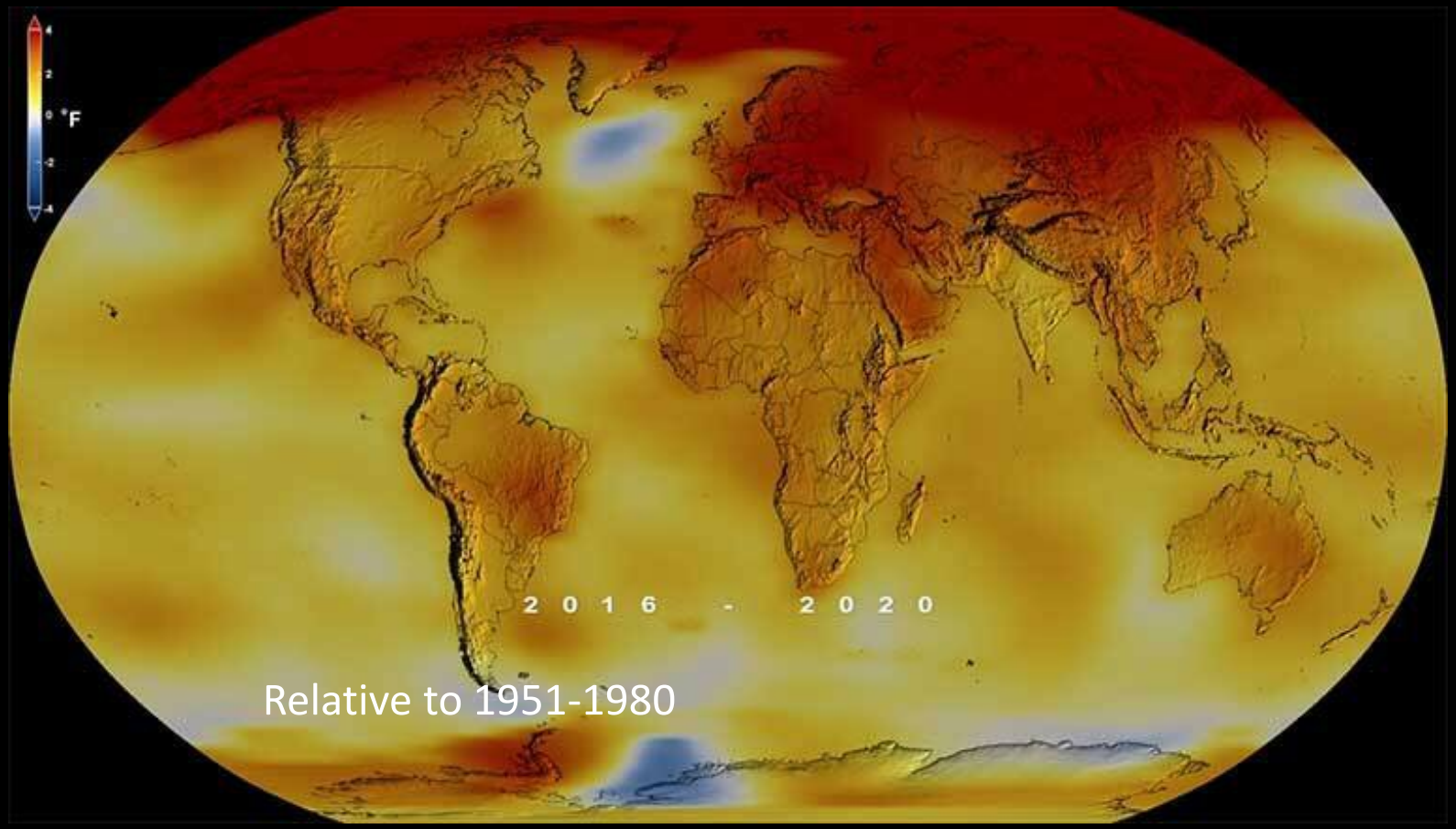
- Our climate is changing,
  - It is happening now;
  - It is happening extremely rapidly;
- Severe weather is becoming more intense;
- Sea levels are rising;
- It is largely happening because of human activities and associated pollution;
- The climate will continue to change over the coming decades.

# Many Different Observations Show a Changing Climate





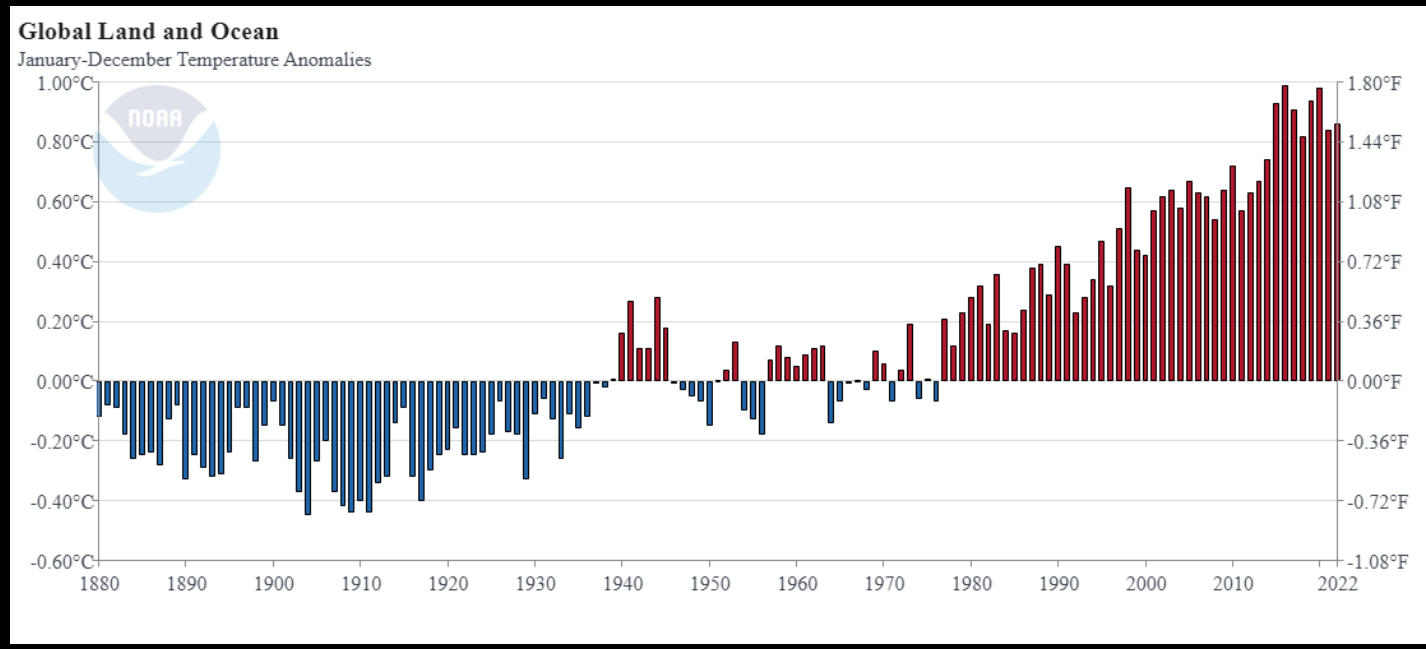

# Our Climate Continues to Change Rapidly

**The global long-term warming trend is continuing.**

**Arctic warming at twice the rate of the rest of the world**

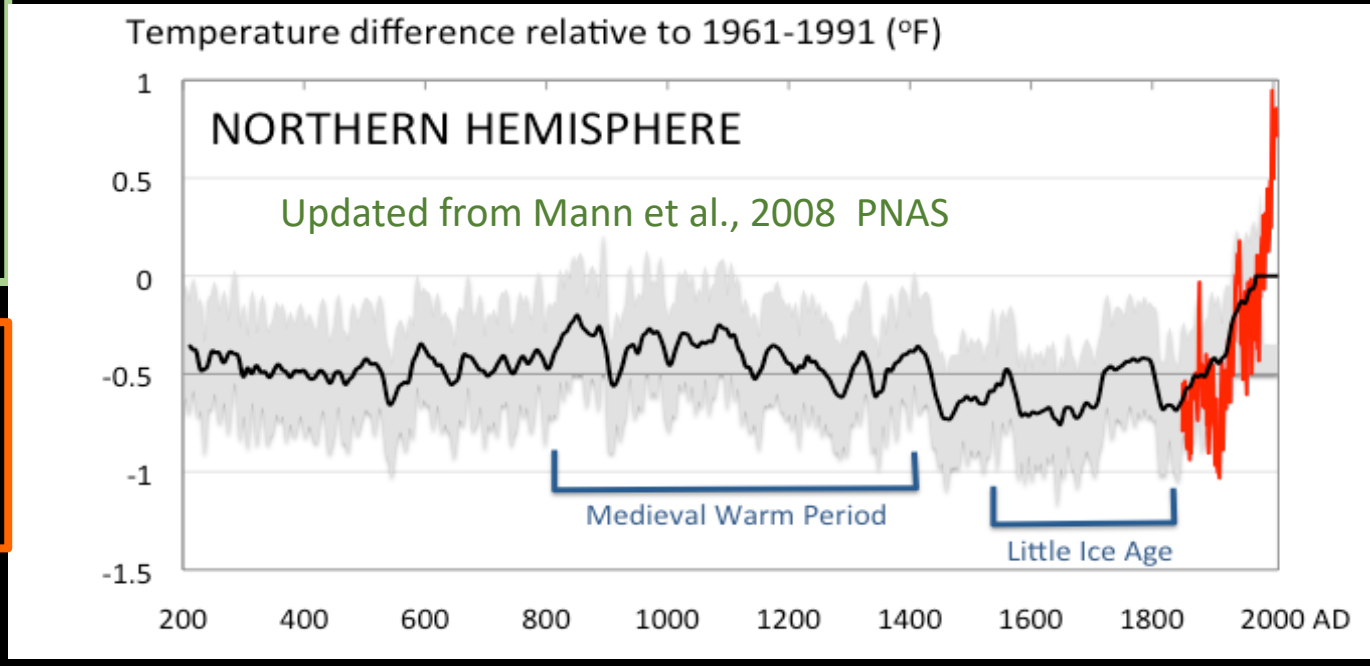
**Land warming faster than oceans**

# Global Annually-Averaged Temperature Record (NOAA, through 2022)



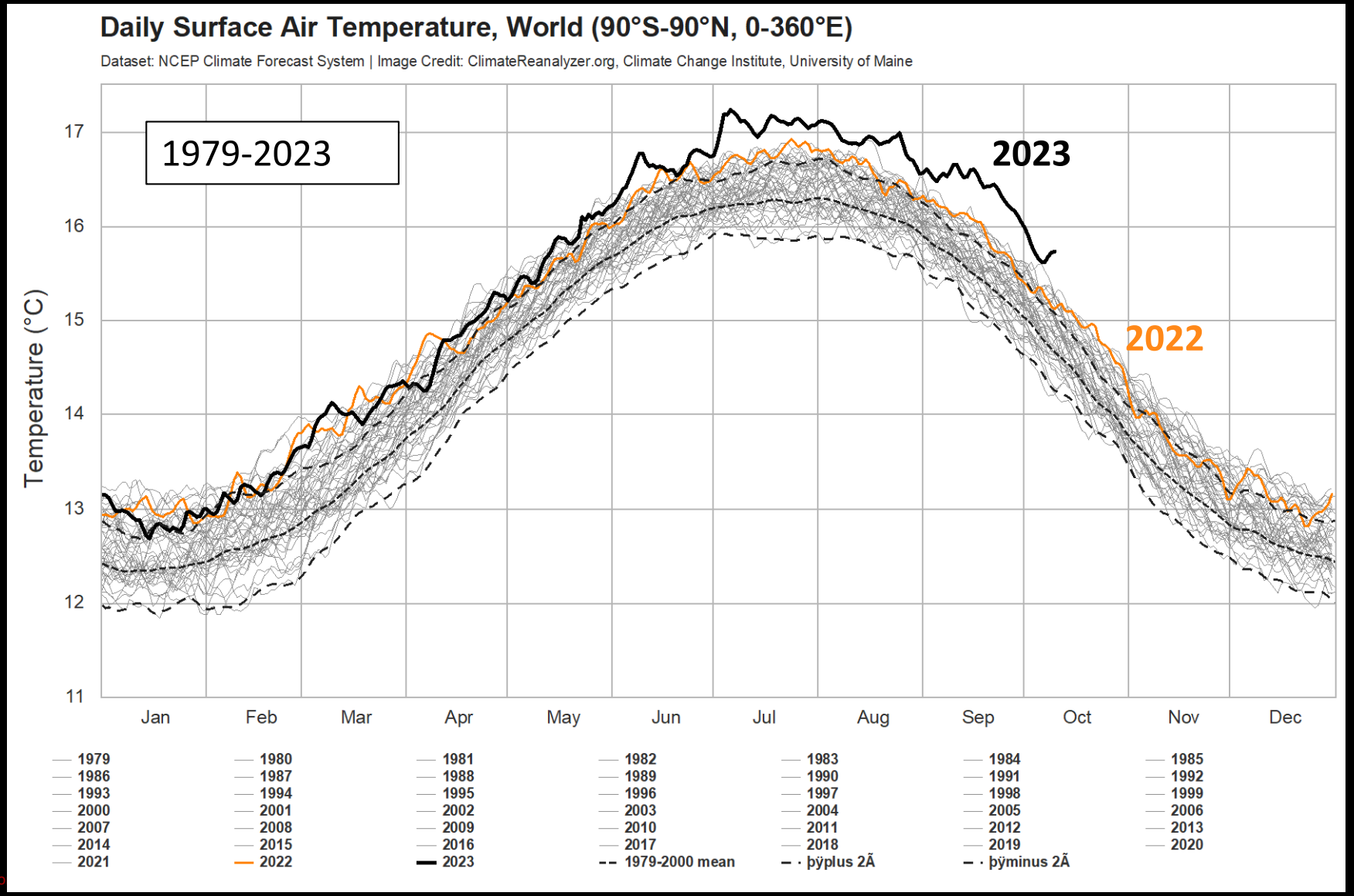

Global, annually-averaged temperature has increased by 1.14°C (2.1°F ) from 1901-2022

2020 and 2016 tied for warmest years on record.

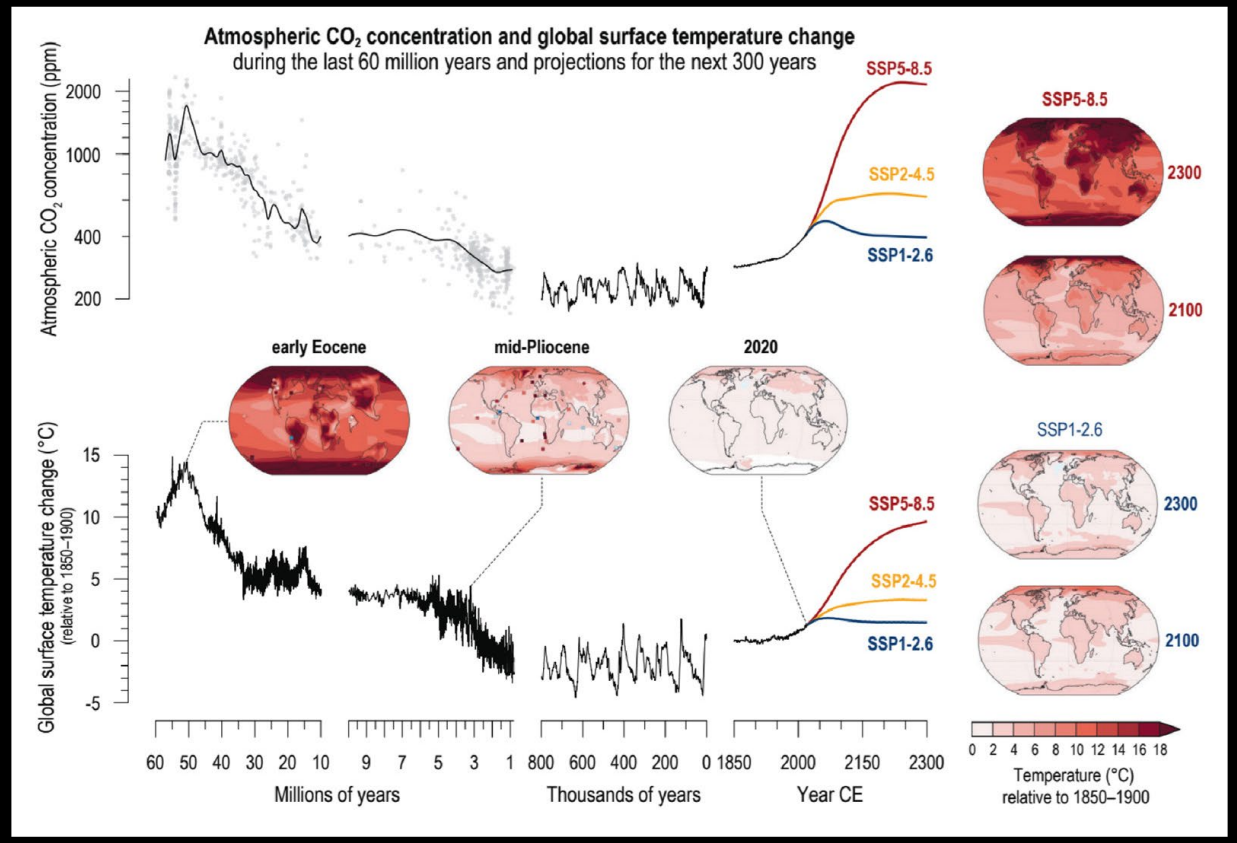


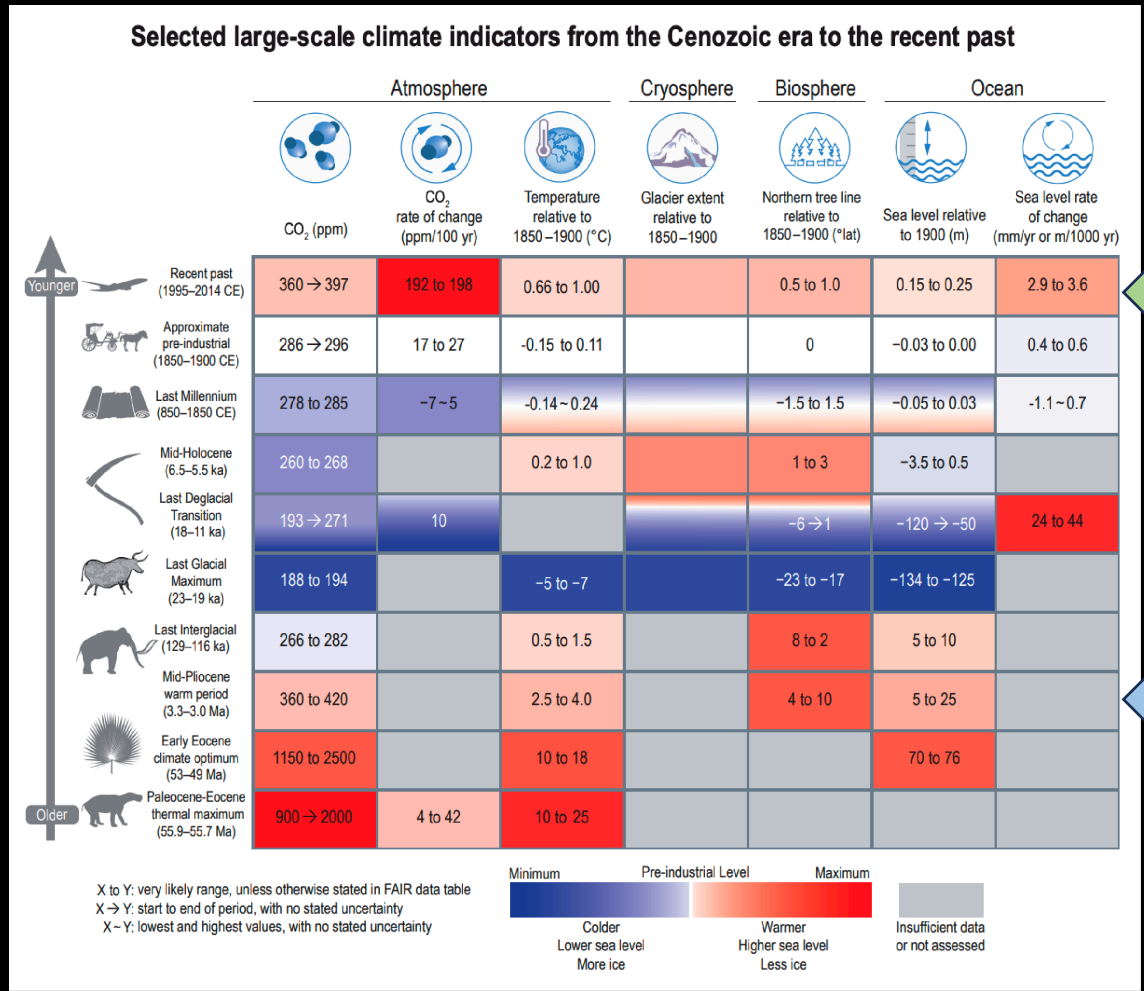
# Our Climate Continues to Change Rapidly

# 2023 will be warmest year in history!

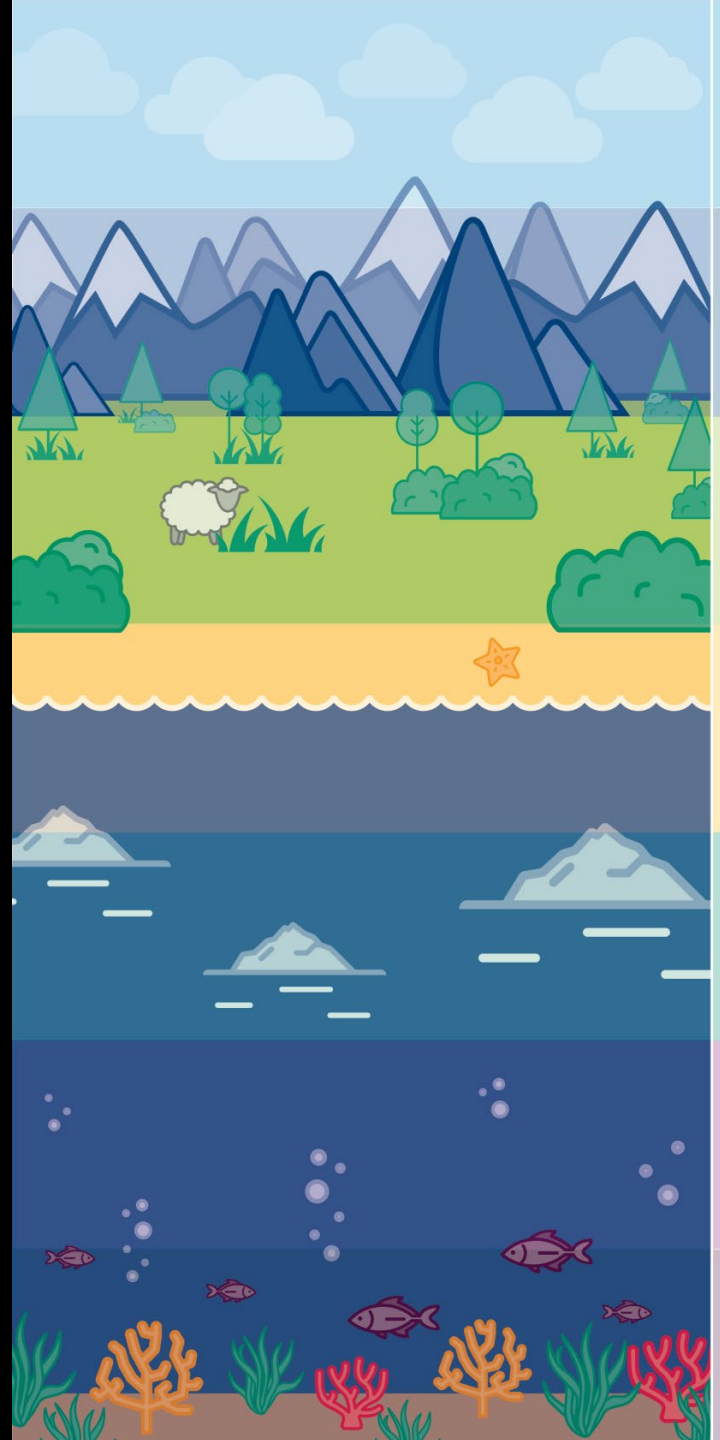


# IPCC AR6 (2021): Past Earth Climates Linked to $CO_2$



# Recent changes in climate are unprecedented in thousands of years



Concentrations of carbon dioxide unmatched for at least 2 million years

Glacial retreat unmatched for 2,000+ years

Last decade warmer than any period for ~125,000 years

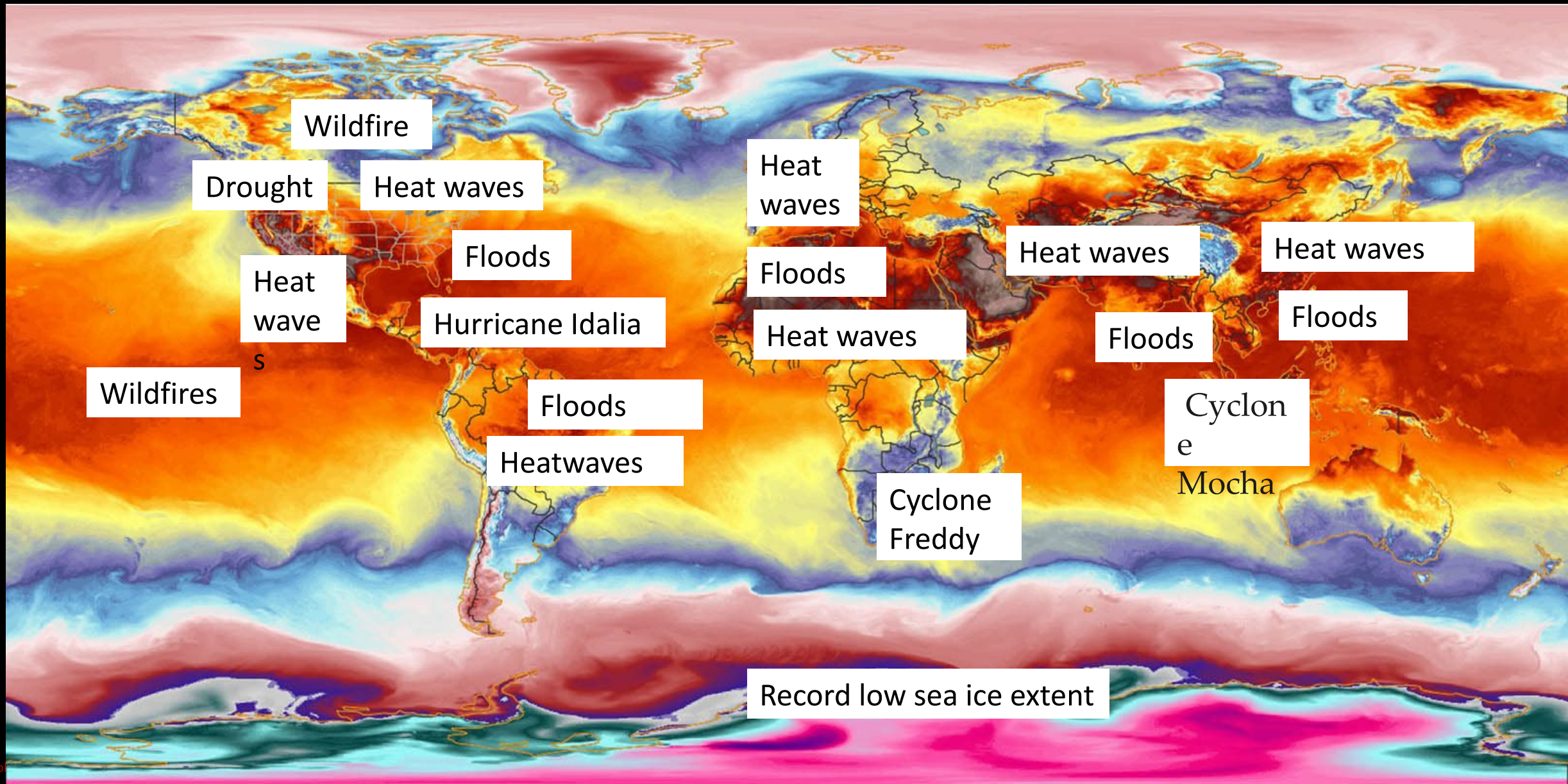
Sea level rise faster than any prior century for 3,000 years

Summer Arctic ice coverage smaller than anytime in last 1,000 years

Ocean warming faster than at any time since end of the last ice age

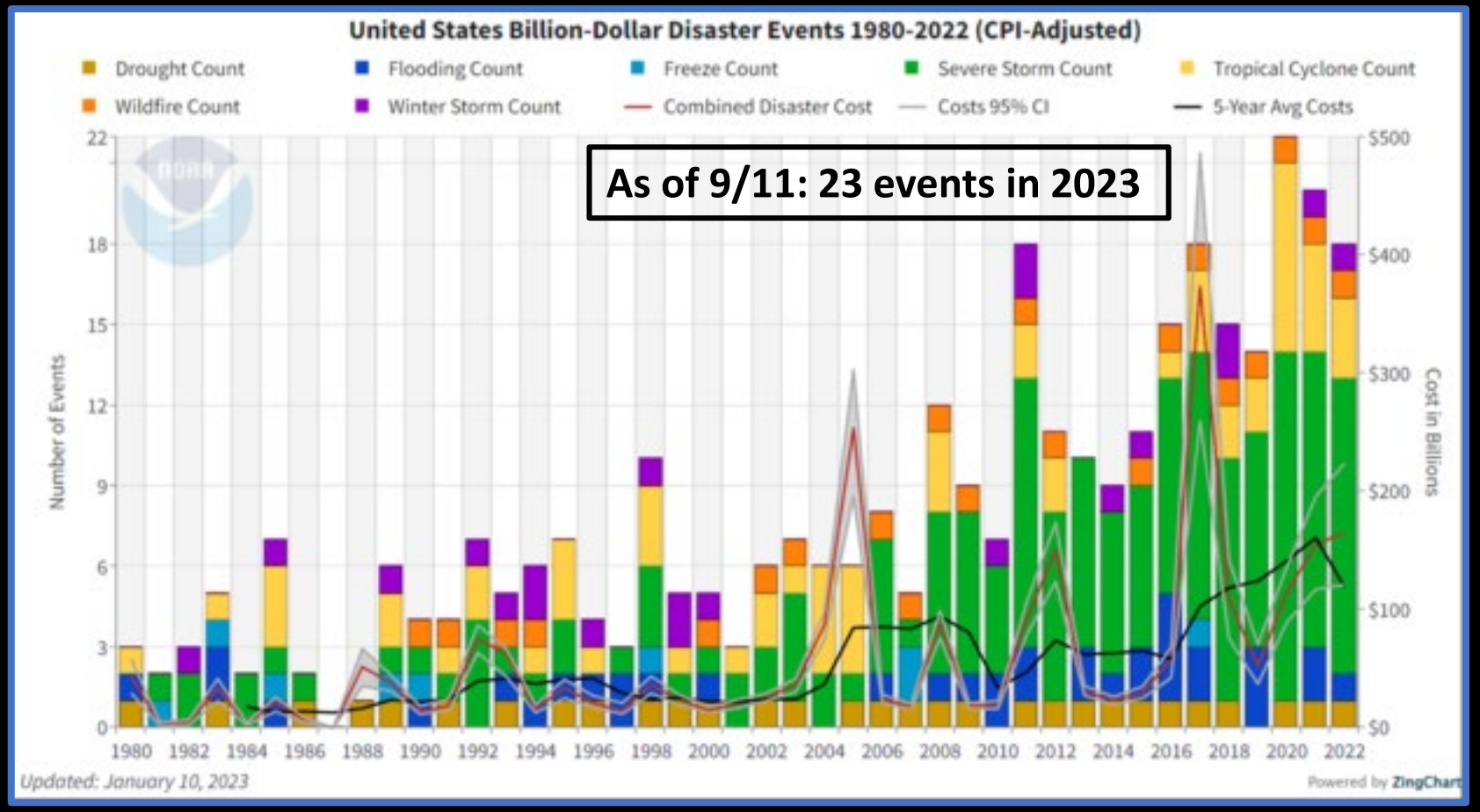
Ocean acidification at highest level of last 26,000 years

# 2023 is Dramatic Year for Extreme Events

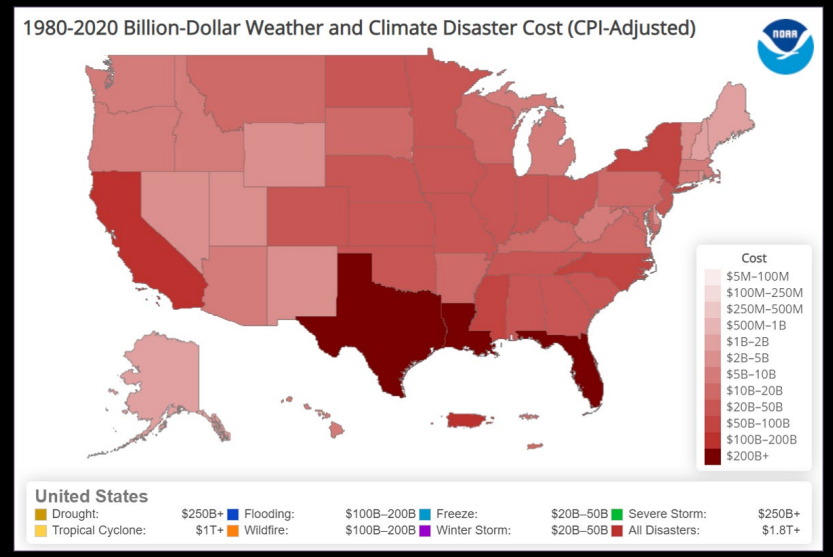


# NOAA: Increasing impact of Severe Weather on U.S. economy: Over $2.6 trillion

## Every U.S. region is affected




Billion-dollar weather and climate disasters frequency: 1980-2022 (accounts for inflation)

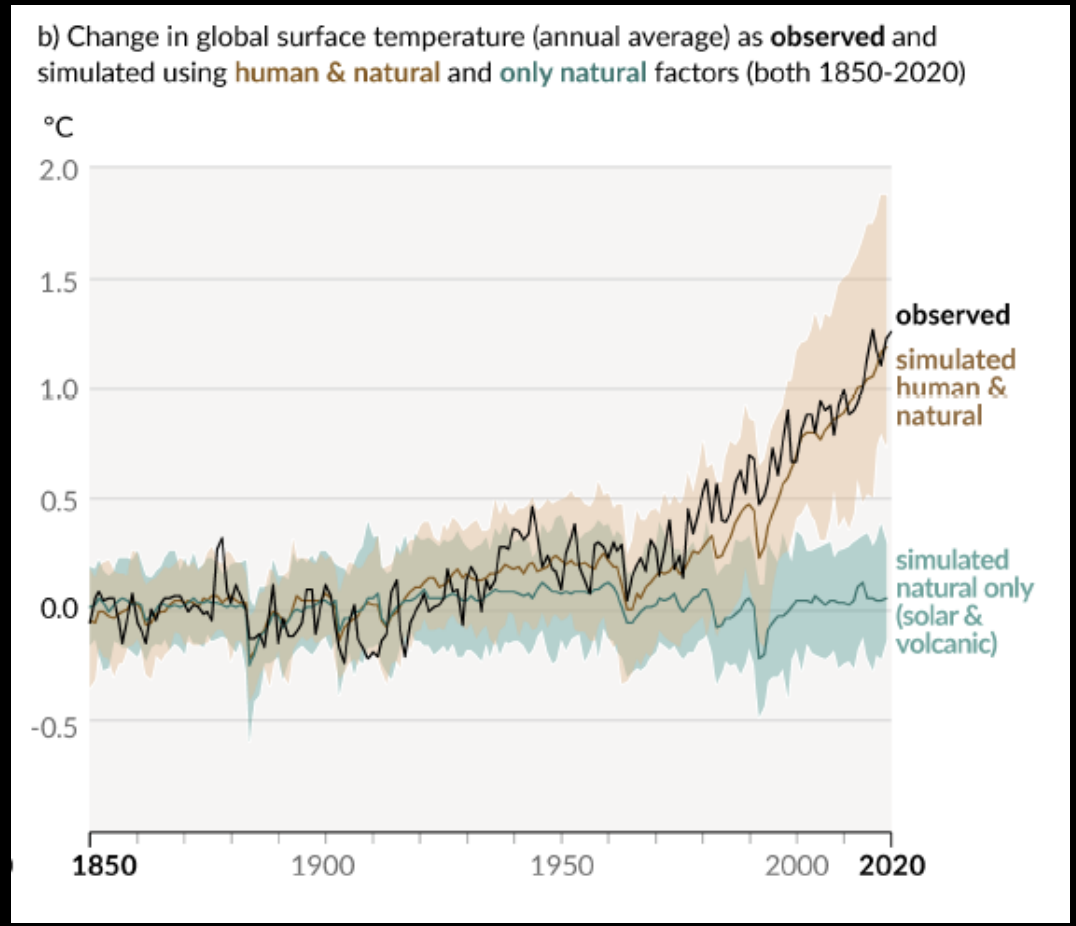



Similar trend globally

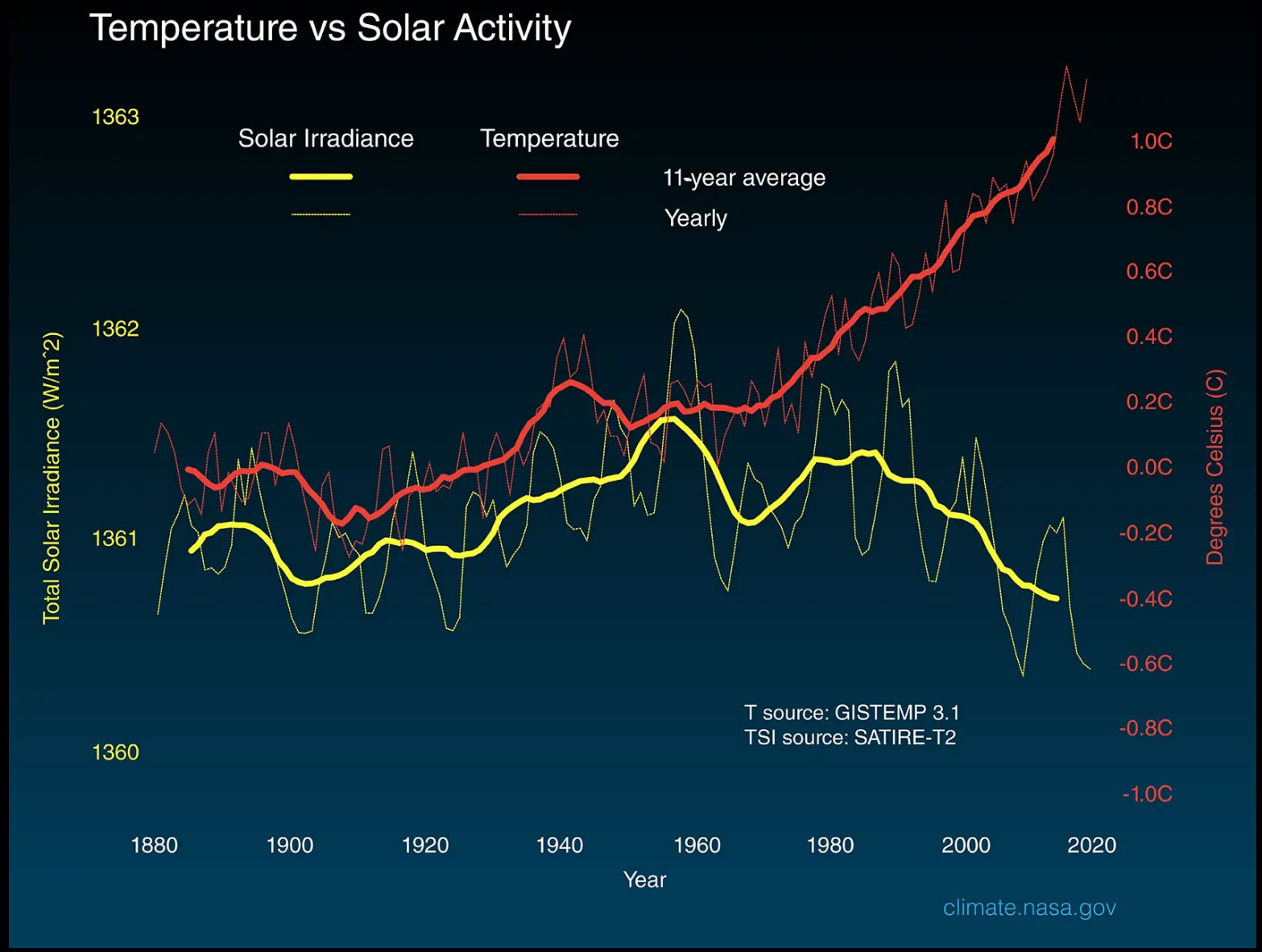
***Non-Publicly releasable information for business use only...

# What is Causing Climate Change?

- **Many lines of evidence** demonstrate that **human activities**, especially emissions of greenhouse gases, are primarily responsible for the observed climate changes.
- For the period extending over the last century, there are **no credible alternative explanations** supported by the extent of the observational evidence.
  - **It's not the Sun**
  - **It's not natural cycles**



# It’s Not the Sun!

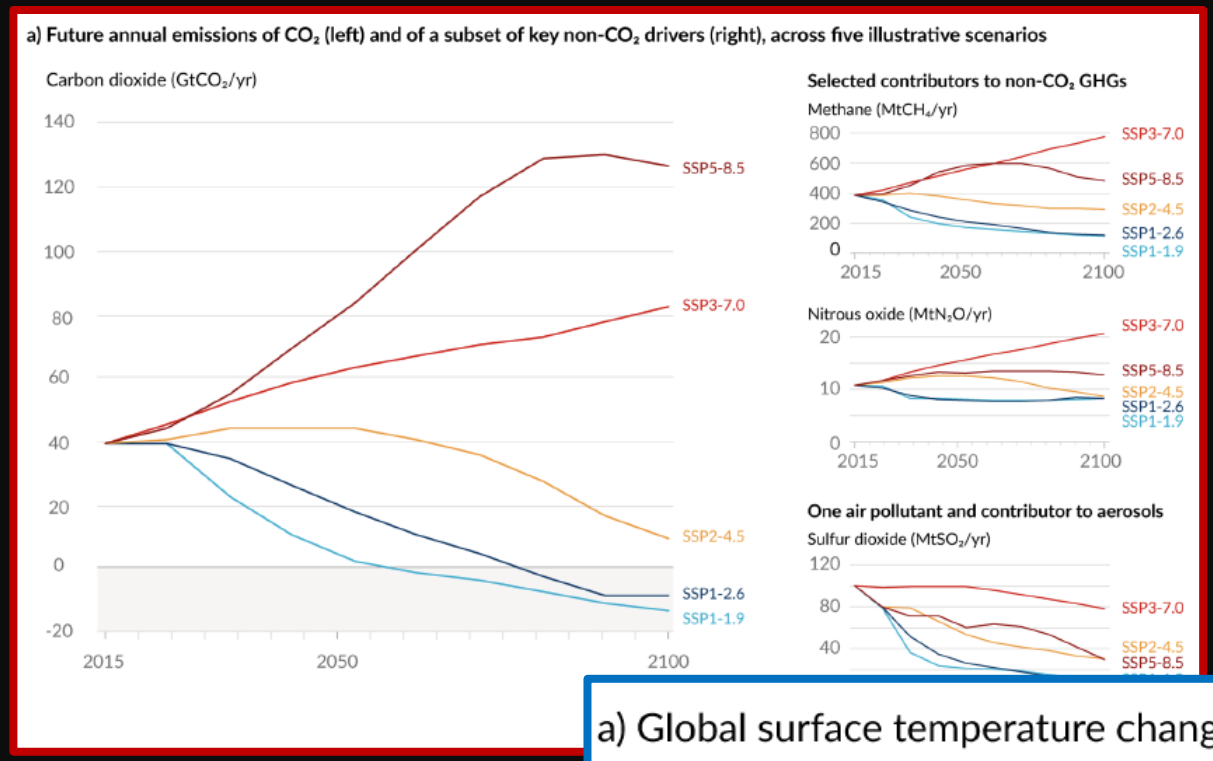


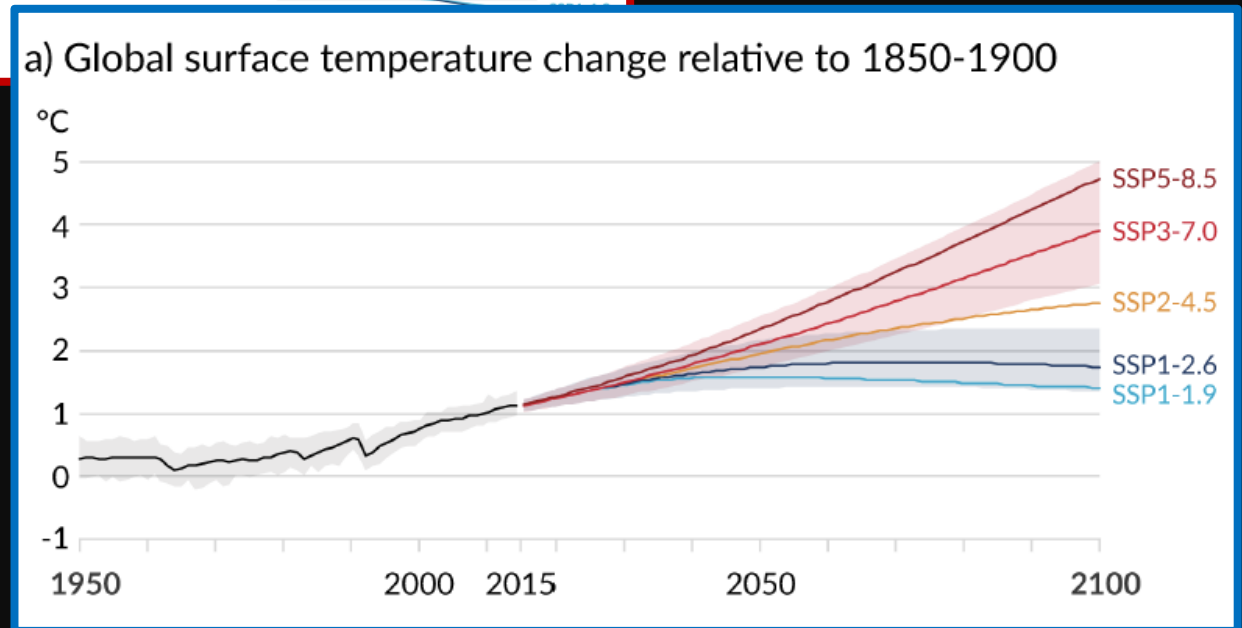

Variations in solar energy (received at Earth) are  too small to explain changes in climate.

Solar output is decreasing over last 40 years).

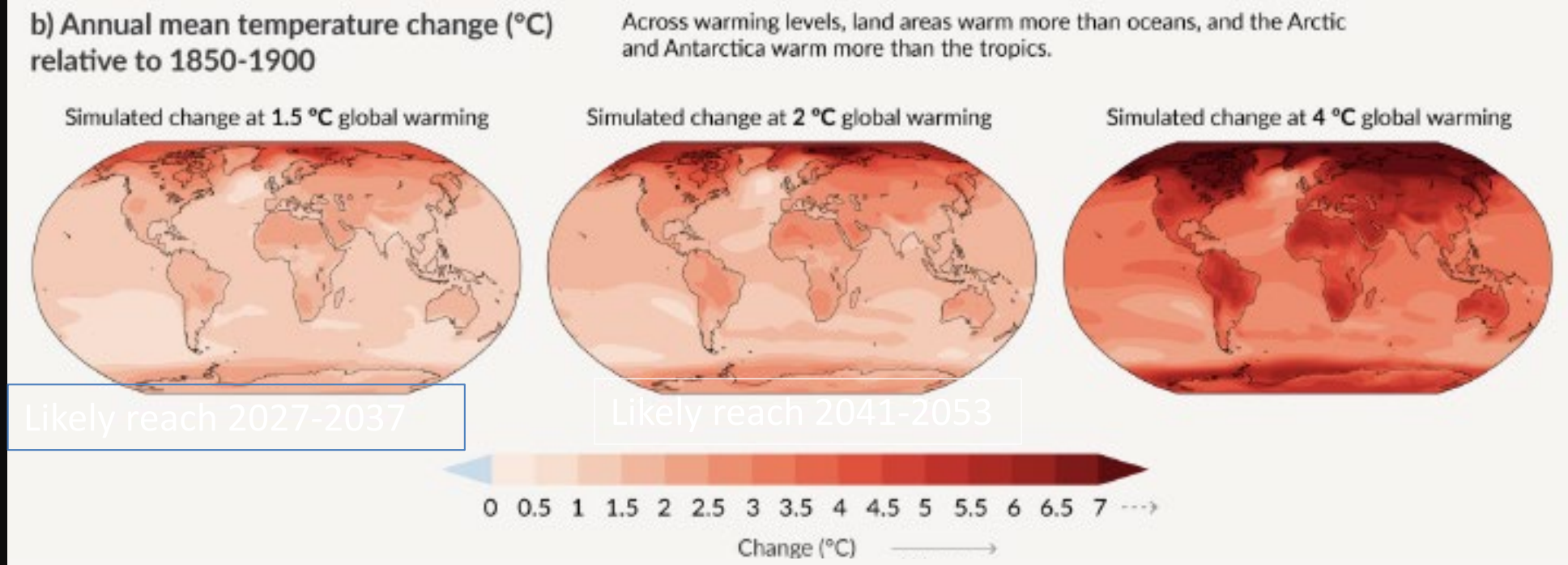
# The Forecast: Climate will Continue to Change

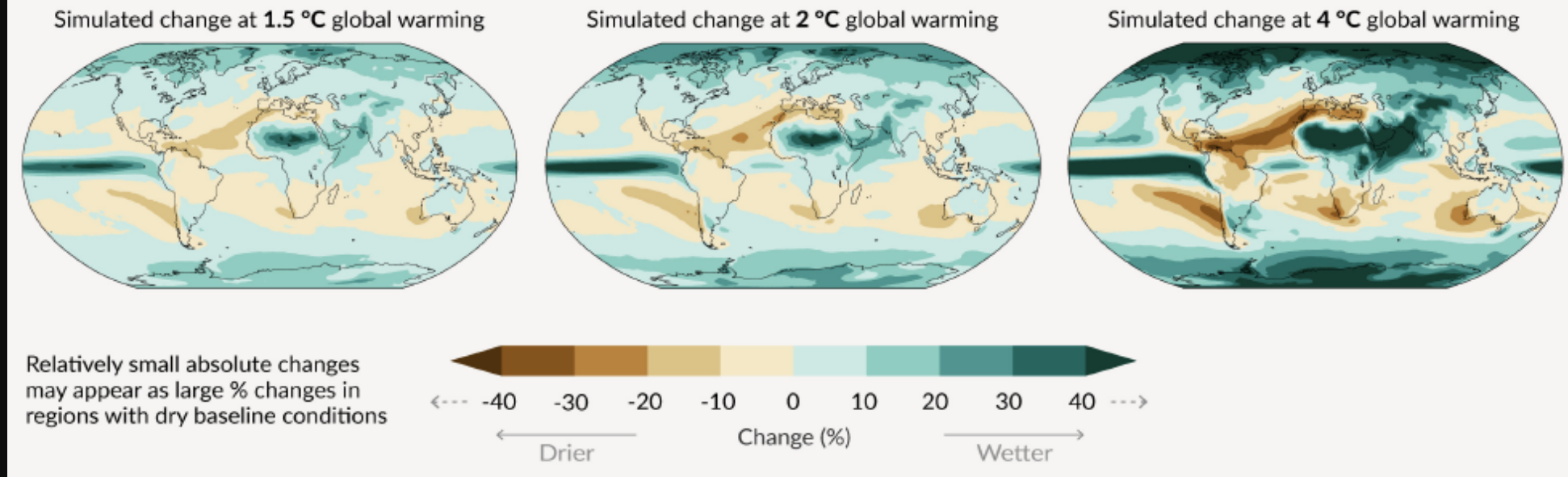
**Climate change beyond the next few decades depends primarily on the heat-trapping gases emitted and the sensitivity of Earth's climate to those emissions.**



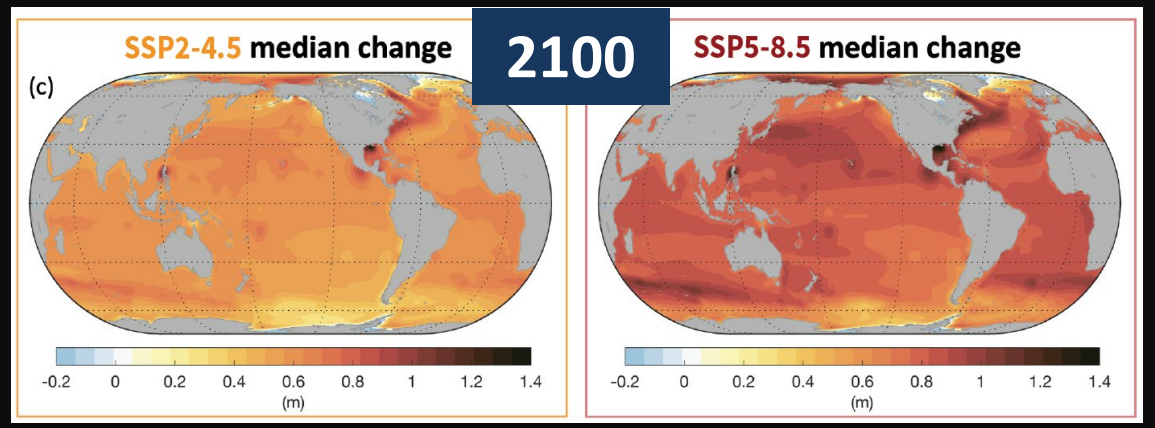
# Temperature and Precipitation Projections



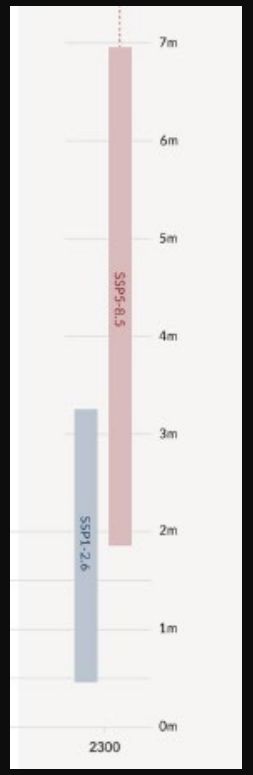



# Changes in the Oceans

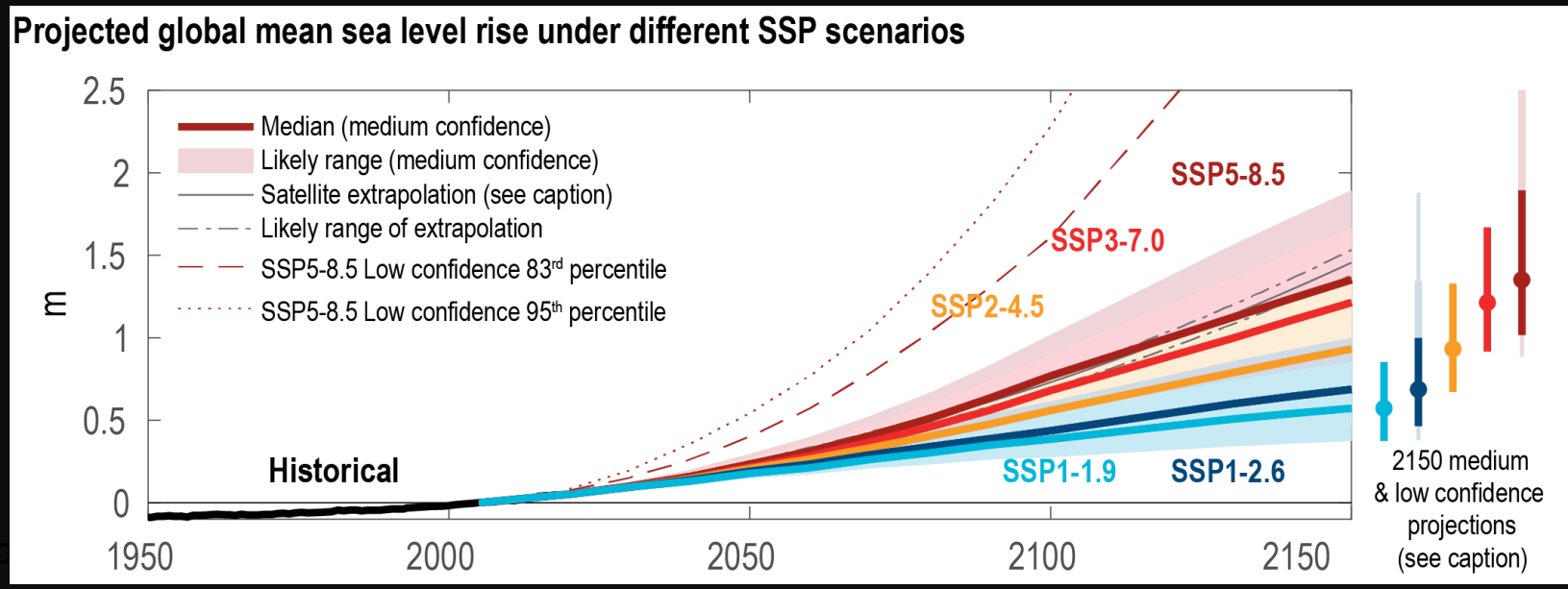
- Sea levels have risen ~8 inches since 1900
- Sea Level Rise at Highest Rate in at least 2800 years
- Nuisance flooding issues
- Sea levels expected to rise another 1-4 feet this century
- Acidification of the Oceans
- Changing ocean circulation




to 2300




1950 to 2150



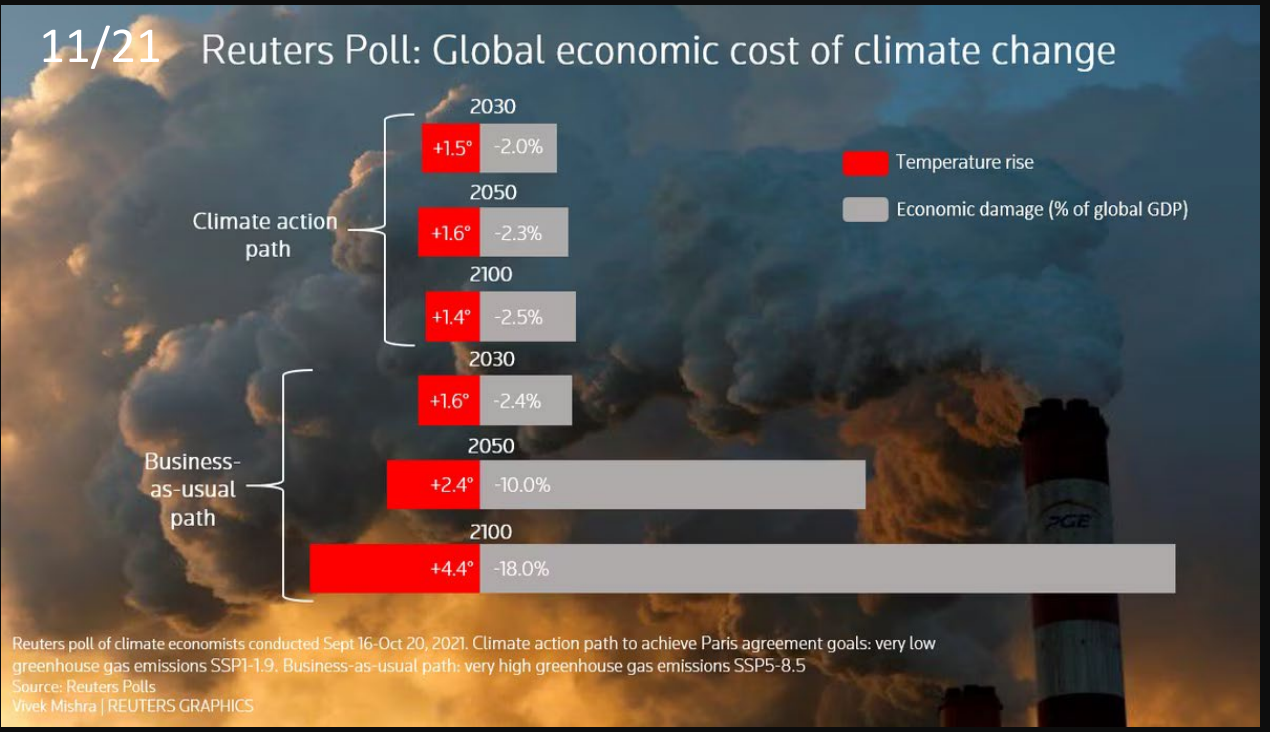
# What should we do?

There are only three options:

- **Mitigation**: measures to reduce the pace & magnitude of the changes in climate.
- **Adaptation**: measures to reduce the adverse impacts on human well-being resulting from climate change.
- **Suffering**: the adverse impacts and societal disruption not avoided by mitigation or adaptation.

Minimizing suffering can only be achieved by doing a lot of mitigation and a lot of adaptation.

# Costs of Climate Inaction are far greater than Taking Action



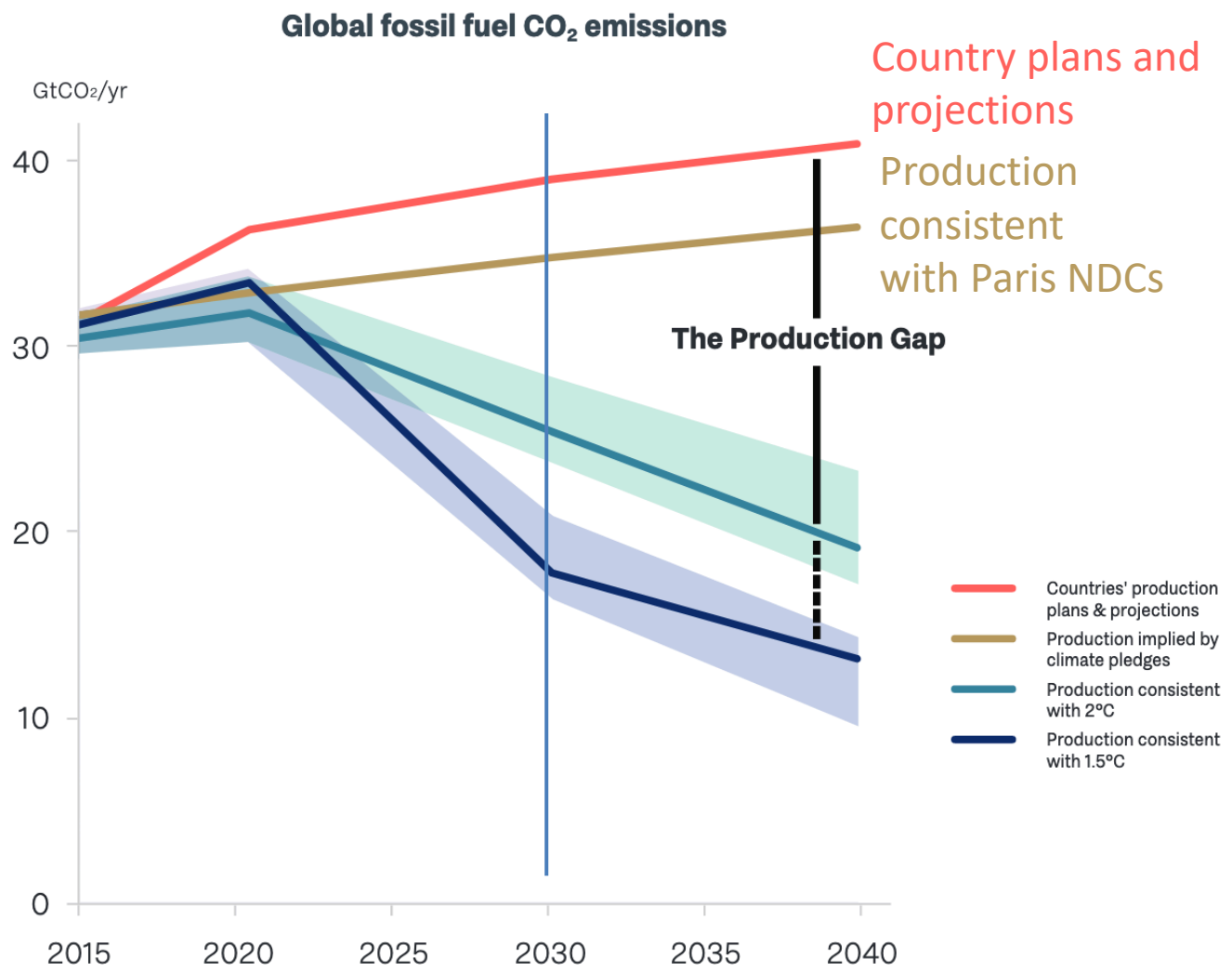

- Global GDP in 2100 lower by 37% unless take action (UCL, 2023)
- Deloitte: **Climate change will cost the US Economy $14.5 Trillion by 2070**
- Heal (2017): **Reducing U.S. emissions 80% by 2050 would cost $1.2-3.9 trillion**
- Other studies say there could be a net gain from the energy transition!

# The Paris Agreement: December 2015

The Paris Agreement establishes a bridge between today's policies and climate neutrality before the end of the century.

# The Paris Agreement: Avoiding High Risks

The fossil fuel production gap — the difference between national production plans and low-carbon pathways (1.5°C and 2°C), as expressed in fossil fuel carbon dioxide ($CO_2$) emissions — widens between 2015 and 2040.

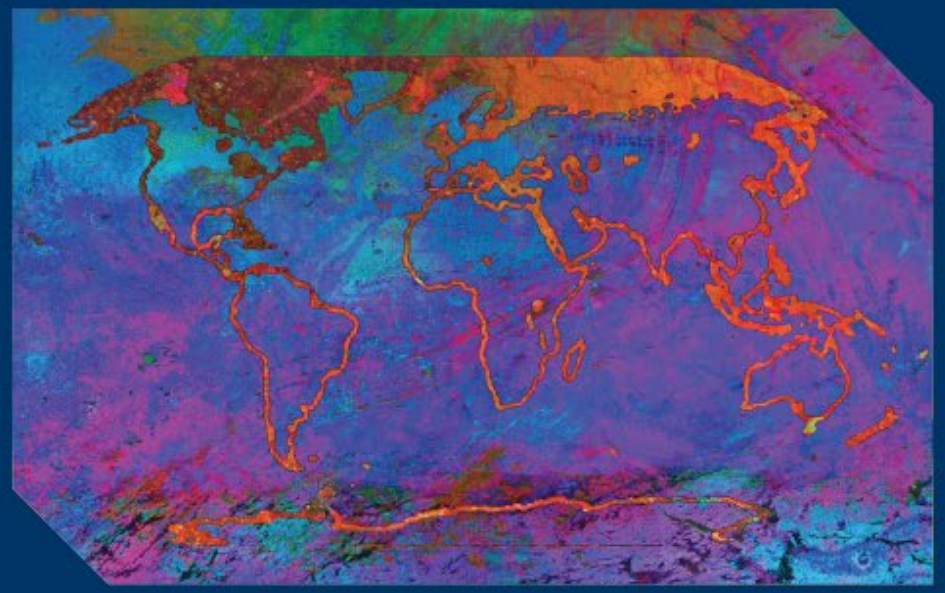



International agreed upon targets of 1.5 to 2 °C require rapid reductions in emissions. starting now.

Getting to Net Zero Emissions by 2050 (or 2060) Means Greatly Reducing Emissions from Burning of Fossil Fuels

# Maintain a Sense of Hope

- Our future depends on how we act to limit climate change.
- We also need to be Resilient: Adaptation is not a choice – our choice is whether to adapt proactively or respond to the consequences.
- We can respond to the changing climate while making this into an engine for a winning economy.



“ The climate we experience in the future depends on our decisions now.

ipcc
INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP


Thank you!

# We Each Can Be the Difference!
# There is Much We Can Do

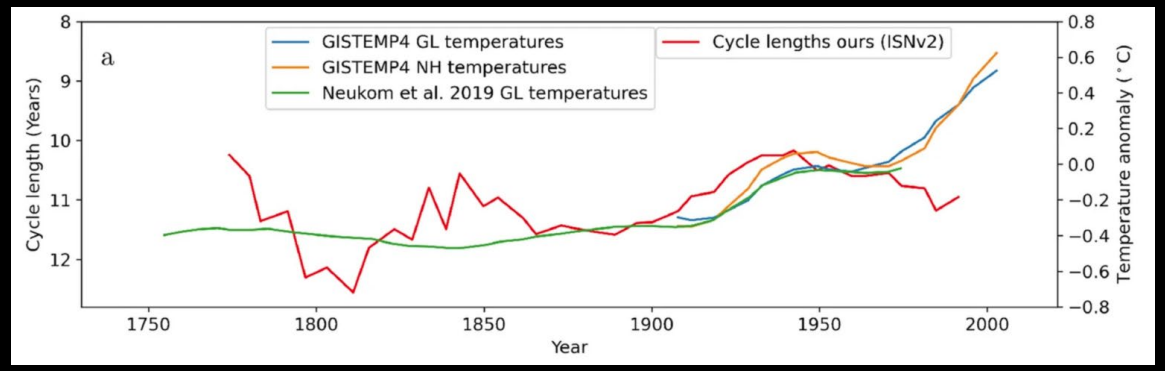
## Communicate!!!!

- Speak up!
- Contact your representatives
- Influence friends and family!
- Vote with care

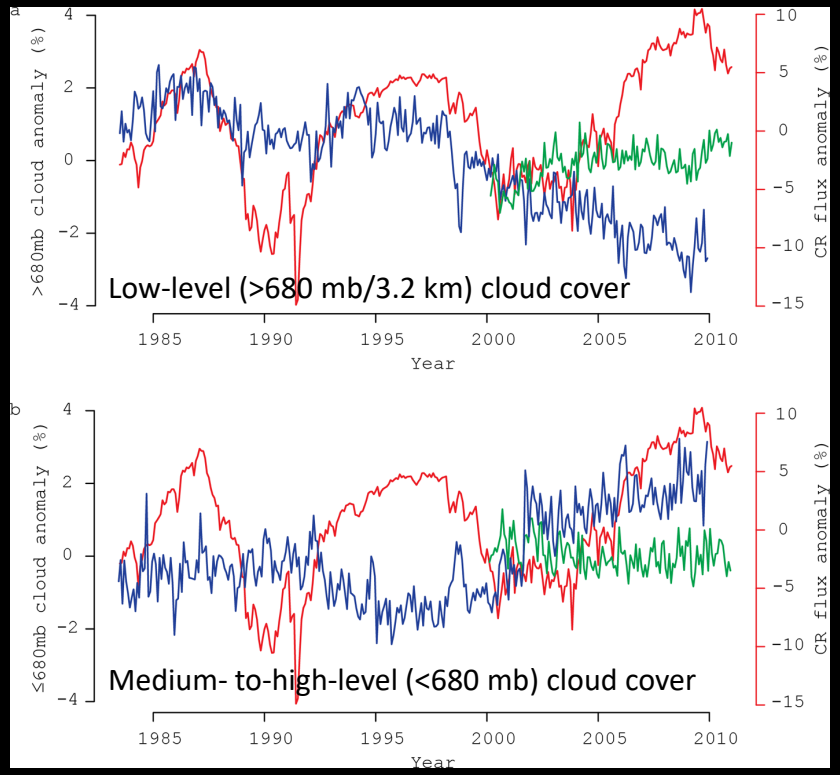
## Reduce emissions and adapt

- Be energy efficient!
  - Use solar or renewable energy
  - Drive a fuel efficient or electric vehicle
  - Use mass transit, walk, etc.
  - LED light bulbs.
  - Get efficient appliances.
  - Be water efficient

# It’s Not the Sun!




Chatzistergos (2023):
It’s not the length of the solar cycle




Laken et al. (2012):
It’s not cosmic rays effects on clouds

# Key Mitigation Realities

- Human $CO_2$ emissions are the biggest piece of the problem (50% and growing)
  - About 85% comes from burning coal, oil, & natural gas (providing >80% of world energy)
  - Most of the rest comes from land use change – e.g., deforestation & burning in the tropics
- Developing countries now exceed industrialized ones in total $CO_2$ emissions (but not per capita).
- Global energy system can't be changed quickly: ~$20T is invested in it; normal turnover is ~40 yrs.
- Deforestation trends are not easy to change: embedded in economics of food, fuel, timber, trade, & development.
- Achieving 1.5 ℃ with little to no overshoot means nearly "net zero" GHG emissions by 2050. And 40-58% by 2030.