Climate Change: Science and Impacts

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Science Overview

1. What is climate change?
2. Why is our planet warming faster now?
3. How do we measure our changing climate?
4. How sure are we?

‘Climate’ means…

- the average weather conditions of a place or area (or the whole globe) over a period of years

- So ‘Climate change’ is a long term change in the average weather

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What do we know about climate change?

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- Our climate has always been variable.

- Glacial periods and warmer periods have occurred throughout Earth's history.

- This variability is natural and is caused by many things

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However…

- Global temperature change (between glacial and interglacial periods) occurs normally at a rate of 0.05 – 0.005°C every 100yrs.

- In the last 50yrs the global average temperature has increased by 0.5 degrees

- This is between 20 and 200 times the normal rate, and it's accelerating

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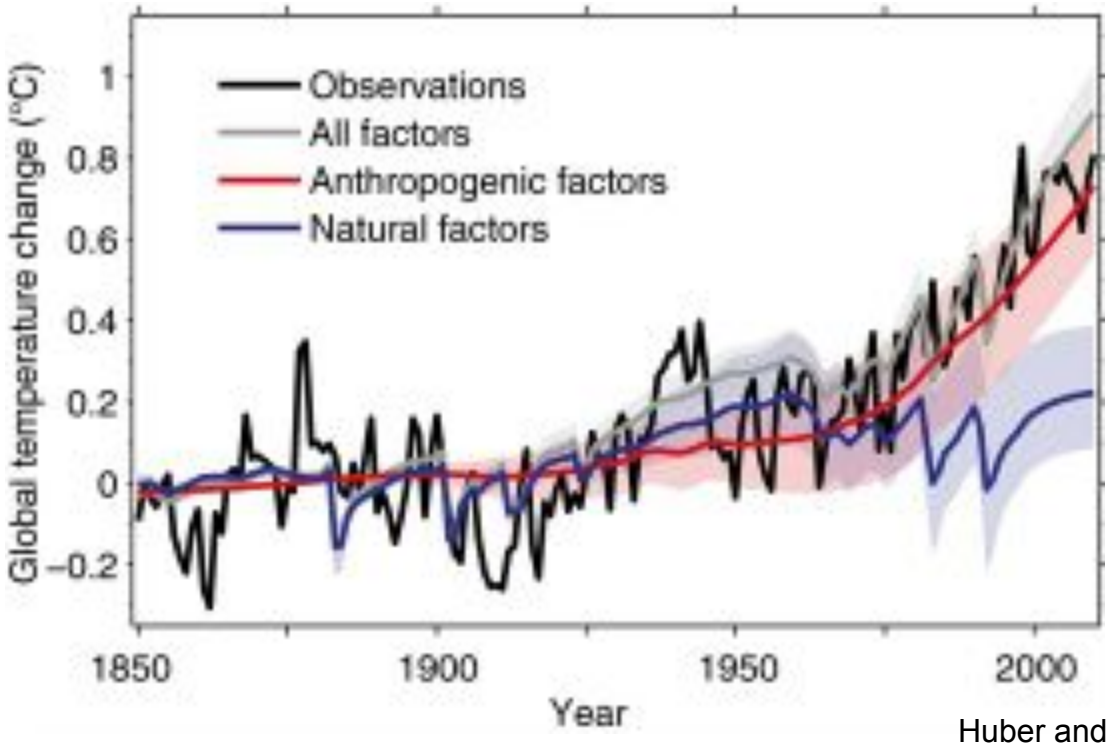
We also know the Earth is warming up quickly (because we can measure it)



Huber and Knutti (2012)

Global average temperature change from 1850

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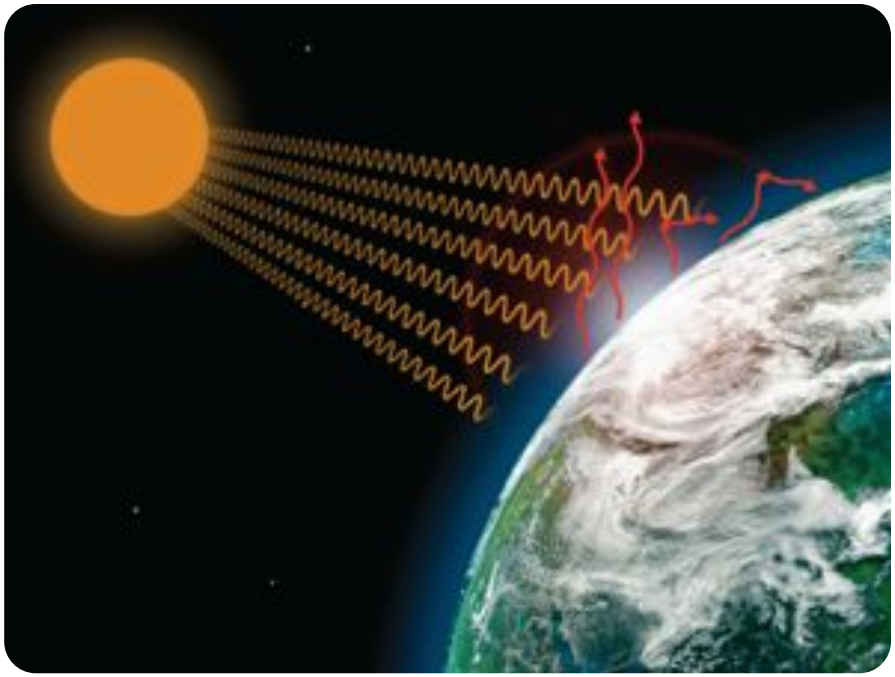
Why is the Earth warming? The Greenhouse Effect



There are many greenhouse gases

- Carbon dioxide (CO_2) – most abundant
- Methane
- Nitrous oxide

The gases in the atmosphere that trap heat in the earth's surface are called greenhouse gases and they occur naturally in our atmosphere, in small amounts.

Some greenhouse gases are good – they allow our planet to be warm enough to support life.

	Mercury	Venus	Earth	Mars
Temperature:	167°C	464°C	15°C	-65°C
Greenhouse Effect:	none	~470°C	~30°C	a few degrees

Carbon Cycle

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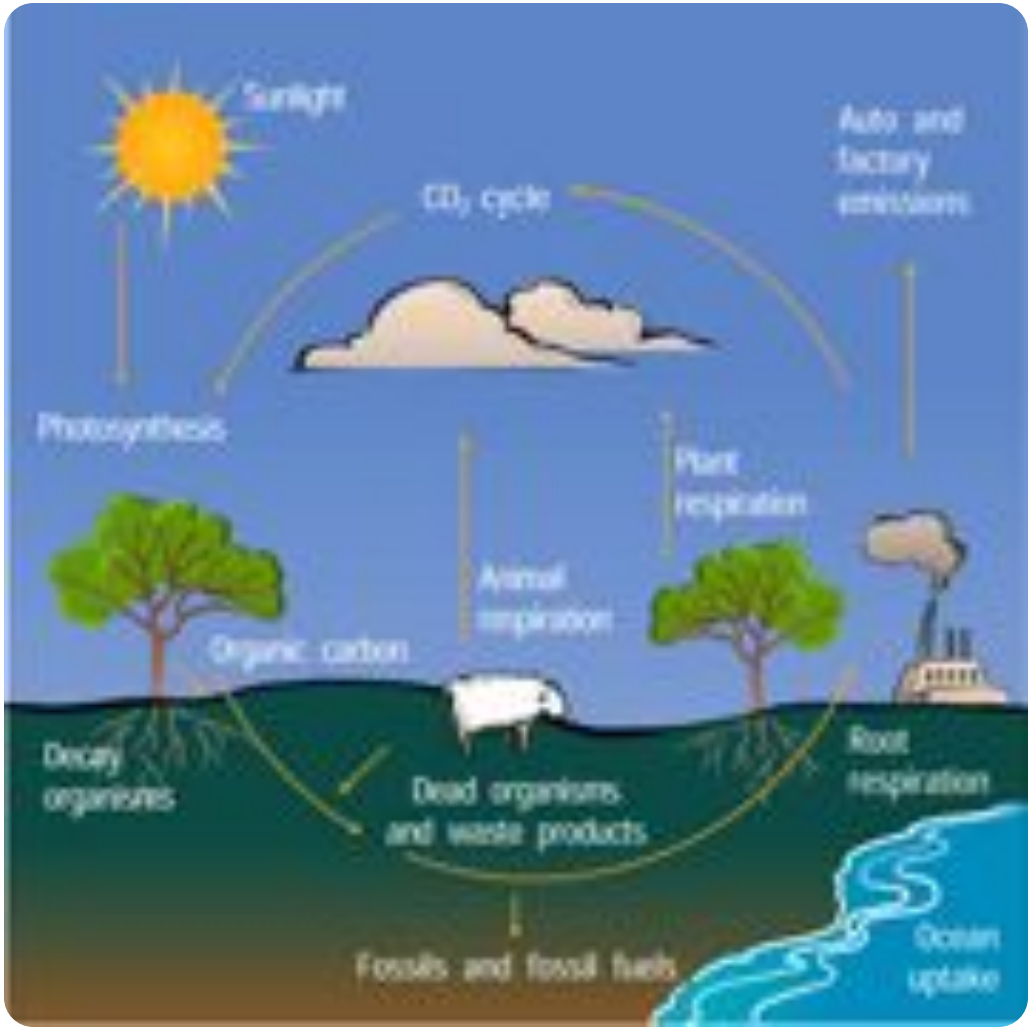
Greenhouse gases are naturally stored on our planet

- above ground, in plants, trees, and our oceans

- below the ground as fossil fuels – coal, oil, natural gas, and more.

The Carbon cycle



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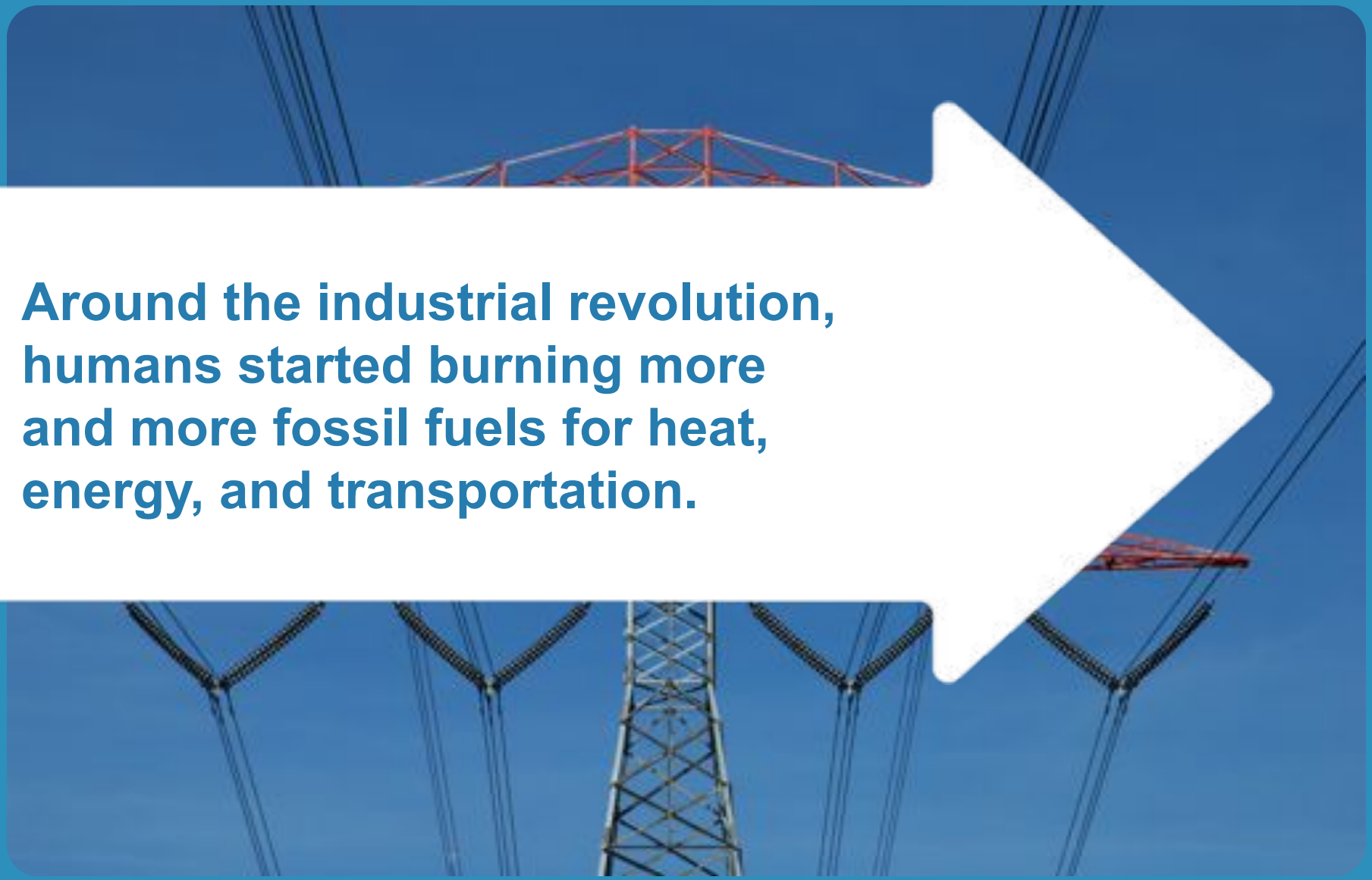
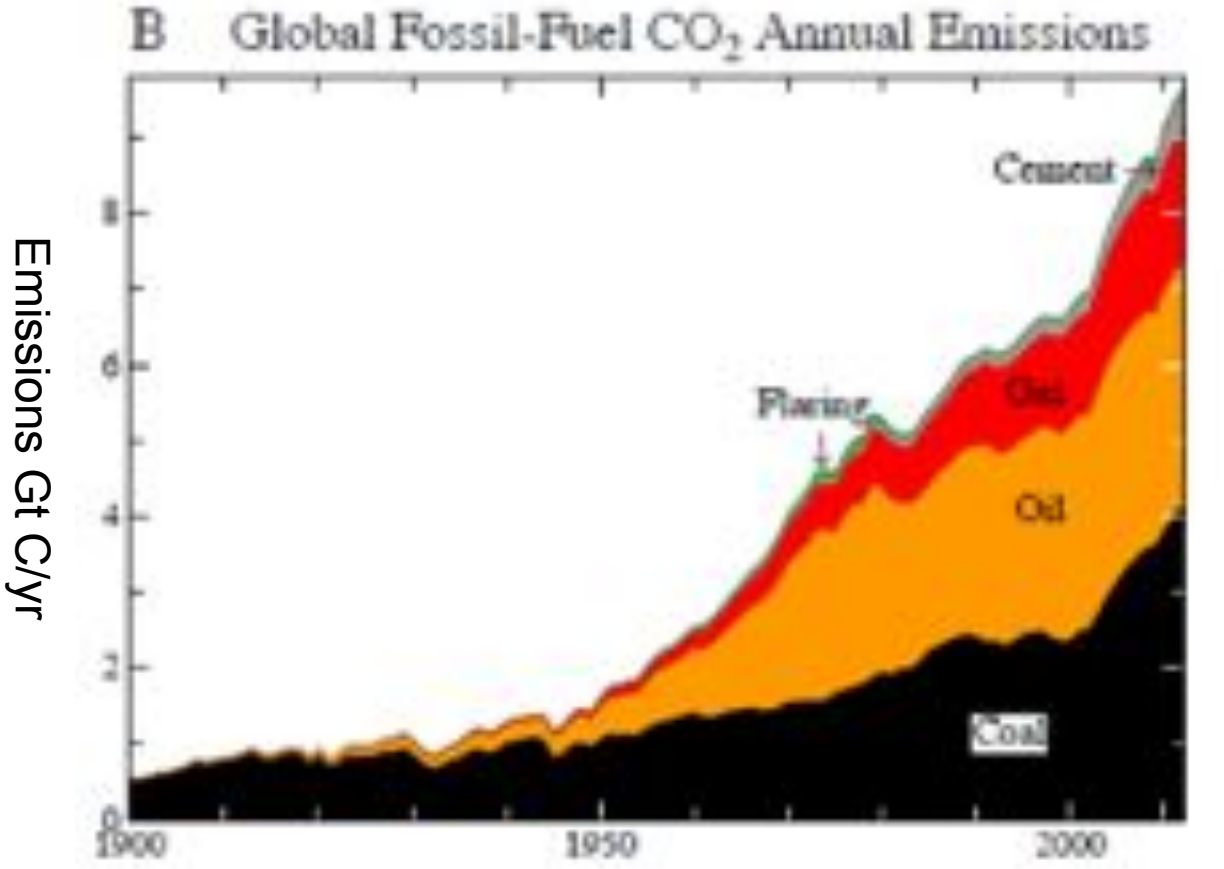


Around the industrial revolution, humans started burning more and more fossil fuels for heat, energy, and transportation.



Hansen et al. (2013)

We have burned 370 GtC between 1870-2011. If we account for all sources (fossil fuels, cement, deforestation/land use, flaring), we have emitted 531 GtC during that time.

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How do we measure how our climate is changing?

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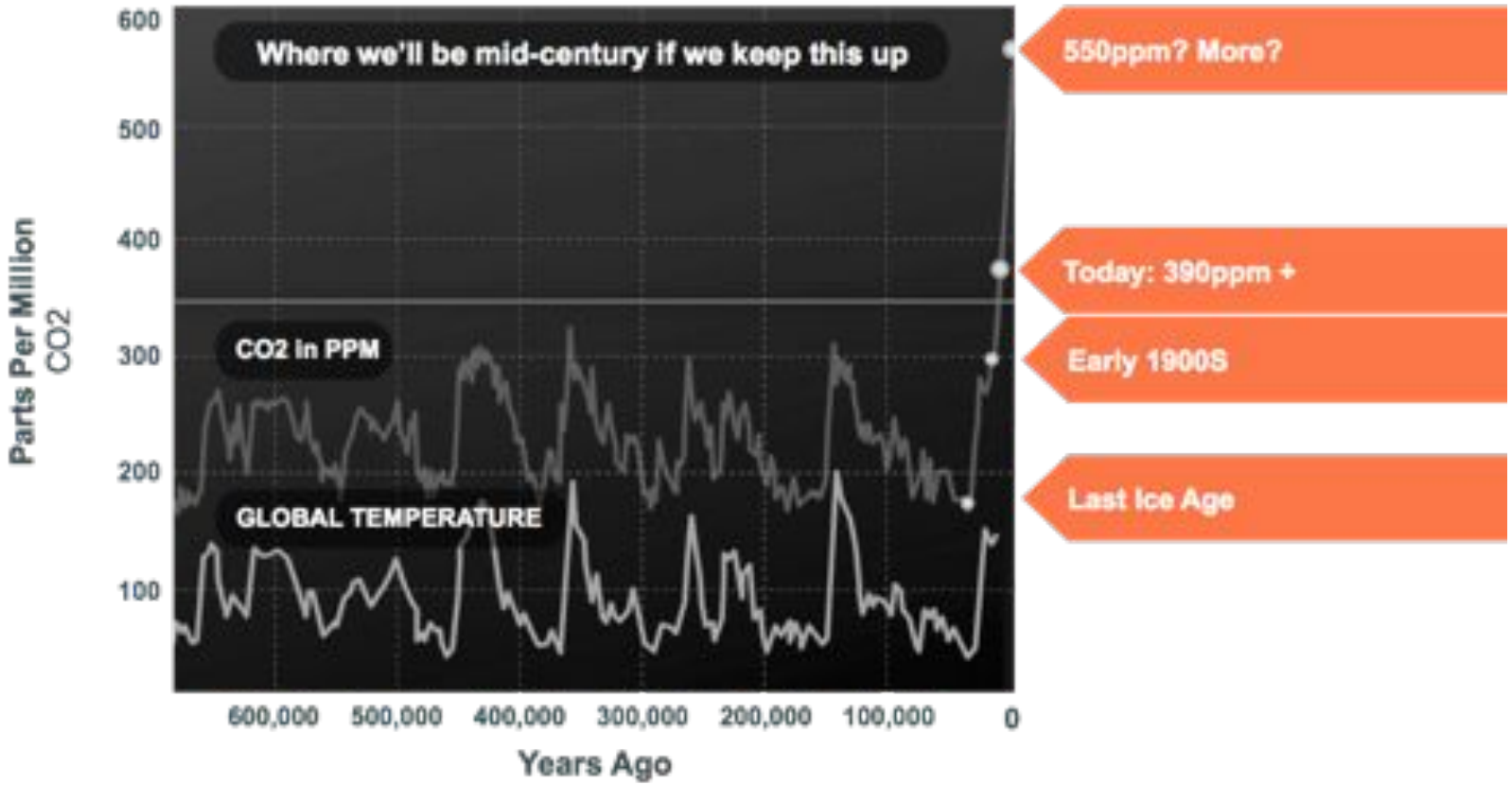
A few ways:

- Ppm and Ppm-e of CO_2 – parts per million
- Degrees Celsius of global temperature change
- Changing pH of the ocean

Throughout our history, global temperature has followed greenhouse gas concentrations



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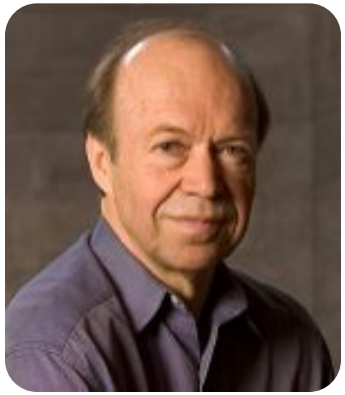
Historically, greenhouse gases have stayed in a particular range. Since industrialization, the concentration of CO_2 in the atmosphere has risen from about 280ppm (parts per million) to 400 ppm due to human activities.

The present CO_2 concentration has not been exceeded during the past 600,000 yrs and likely not in the past 20 million yrs

(humans only appeared on earth 2 million yrs ago!)

Currently we are already in the danger zone:

"If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimate evidence and ongoing climate change suggest that CO2 will need to be reduced from its current 387ppm to at most 350ppm."



NASA climatologist

Dr. James E. Hansen, 2008

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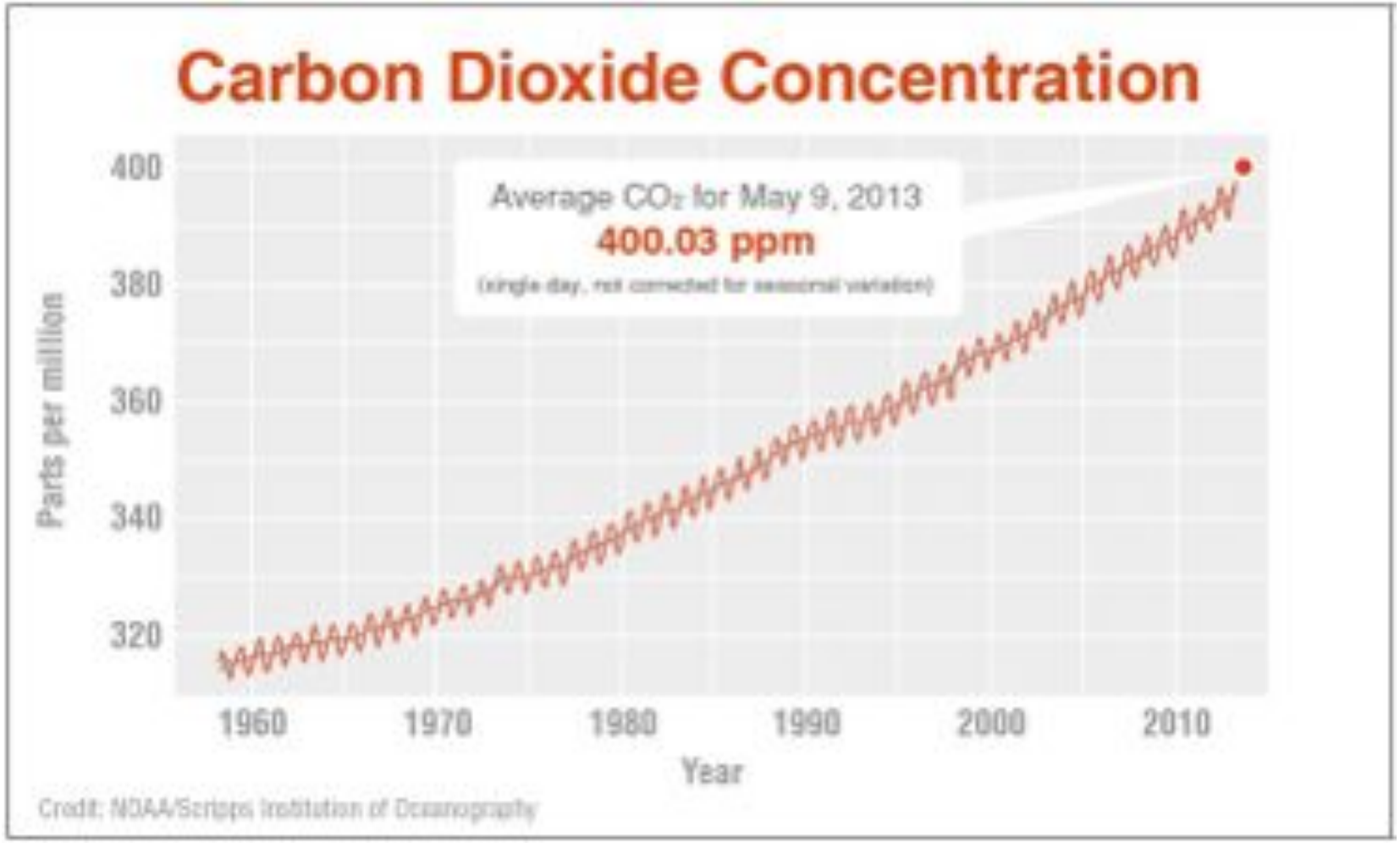
Carbon Dioxide Concentration
Average CO_2 for May 9, 2013
400.03 ppm
(single day, not corrected for seasonal variation)
Parts per million
400
380
360
340
320
1960
1970
1980
1990
2000
2010
Year
Credit: NOAA/Scripps Institution of Oceanography

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So are we too late?

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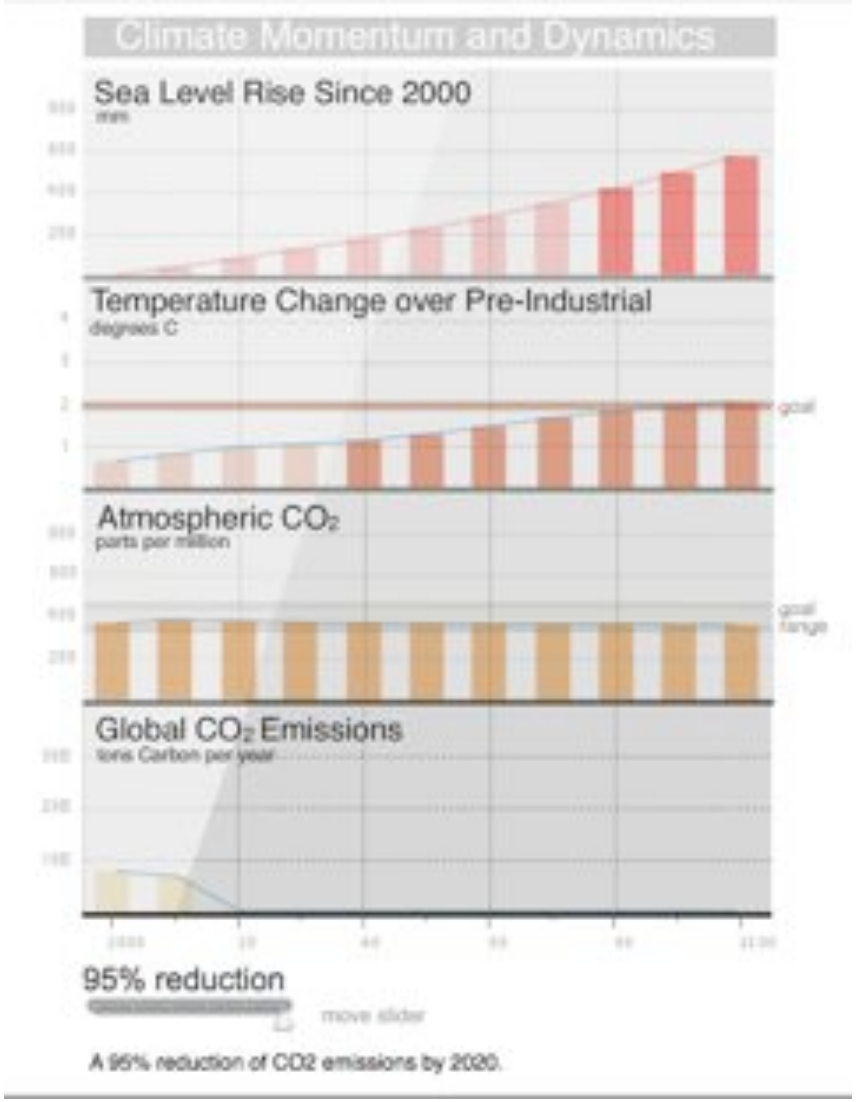
Momentum:

GHGs remain in the atmosphere for a long time, so even if we stopped emitting tomorrow, we would still see the impacts from what we have emitted already.



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Its not too late, but this is an emergency – we need to act NOW.

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How sure are we of all of this?

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The largest research project in history

In 1988, the IPCC was created to “provide the decision-makers and others interested in climate change with an objective source of information about climate change”

2,000 Scientists, New reports every 4 years

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The numbers speak for themselves…

Number of scientific studies dealing with "climate change" published in scientific journals between 1993 and 2003:	928
Number disagreeing with the global consensus that greenhouse gas pollution has caused most of the warming of the last 50 years:	0

Science, December 3, 2004 Vol. 306, Issue 5702,1686

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The numbers speak for themselves…

Number of climate denial studies funded by Exxon Mobil:

9/10

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Uncertainty

- There is uncertainty about just how our climate will change in the future

- That's because our earth is such a big and complex system

- But in general, scientists' predictions have tended to be conservative compared to observed impacts so far (and are still quite scary)

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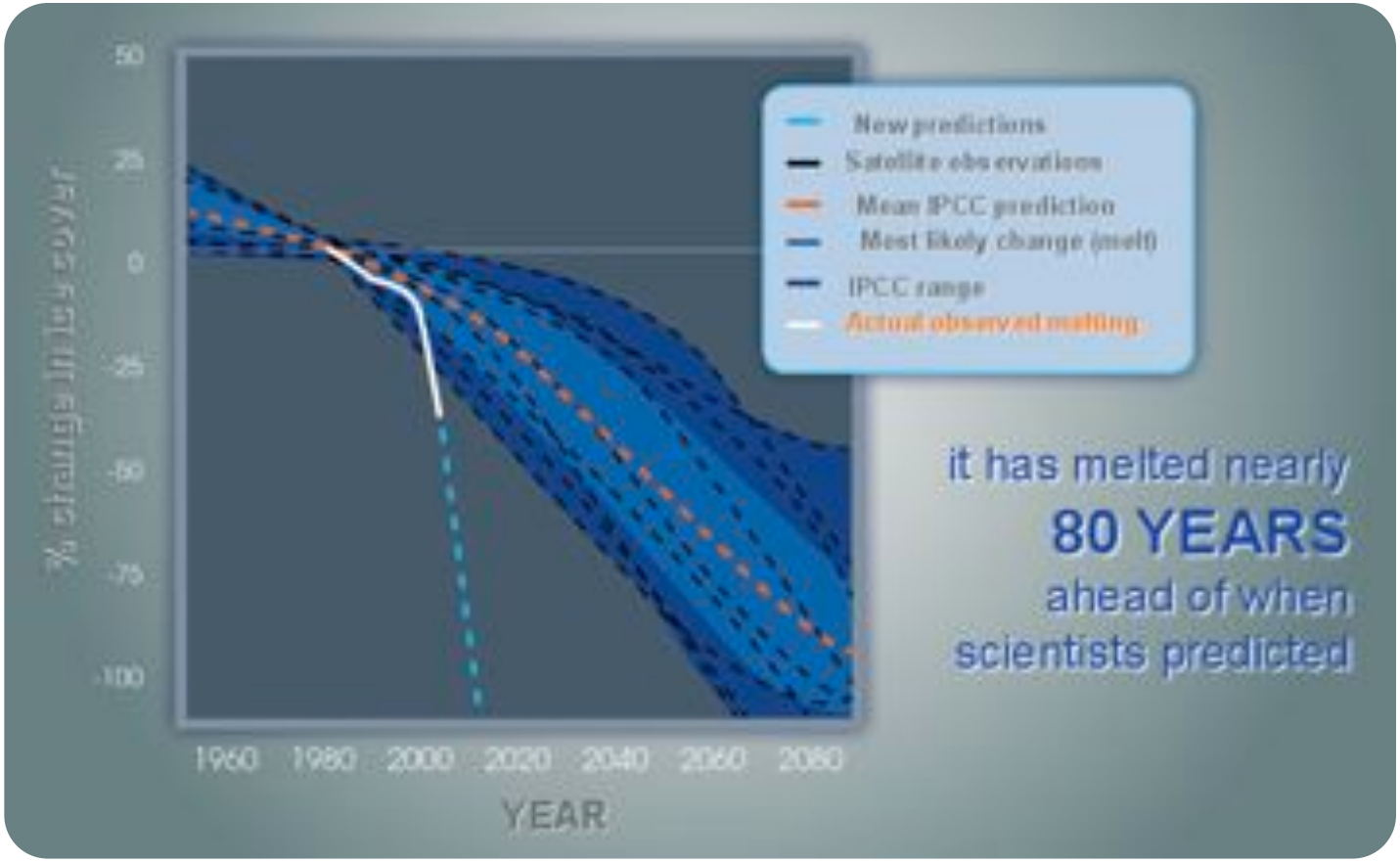
Example: Melting of the arctic



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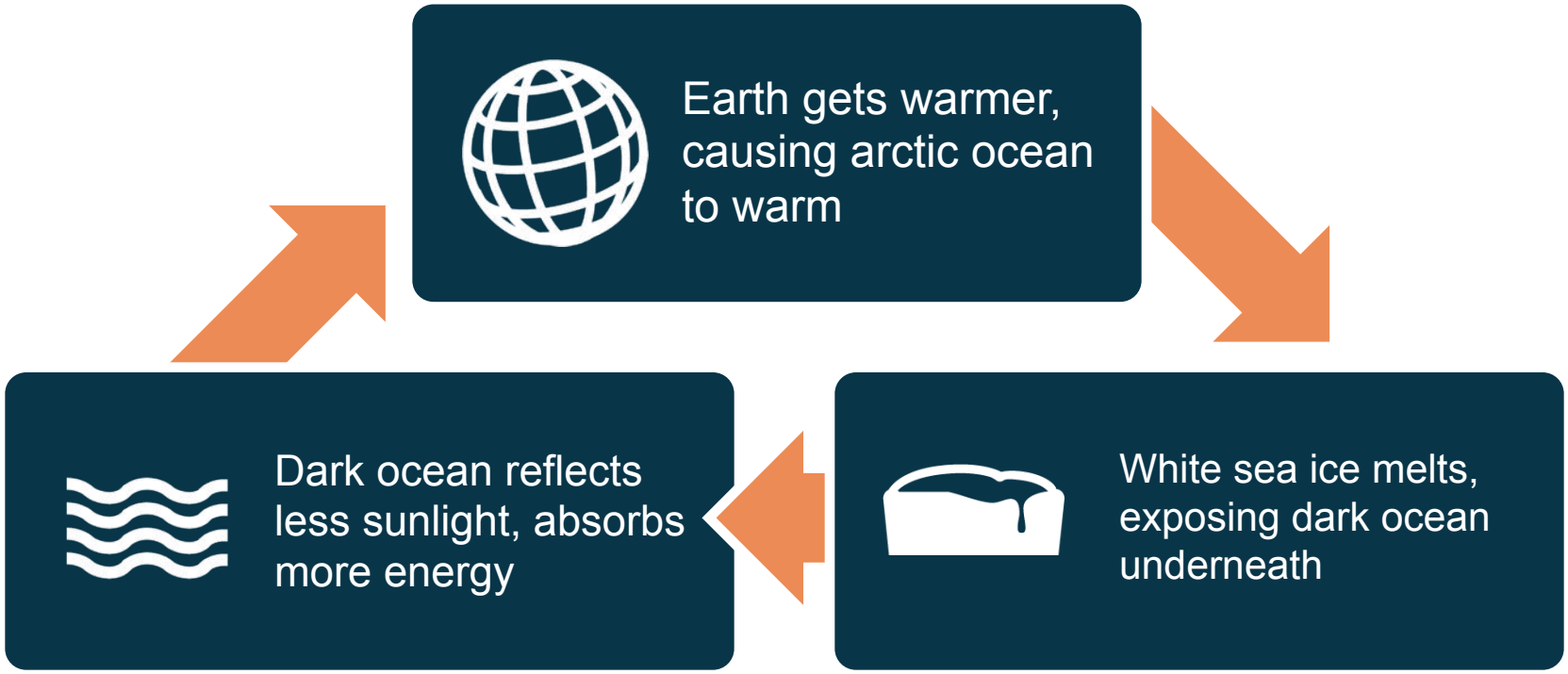
Much of the uncertainty is due to “feedback loops”, when climate impacts reinforce and amplify each other, which can be hard to model

Example: The Albedo feedback loop



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In Summary

- Greenhouse gases trap heat in our atmosphere.
- Humans have been releasing more and more greenhouse gases into our atmosphere since the industrial revolution.
- We can measure that we have increased the concentration of greenhouse gases in our atmosphere higher than at any time in human history.
- The scientific consensus that climate change is real.

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We know our climate is changing from the impacts we are already witnessing.

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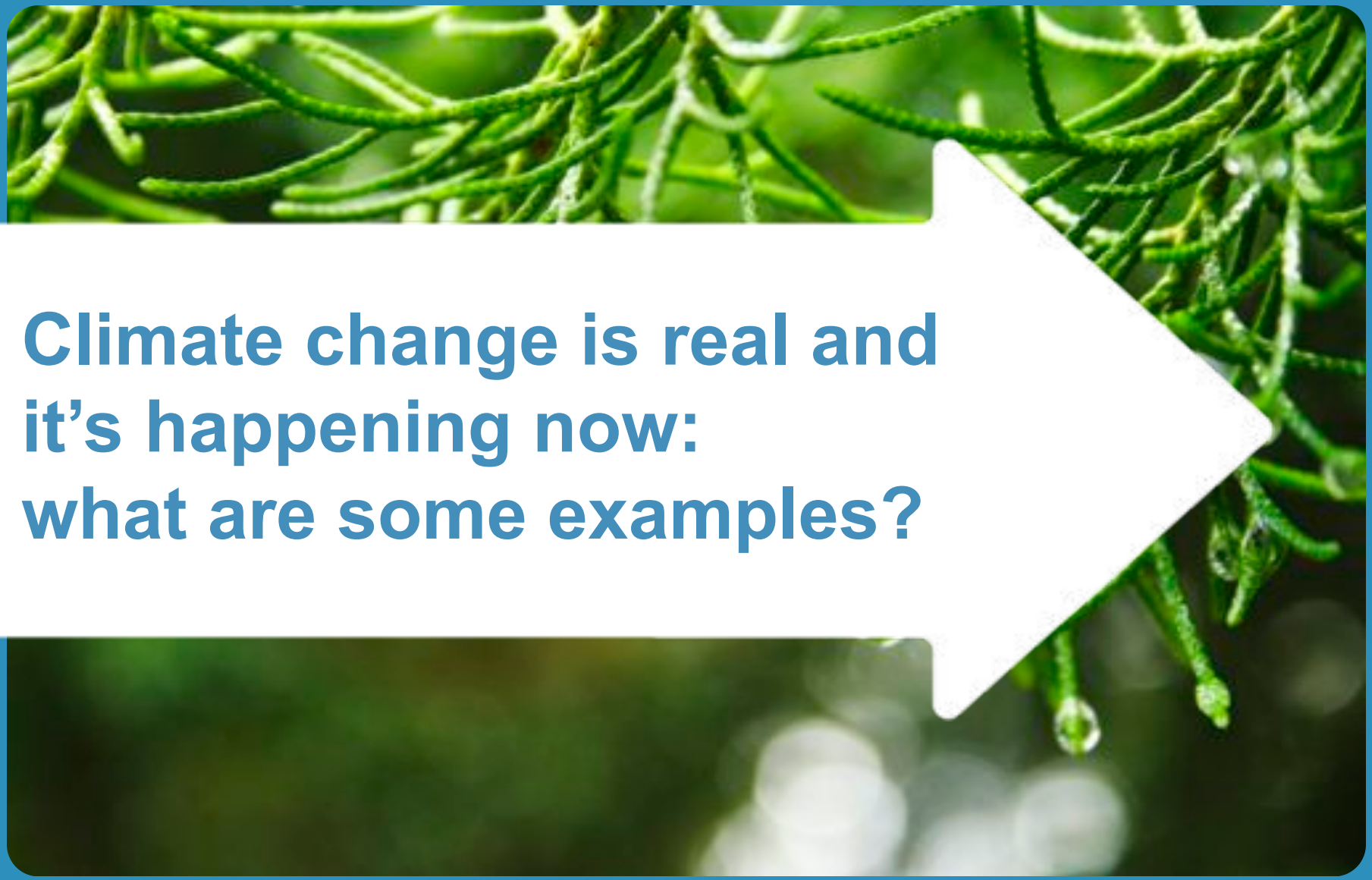

Climate change is real and it's happening now: what are some examples?

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Some things are already changing in very real and measurable ways, like:

- Temperature
- Arctic sea ice
- Glaciers
- Sea level rise
- Extreme weather

The top ten hottest years on record have all been in the past 15 years

The hottest years on record

Deviation from 1961-90 global average temperature, °C

	Met Office Hadley Centre and Climatic Research Unit		NOAA National Climatic Data Center		NASA Goddard Institute for Space Studies	
Rank	Year	Deviation	Year	Deviation	Year	Deviation
1	2010*	0.52	2010*	0.54	2010*	0.58
2	1998	0.52	2005	0.52	2005	0.56
3	2005	0.47	1998	0.50	2007	0.51
4	2003	0.46	2003	0.49	2009	0.50
5	2002	0.46	2002	0.48	2002	0.49
6	2009	0.44	2006	0.46	1998	0.49
7	2004	0.43	2009	0.46	2006	0.48
8	2006	0.43	2007	0.45	2003	0.48
9	2007	0.40	2004	0.45	2004	0.43
10	2001	0.40	2001	0.42	2001	0.40
11	1997	0.36	2008	0.38	2008	0.37
12	2008	0.31	1997	0.38	1997	0.32
13	1995	0.28	1999	0.32	1995	0.30
14	1990	0.26	1995	0.31	1999	0.29

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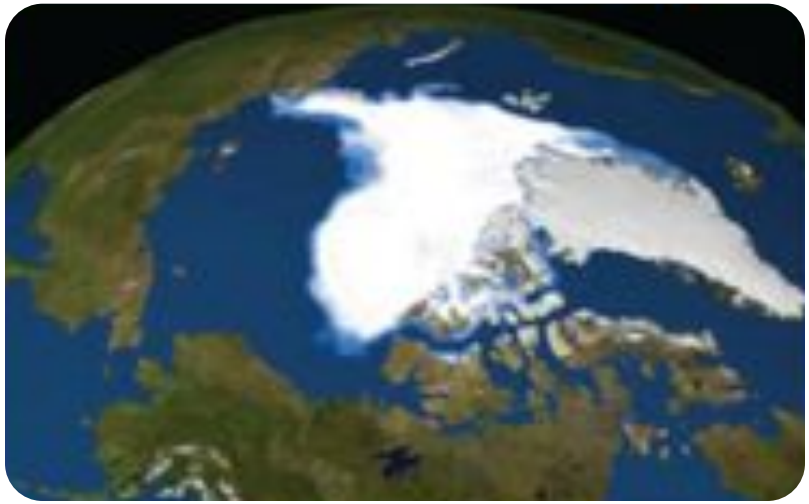
The Arctic is currently warming at twice the rate of the rest of the world

Between 1979 and 2007, the Arctic lost over 40% of its ice

1979

2007



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Glaciers are melting before our eyes – Chorabari Glacier receded 260 m since 1962

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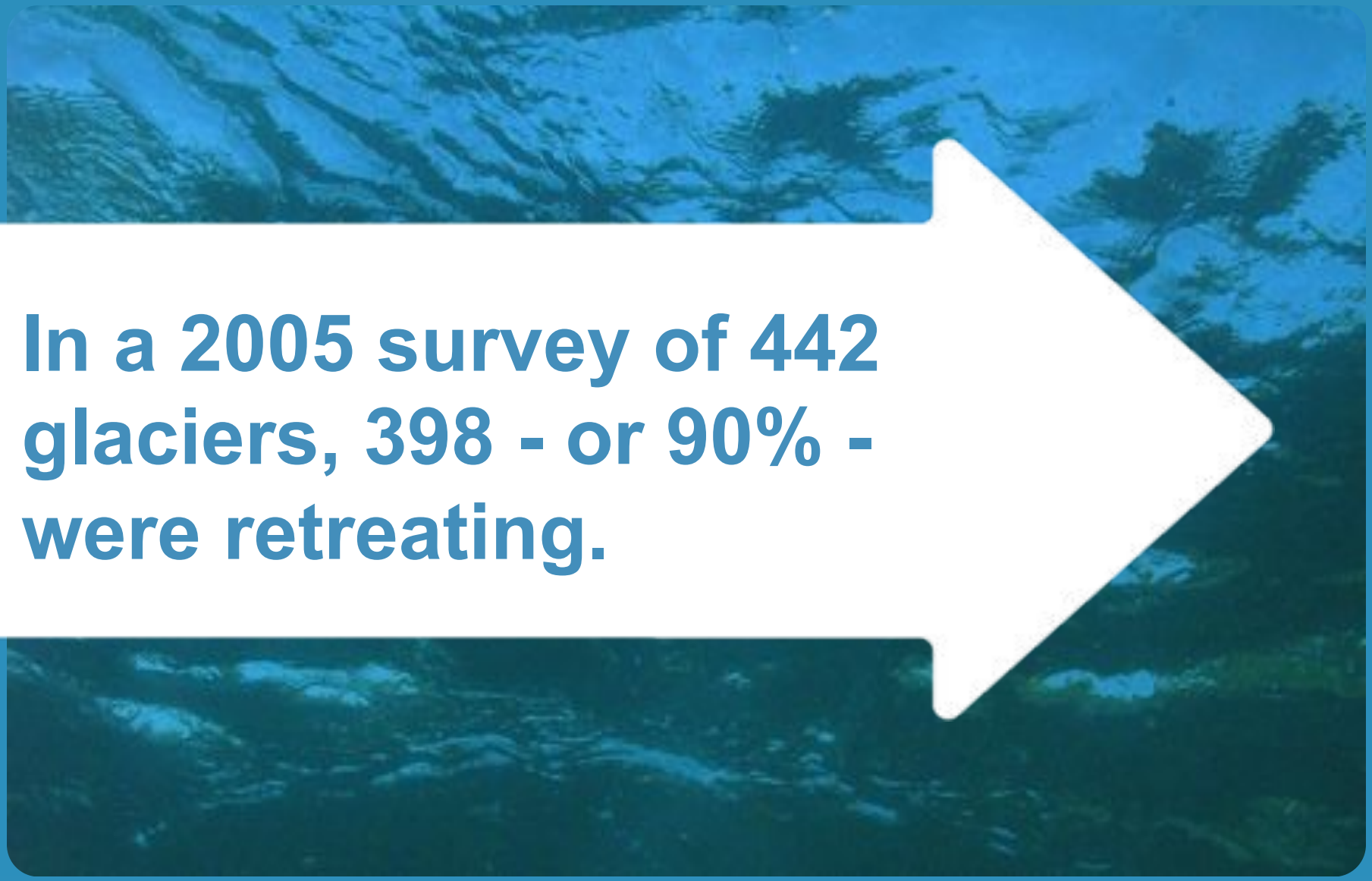
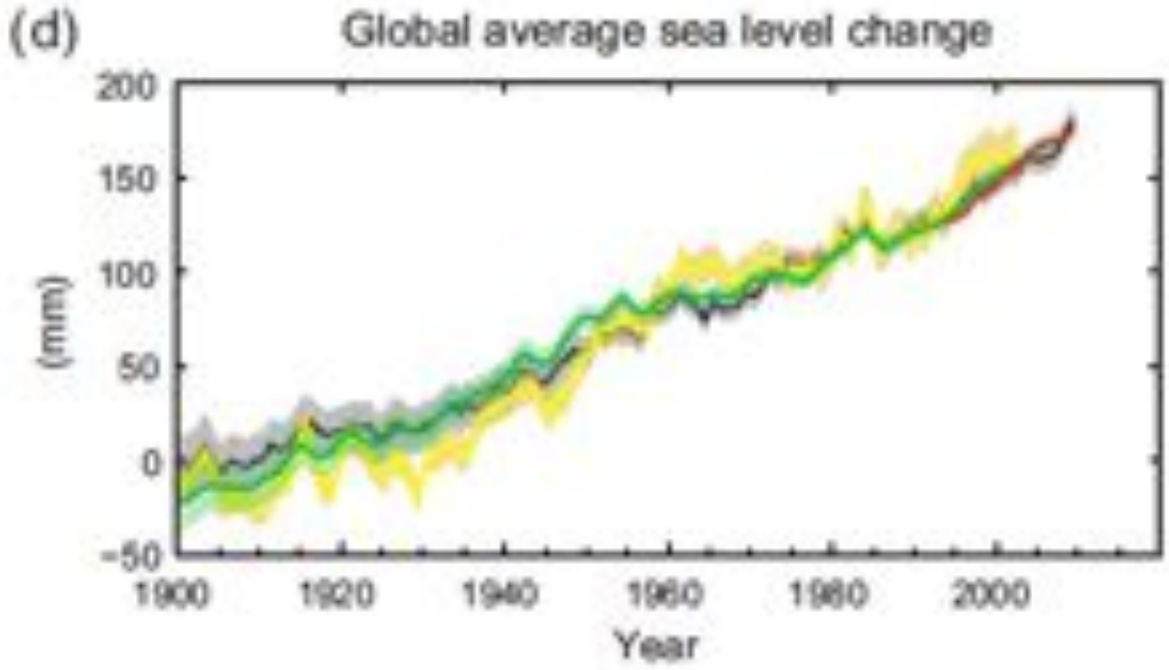

In a 2005 survey of 442 glaciers, 398 - or 90% - were retreating.

Sea levels are already rising



IPCC, 2013

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Small islands are already planning relocation.

Photo: Toby Parkinson/Oxfam

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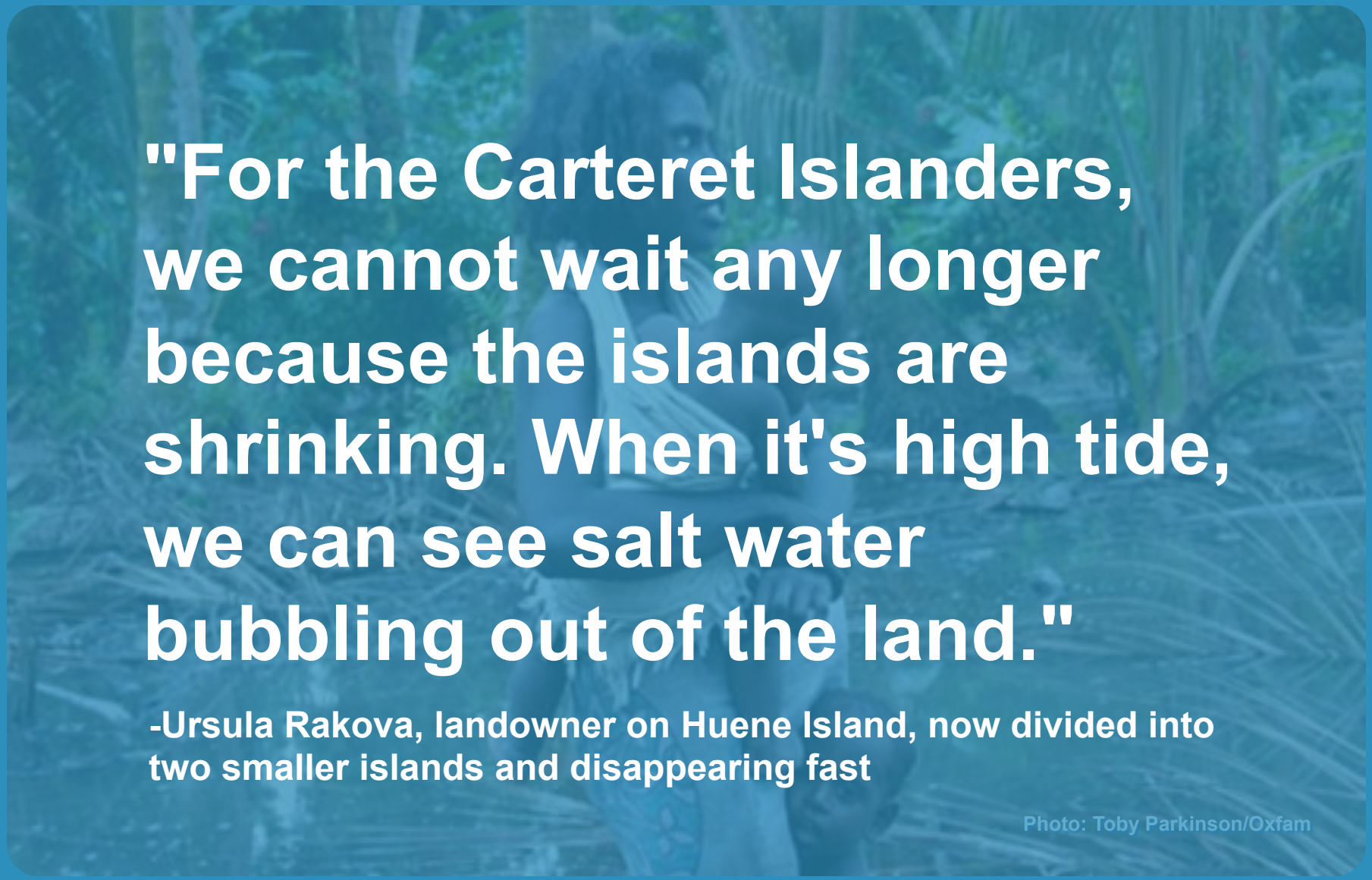
"For the Carteret Islanders, we cannot wait any longer because the islands are shrinking. When it's high tide, we can see salt water bubbling out of the land."
-Ursula Rakova, landowner on Huene Island, now divided into two smaller islands and disappearing fast
Photo: Toby Parkinson/Oxfam

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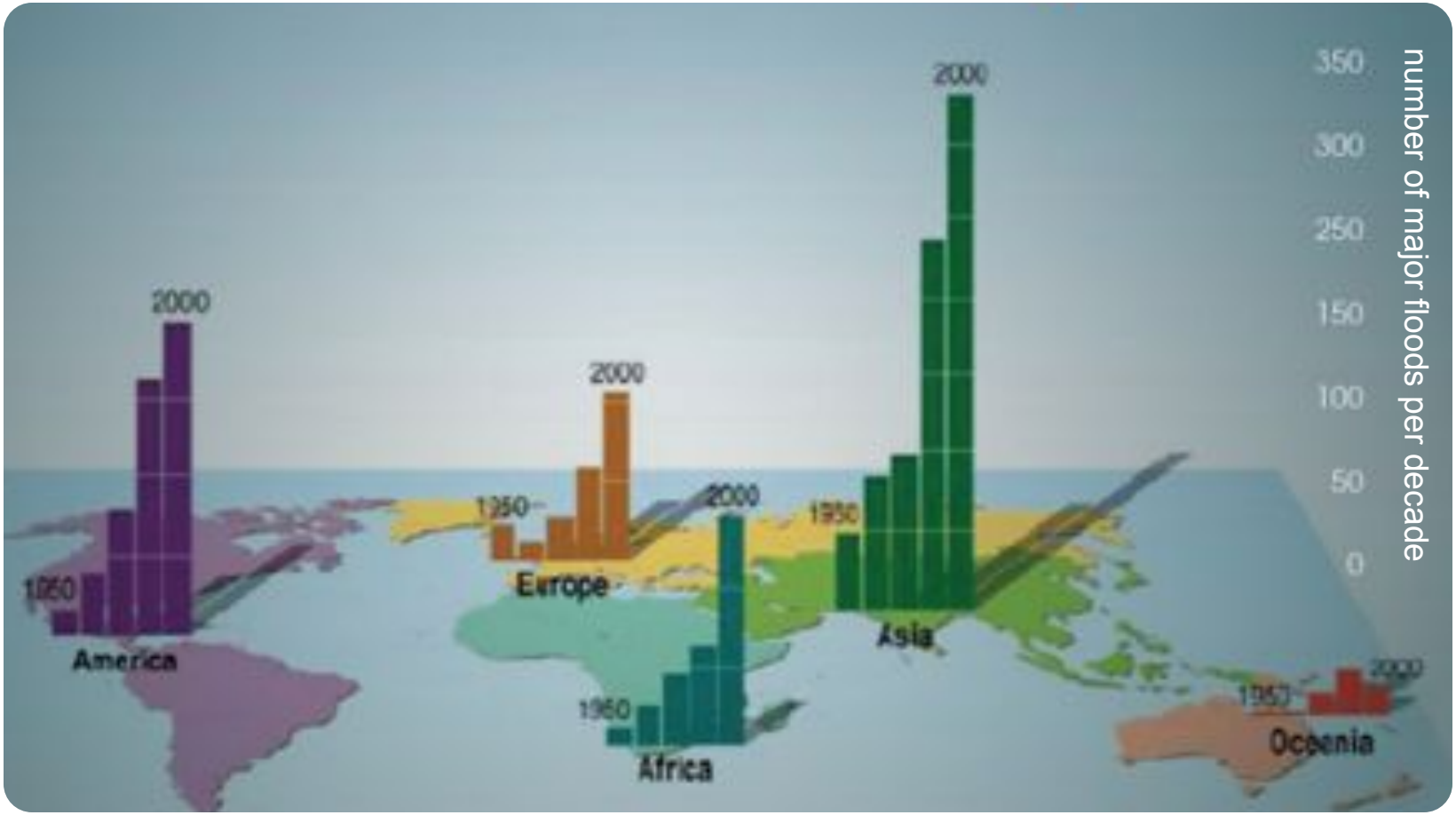
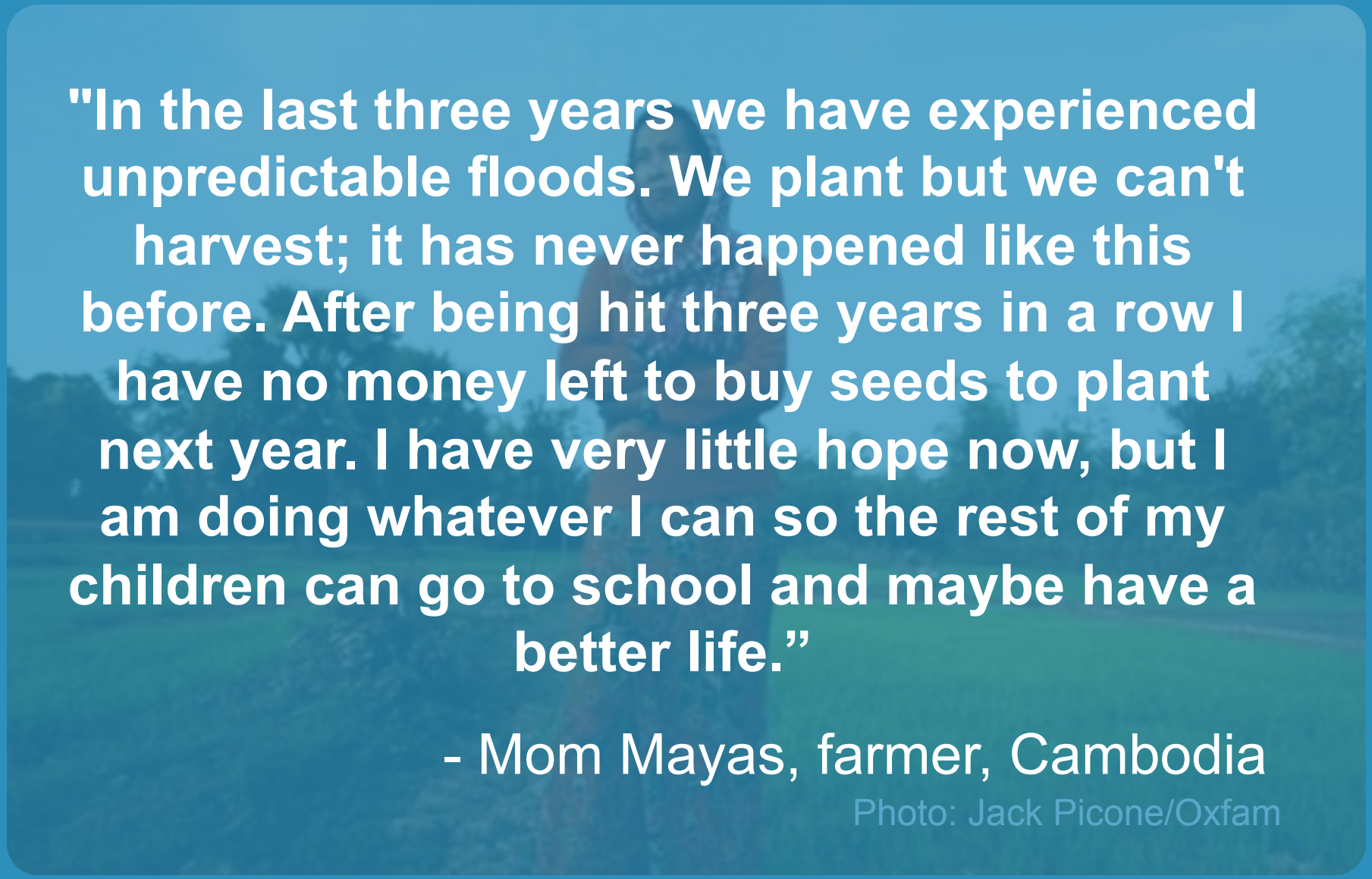
Major floods per decade



IMPACTS


Photo: Jack Picone/Oxfam



"In the last three years we have experienced unpredictable floods. We plant but we can't harvest; it has never happened like this before. After being hit three years in a row I have no money left to buy seeds to plant next year. I have very little hope now, but I am doing whatever I can so the rest of my children can go to school and maybe have a better life."

- Mom Mayas, farmer, Cambodia

Photo: Jack Picone/Oxfam

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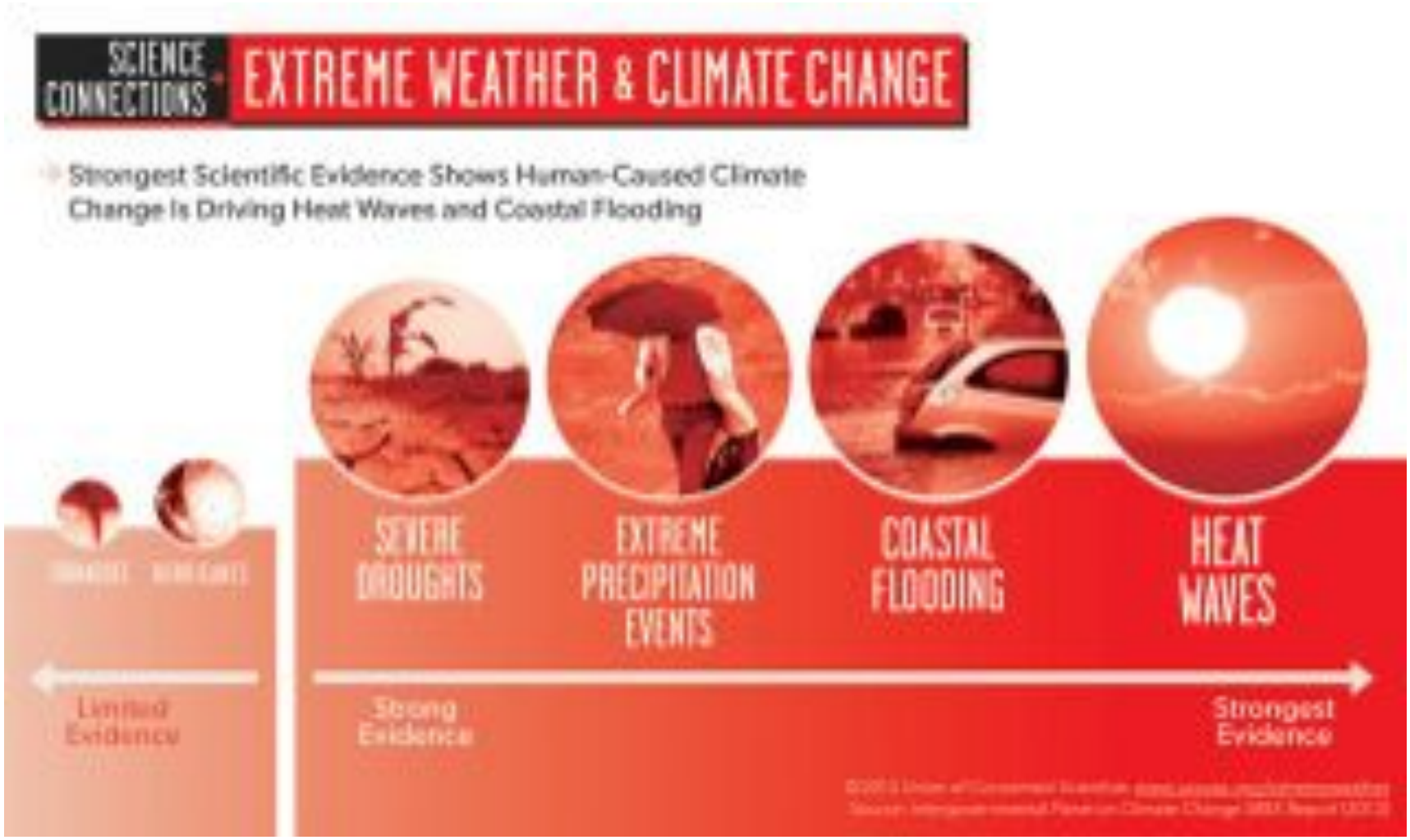
Impacts on the ocean

- Ocean acidification
- Sea surface temperature increase


SCIENCE CONNECTIONS
EXTREME WEATHER & CLIMATE CHANGE
Strongest Scientific Evidence Shows Human-Caused Climate Change Is Driving Heat Waves and Coastal Flooding
SEVERE DROUGHTS
EXTREME PRECIPITATION EVENTS
COASTAL FLOODING
HEAT WAVES
Limited Evidence
Strong Evidence
Strongest Evidence

IMPACTS

“The fact remains that there is 4 percent more water vapor available both to power individual storms and to produce intense rainfall from them. Climate change is present in every single meteorological event, in that these events are occurring within a baseline atmospheric environment that has shifted in favour of more intense weather events.”

- Michael Mann, climate scientist

Future Impacts – if CO2 emissions don't decrease

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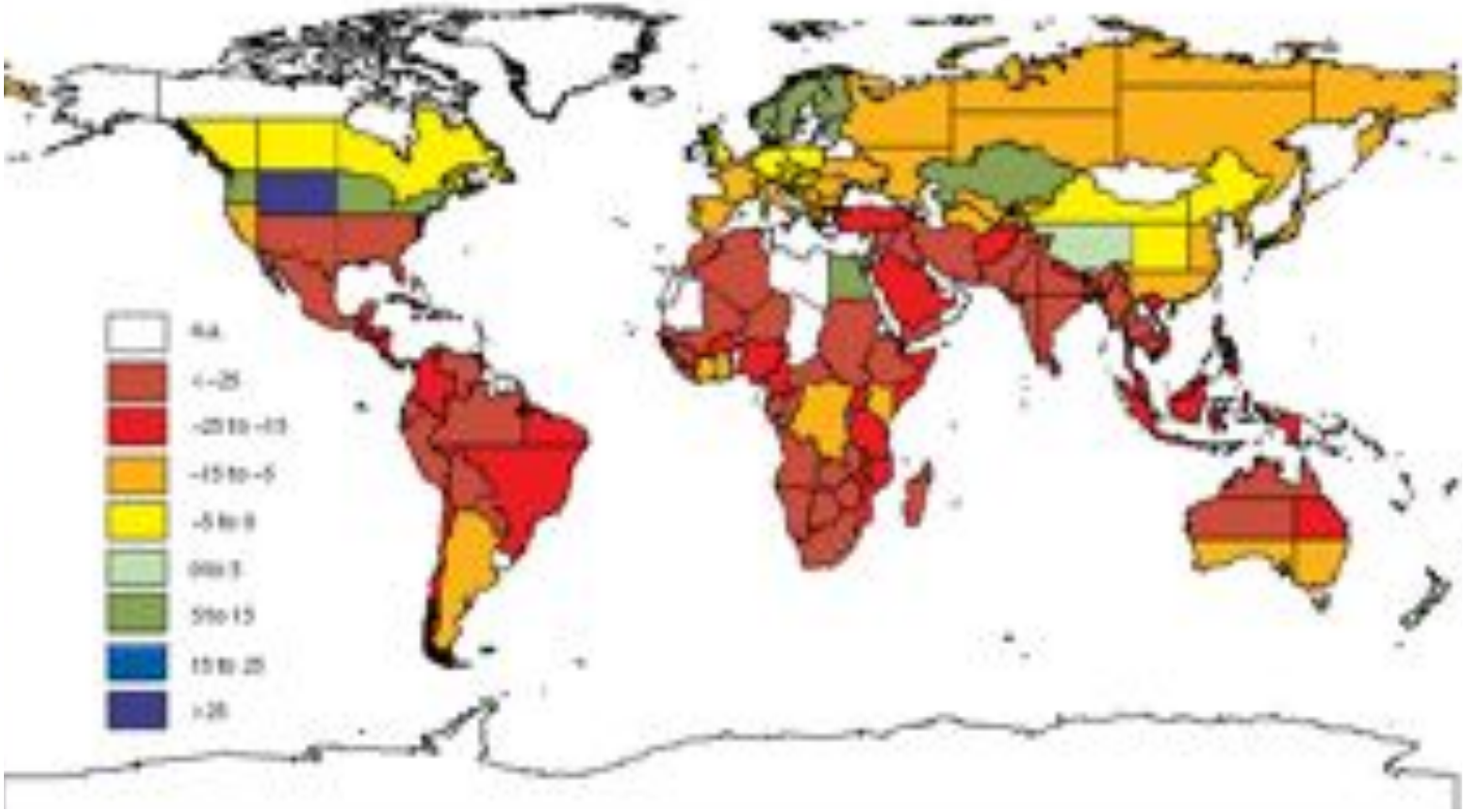
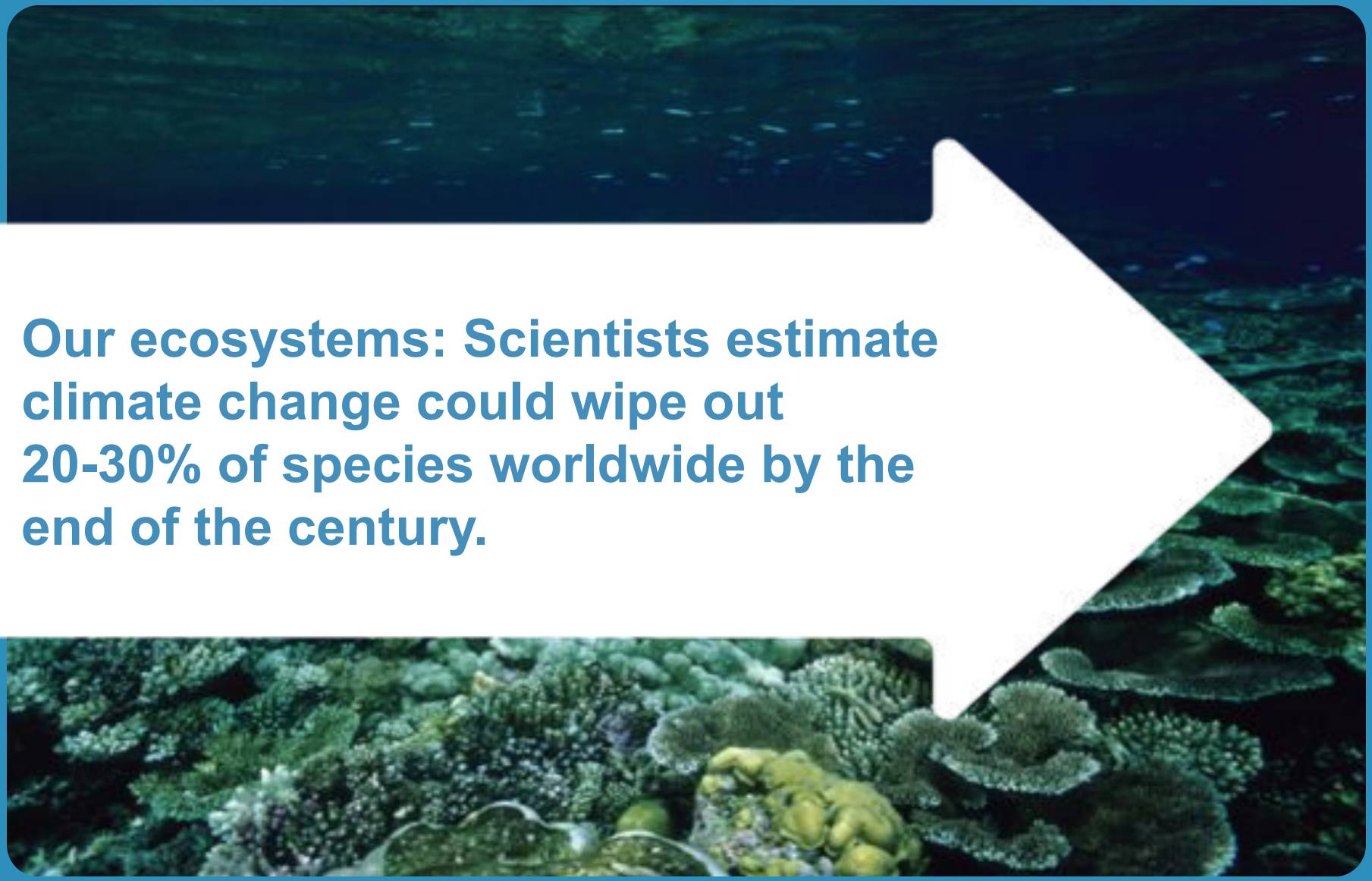
Droughts will have major impacts on our ability to grow food

(Source: William Cline, Center for Global Development)



This measurement is "% predicted agricultural productivity loss"



Our ecosystems: Scientists estimate climate change could wipe out 20-30% of species worldwide by the end of the century.

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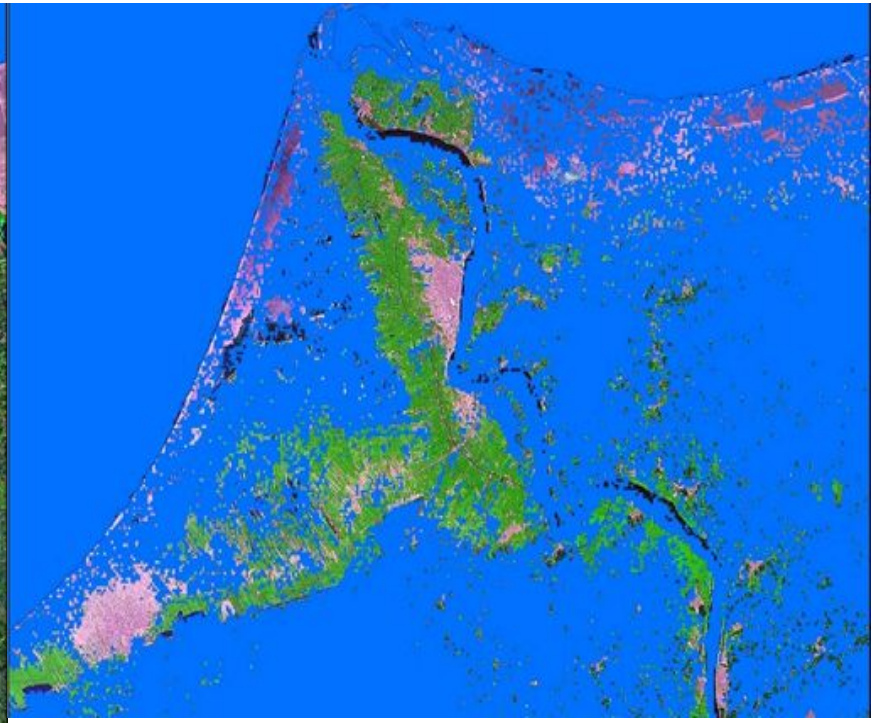
Conservative estimates predict at least 1m of sea level rise this century

Nile Delta 2000

Nile Delta with 1 meter sea level rise



IPCC-AR4: “0.18 – 0.59 m by 2100”

Post-AR4: “0.8 to 2.4 m by 2100“ (Hansen: “several meters“)

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Given our current emissions trajectory, we are headed for a 3-4 degree C rise in temperature, which scientists predict would cause:

- In Central and South Asia, crop yields are predicted to fall by up to 30 per cent
- By the 2050s in Latin America, 50% of agricultural lands are very likely to be subjected to desertification and salinisation
- 1.5-2.5 billion more people worldwide exposed to Dengue fever
- 50% decrease in water flowing through rivers in the Mediterranean, southern Africa, and parts of South America, producing water shortages for millions

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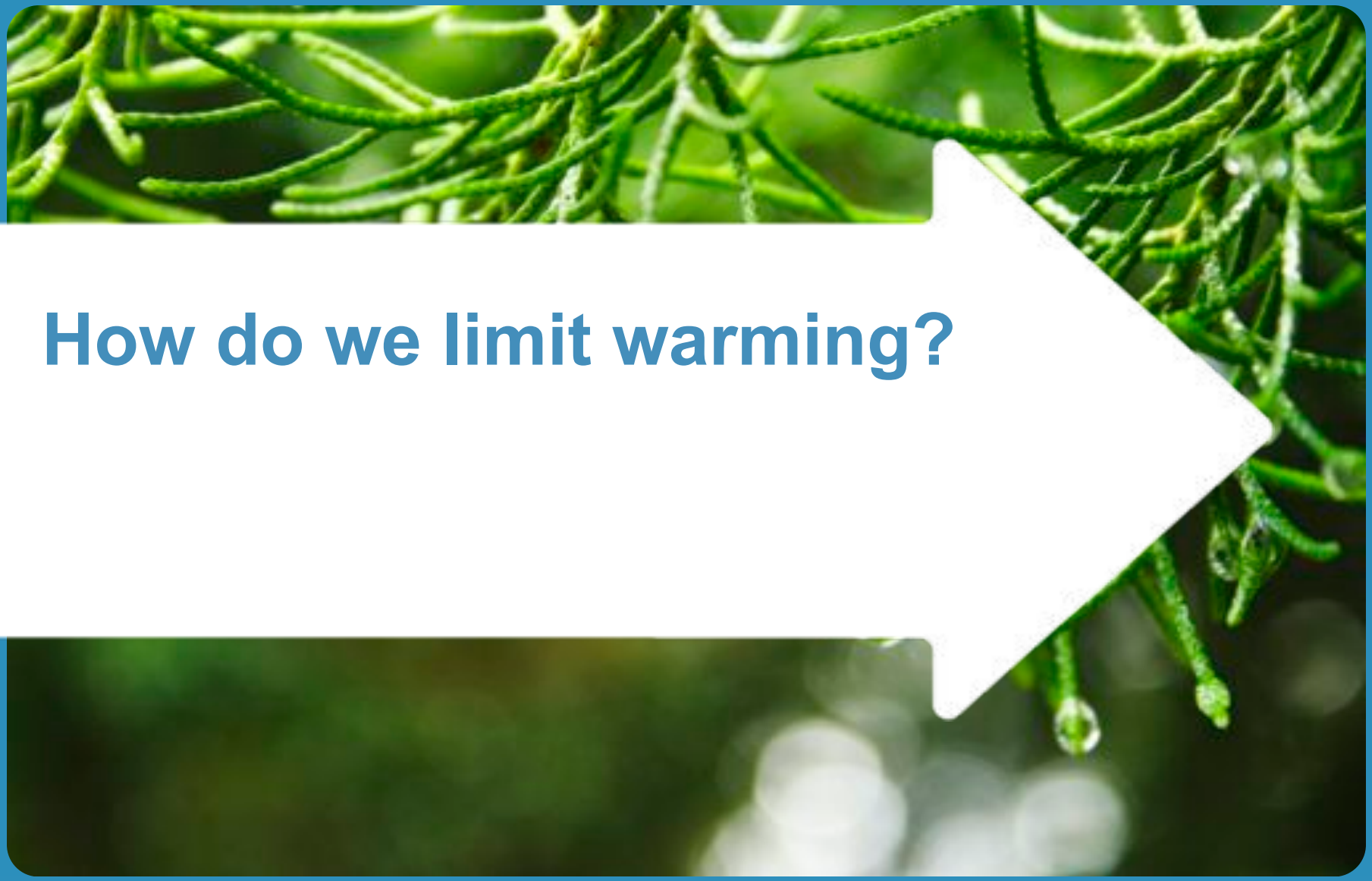
Expected Climate Impacts - India

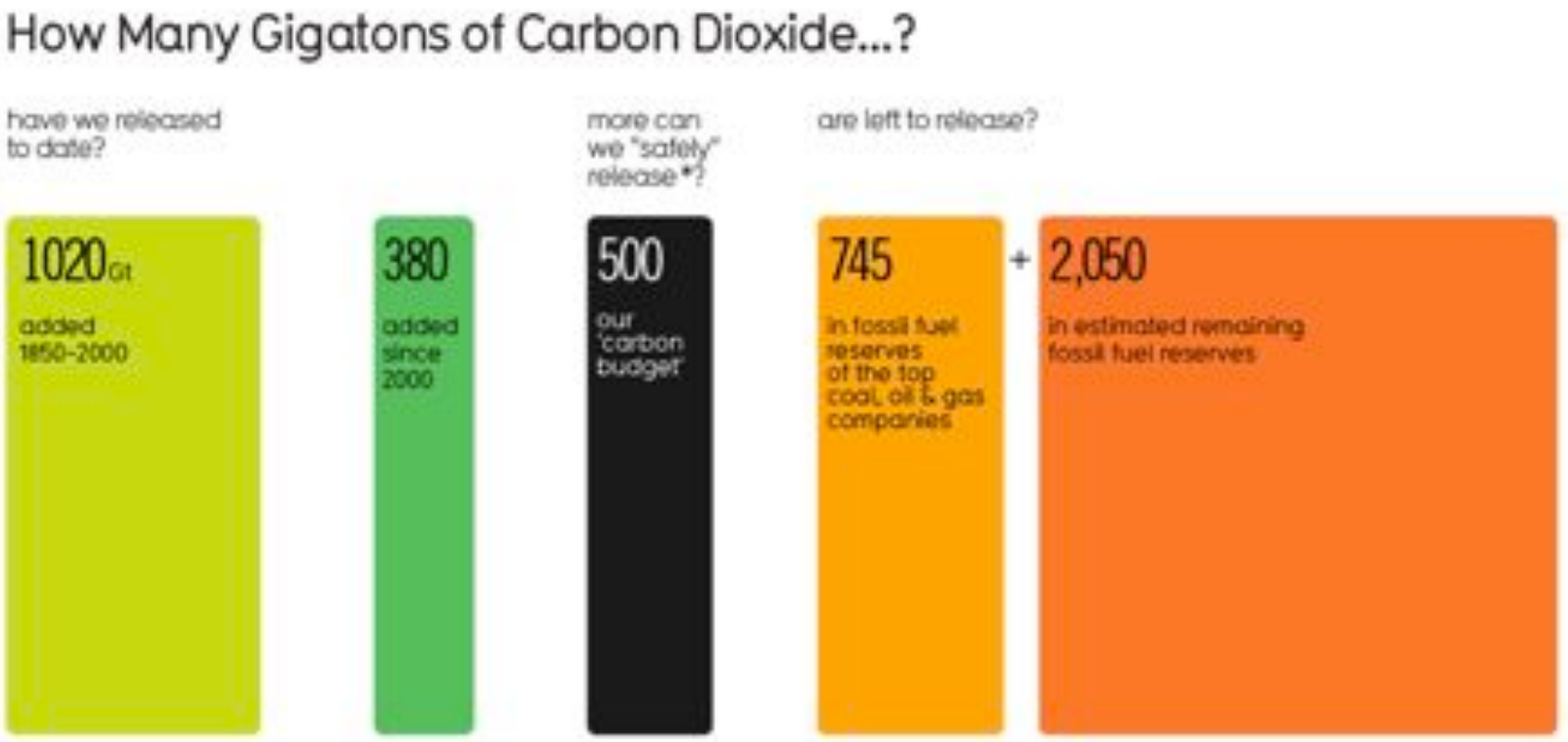
•Once in 100 year extreme monsoon to occur every 10 years by end of the century.
•Kolkata and Mumbai can expect more flooding, rising sea levels and higher temperatures; increased risk of cyclones for Kolkata.
•Significant reduction in crop yield predicted. Some 63 million people may no longer be able to meet caloric demand.
•Substantial reduction in flow of Indus and Brahmaputra in late spring and summer.
•Droughts expected to be more frequent in NW India, Jharkhand, Orissa, Chhattisgarh.

Source: Turn Down the Heat, World Bank Report



How do we limit warming?

Carbon Budget to stay below 2C



The consequences of inaction are serious. But there's reason to hope:

- The solutions to cut emissions exist.
- We have the ability to organise a movement to demand action.

Summary

- We know climate change is real because we can observe impacts that are already happening.
- Future predictions of climate impacts are dire, with sea level rise, extreme weather, and affected agricultural zones potentially driving billions from their homes.
- We need to keep 80% of carbon in the ground to keep temperature rise within 2 C and provide renewable energy.