Last Time…

Global Climate Models (GCM)

Difficult to Make Predictions

Climate forcing mechanisms (internal and external) prohibit direct experimental manipulation

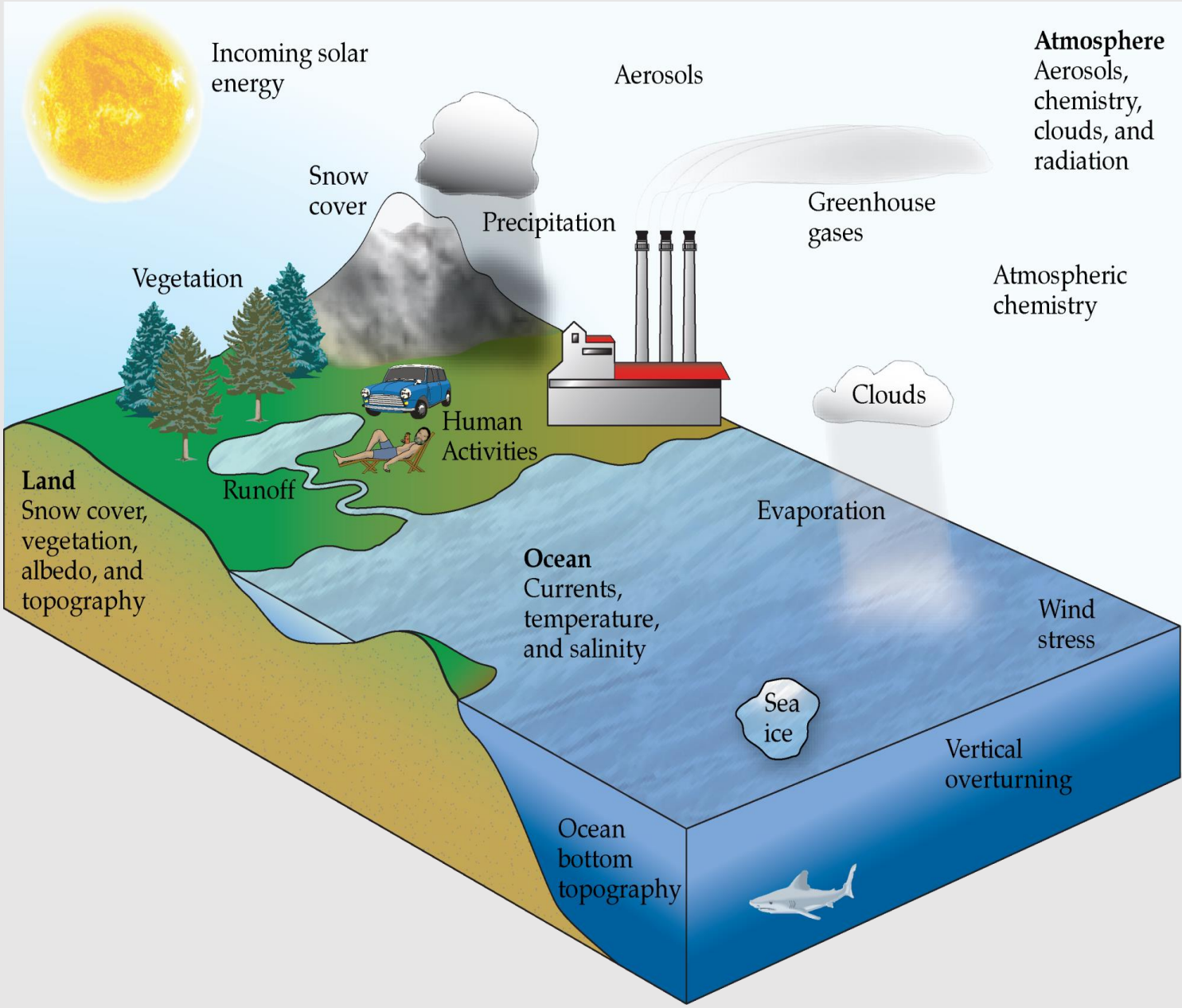
- –Slow
- –Large
- –Unapproachable
- –Costly

How Do They Work?

- Divide the world into boxes
  - The breadth and width of the boxes varies by model
- Passage of time is calculated in steps
  - Calculations made for discrete moments separated by certain time intervals (vary by model)
- Accuracy of models increases with smaller grid size and shorter time steps, but this requires longer computation time

GCMs divide the planet into separate processes

Each process has a separate model



- GCMs vary:
  - In the information they use as an input
  - In the equations used in the GCM

- Different GCMs give different output (predictions)
  - These give us different scenarios

Storylines/Scenarios Have Been Replaced by Representative Concentration Pathways (RPCs)

4 different GHG concentration trajectories

4 possible climate futures, depending on how much GHGs are emitted in years to come

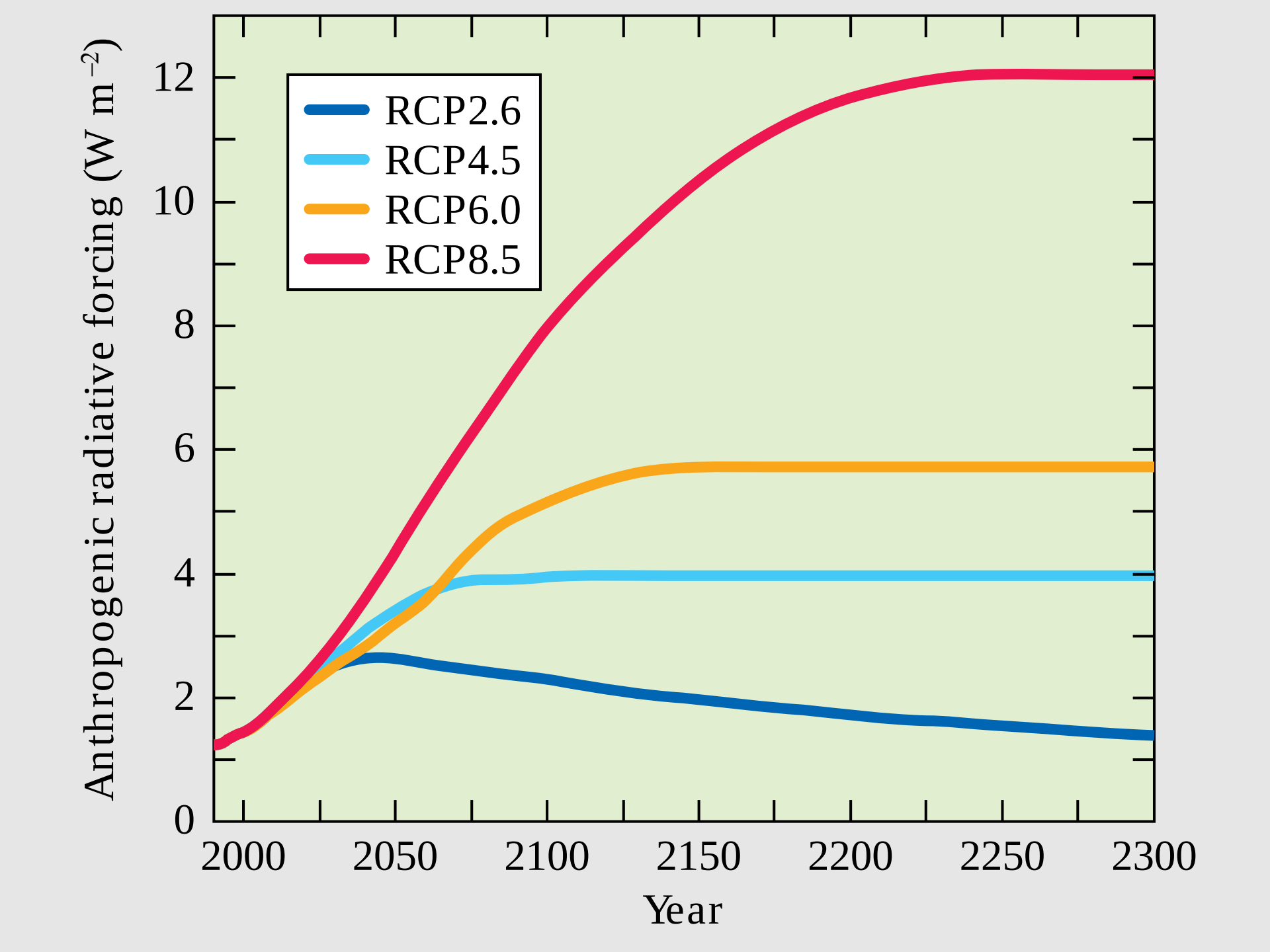
Each named after range of radiative forcing values in the year 2100 relative to pre-industrial values:

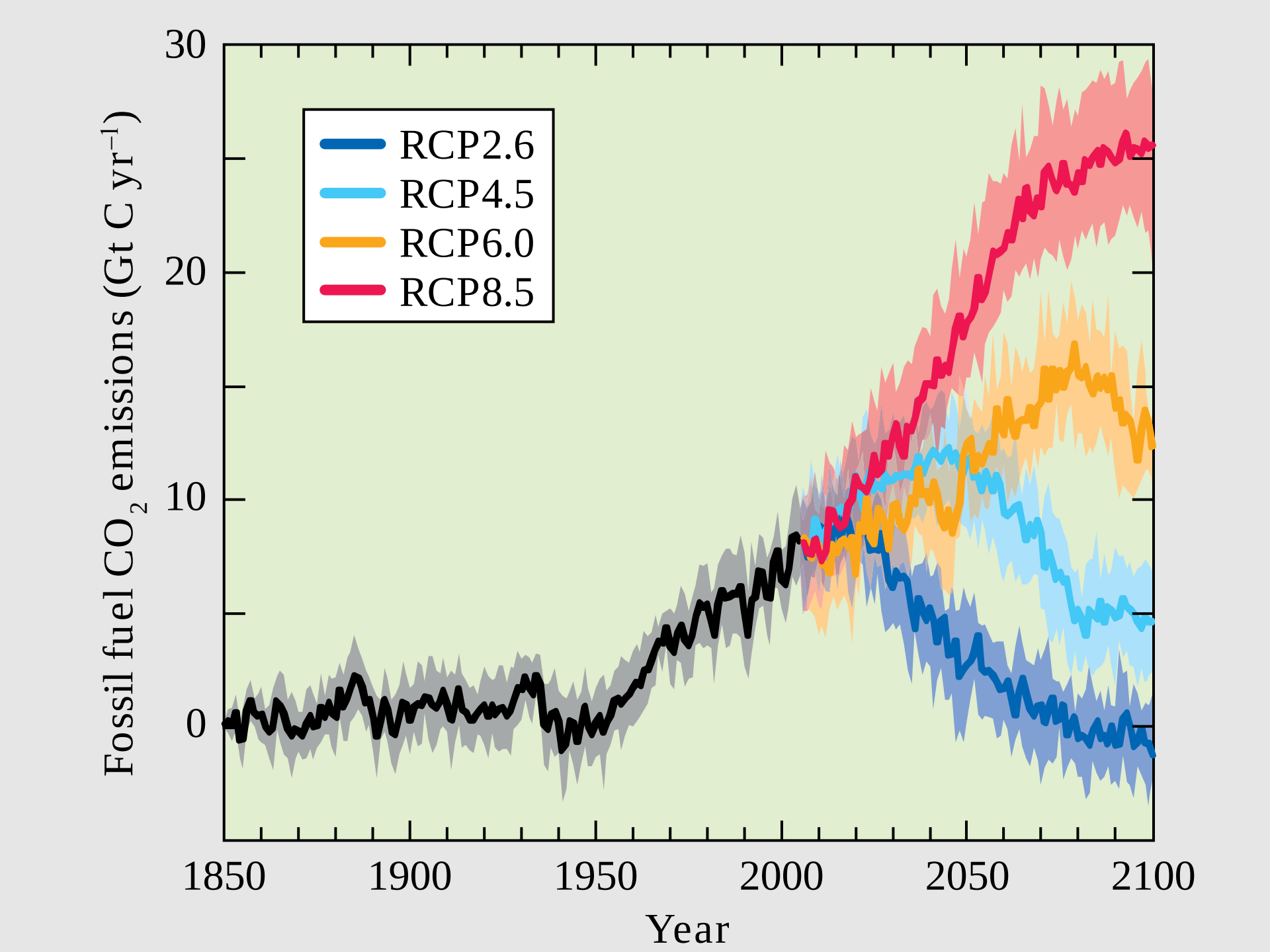
+2.6

+4.5

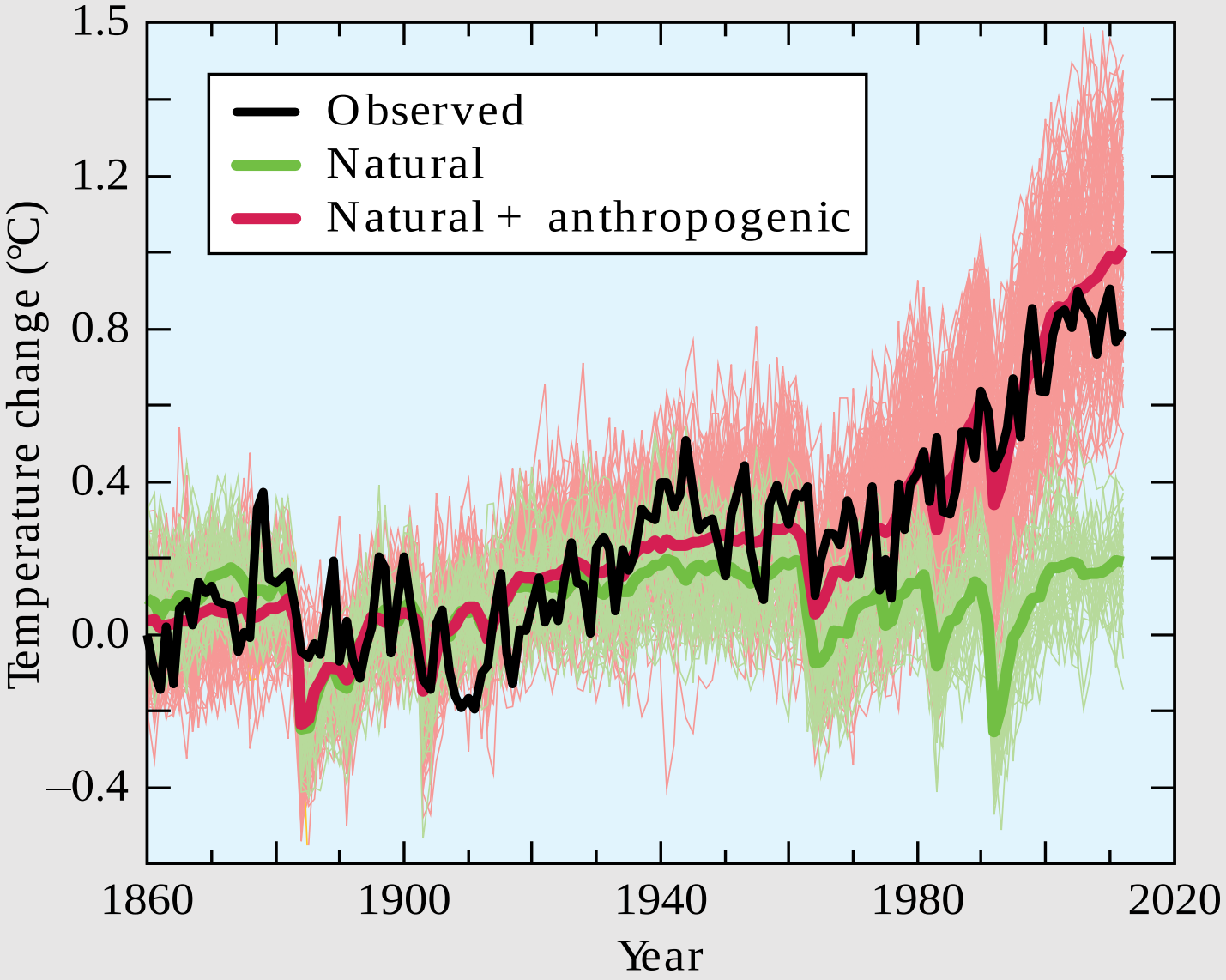
+6.0

+8.5


RCP2.6
RCP4.5
RCP6.0
RCP8.5
Anthropogenic radiative forcing (W m⁻²)
0
2
4
6
8
10
12
2000
2050
2100
2150
2200
2250
2300
Year


RCP2.6
RCP4.5
RCP6.0
RCP8.5
Fossil fuel CO_2 emissions (Gt C yr^{-1})
30
20
10
0
1850
1900
1950
2000
2050
2100
Year

Is the observed global temperature changes over the past 125 years natural or caused by humans?

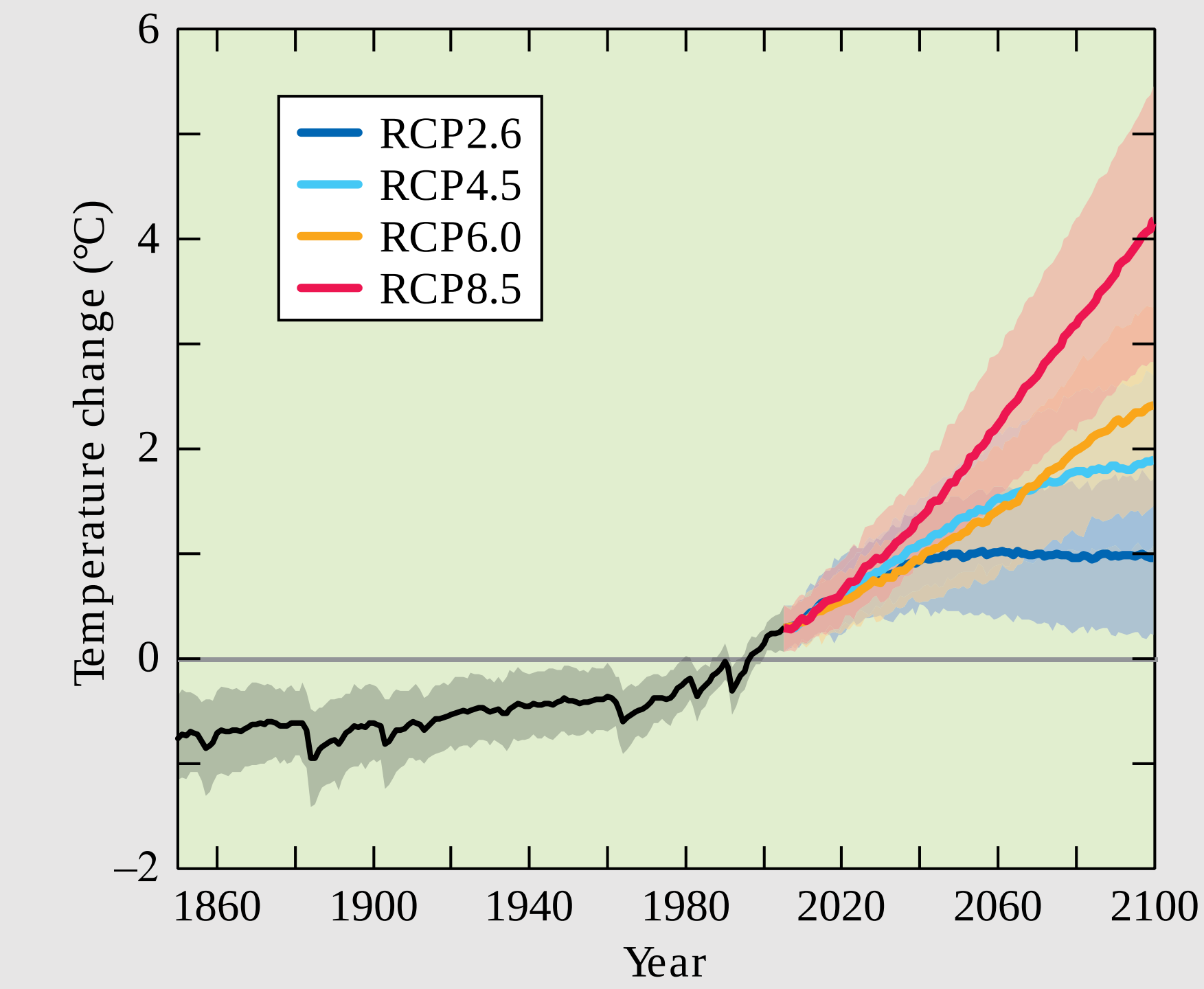


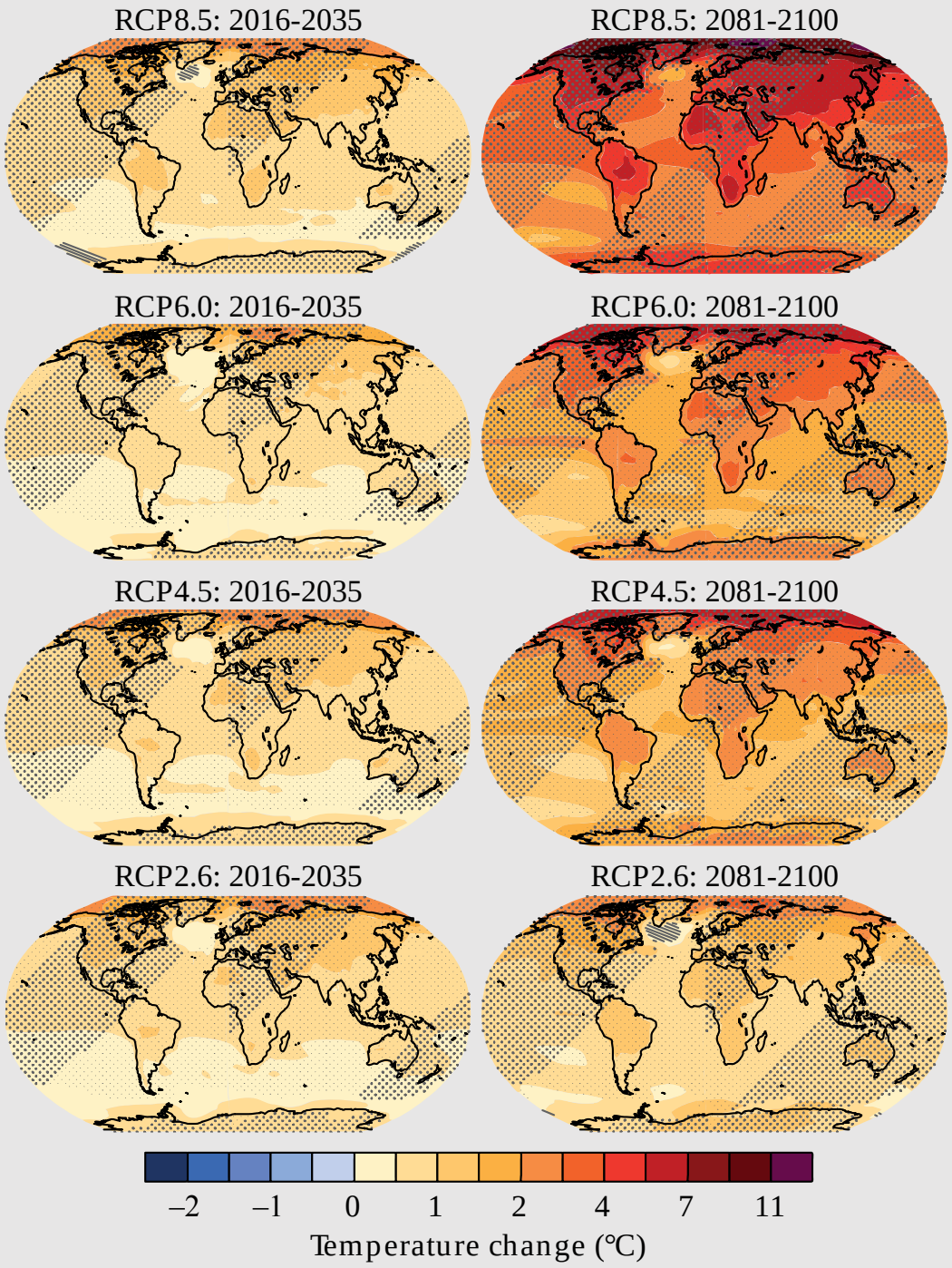
Based on 16+ GCMs
Models run 3 times
0 is the mean temp
for the time period

GCM Predictions

Changes in climate observed over the last few decades will be small compared to those that will occur before the end of this century

- Temperature changes
- Albedo
- Sea level
- Quantity of precipitation
- Ocean pH
- Intensity of major storms
- Frequency/severity of forest fires


RCP2.6
RCP4.5
RCP6.0
RCP8.5
Temperature change (°C)
6
4
2
0
–2
1860
1900
1940
1980
2020
2060
2100
Year


RCP8.5: 2016-2035
RCP8.5: 2081-2100
RCP6.0: 2016-2035
RCP6.0: 2081-2100
RCP4.5: 2016-2035
RCP4.5: 2081-2100
RCP2.6: 2016-2035
RCP2.6: 2081-2100
–2
–1
0
1
2
4
7
11
Temperature change (°C)

Temperature

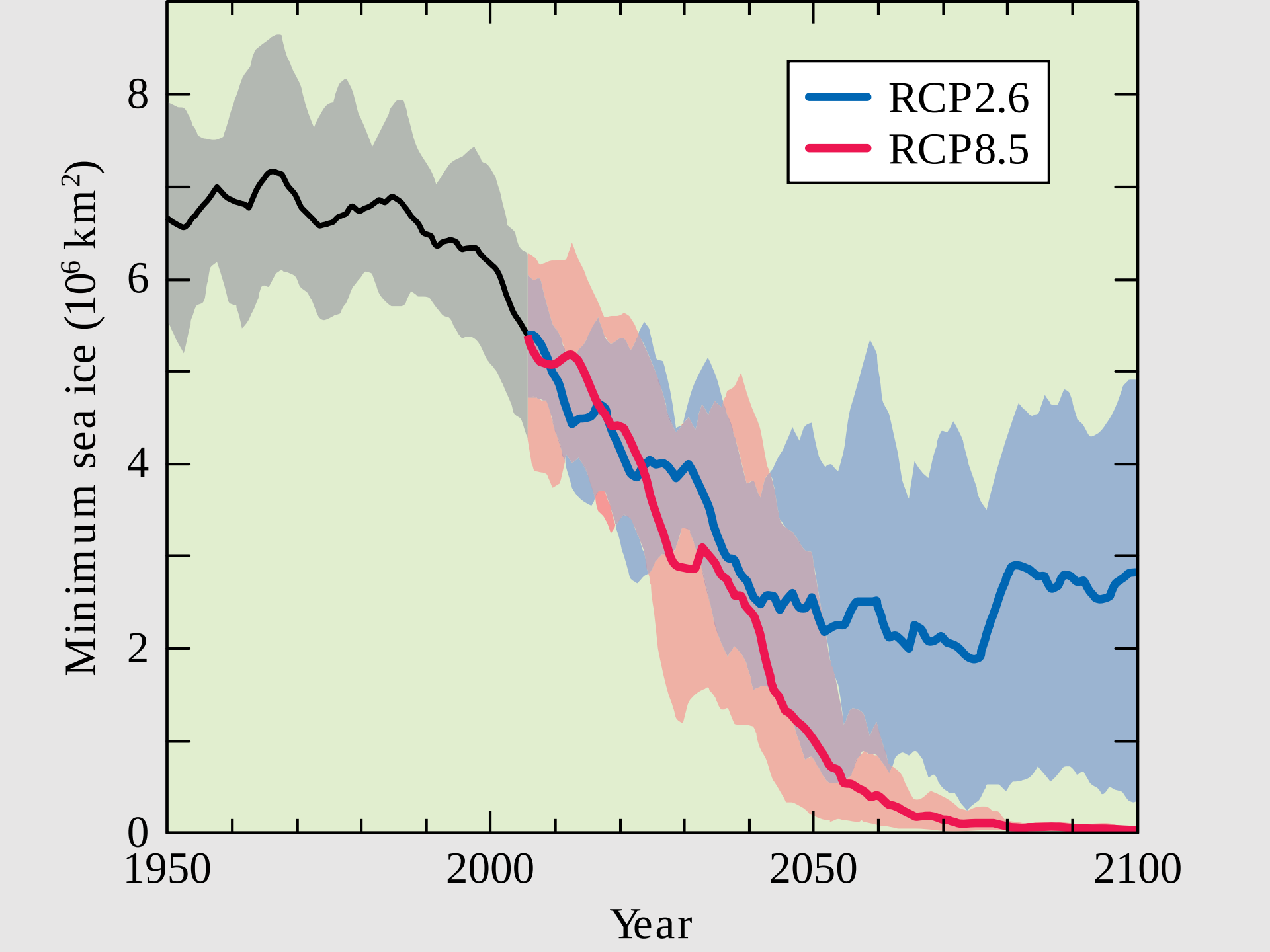
Average global temperatures predicted to warm between 1.5° C and 6.8° C from 2000 to 2100

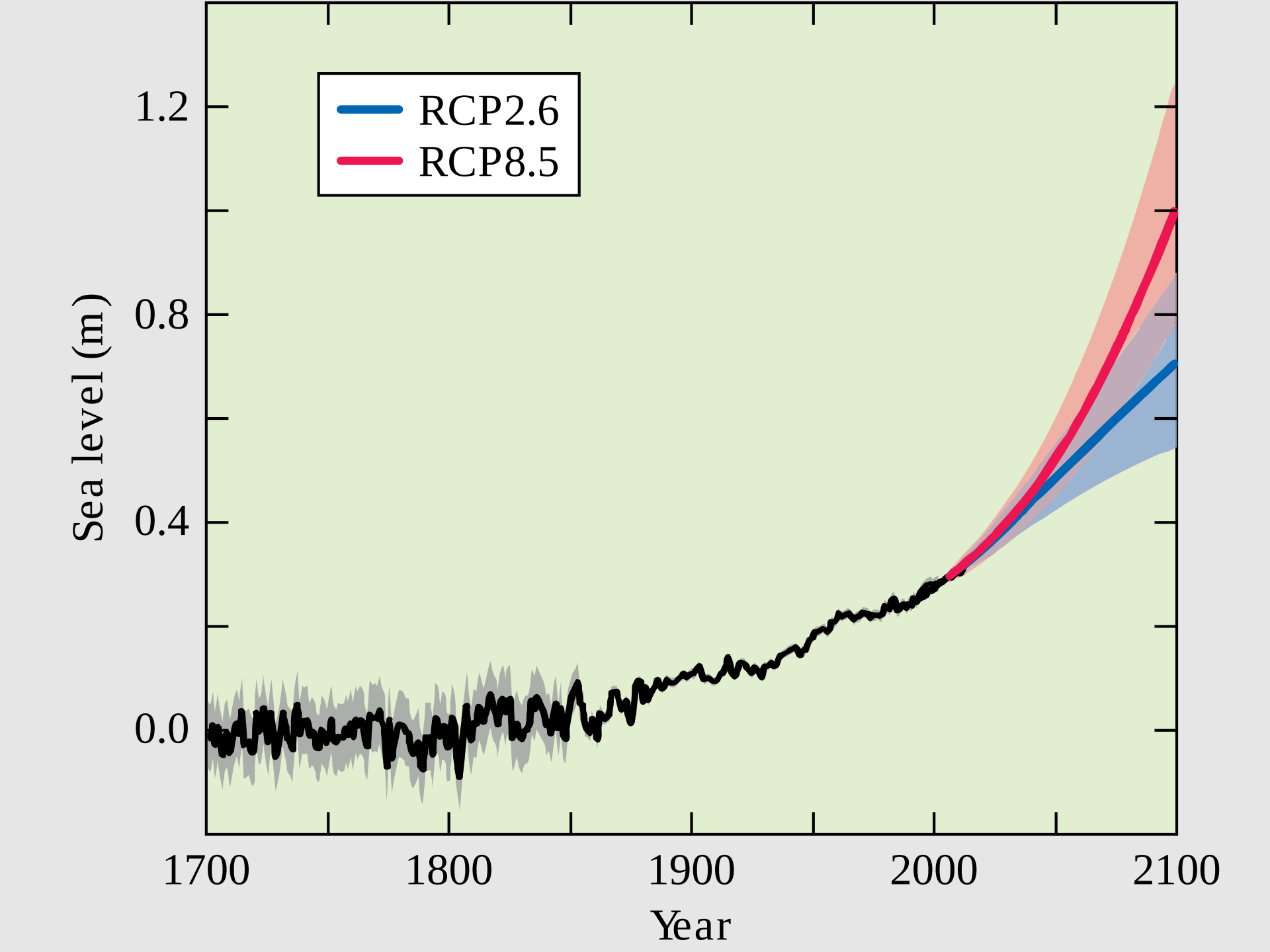
- Not uniform, some regions will cool
- Arctic regions will warm more than other areas

Announced Yesterday: 2015 was the warmest year on record

http://www.buzzfeed.com/peteraldhous/this-is-your-planet-on-co2

- Thanks Rachel Sniderman!
- **Last year was the Earth's warmest since record-keeping began** in 1880, the U.S. National Oceanic and Atmospheric Administration and NASA said Wednesday
- 15 of the top 16 warmest years have occurred since 2000 (1998 being the lone pre-21st century year on the list)

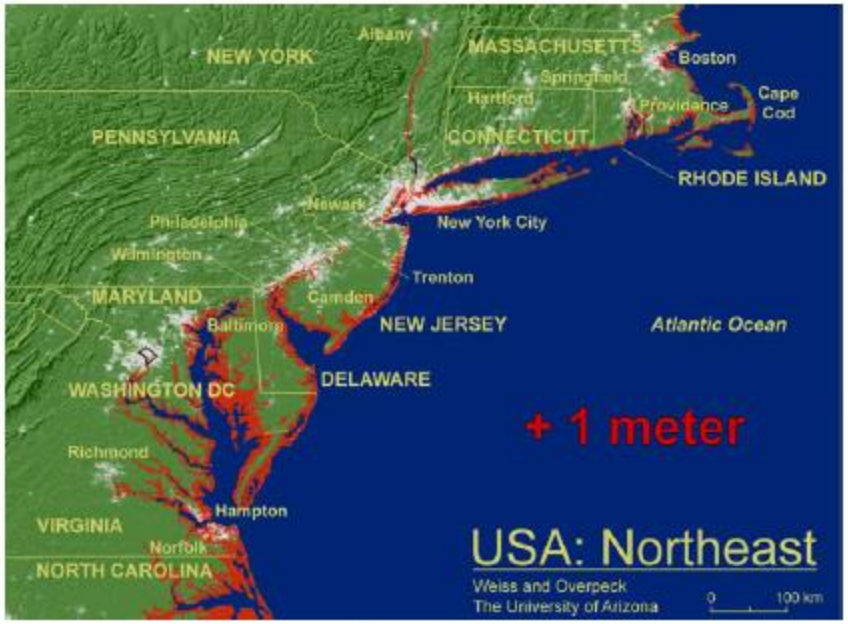

RCP2.6
RCP8.5
Minimum sea ice (10^6 km^2)
0
2
4
6
8
1950
2000
2050
2100
Year

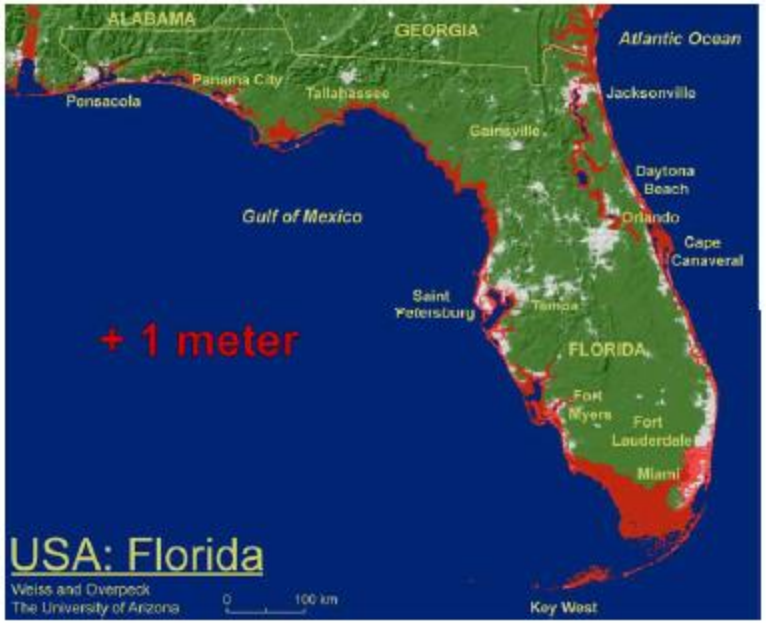

RCP2.6
RCP8.5
Sea level (m)
1.2
0.8
0.4
0.0
1700
1800
1900
2000
2100
Year

Sea Ice and Sea Level

- Sea Ice: may disappear entirely during summer months in polar regions
- Sea Level: predicted to rise as higher temperatures melt land ice (Greenland and Antarctica)
  - Over 20 GCMs predict sea level will rise by 0.2 m to 0.5 m from 2000 to 2100.
  - Puts costal cities at risk
  - May contaminate water supplies with seawater

ARKANSAS
Shreveport
Monroe
Jackson
LOUISIANA
Alexandria
MISSISSIPPI
TEXAS
Hattiesburg
Baton Rouge
Hammond
Beaumont
Lake Charles
Lafayette
Slidell
New Orleans
Houma
+ 1 meter
USA: Louisiana
Gulf of Mexico
Weiss and Overpeck
The University of Arizona
0
100 km


NEW YORK
Albany
MASSACHUSETTS
Boston
Springfield
Hartford
Providence
Cape Cod
PENNSYLVANIA
CONNECTICUT
RHODE ISLAND
Philadelphia
Newark
New York City
Wilmington
Trenton
MARYLAND
Camden
Baltimore
NEW JERSEY
Atlantic Ocean
WASHINGTON DC
DELAWARE
+ 1 meter
Richmond
Hampton
VIRGINIA
Norfolk
NORTH CAROLINA
USA: Northeast
Weiss and Overpeck
The University of Arizona
0
100 km


ALABAMA
GEORGIA
Atlantic Ocean
Panama City
Pensacola
Tallahassee
Jacksonville
Gainsville
Daytona Beach
Gulf of Mexico
Orlando
Cape Canaveral
Saint Petersburg
Tampa
+ 1 meter
FLORIDA
Fort Myers
Fort Lauderdale
Miami
USA: Florida
Weiss and Overpeck
The University of Arizona
0
100 km
Key West

Bangladesh: 80% of the country is below 10m

0.5-1m rise in sea level will permanently flood 6-10% of land area

Will displace 3.4-17 million people

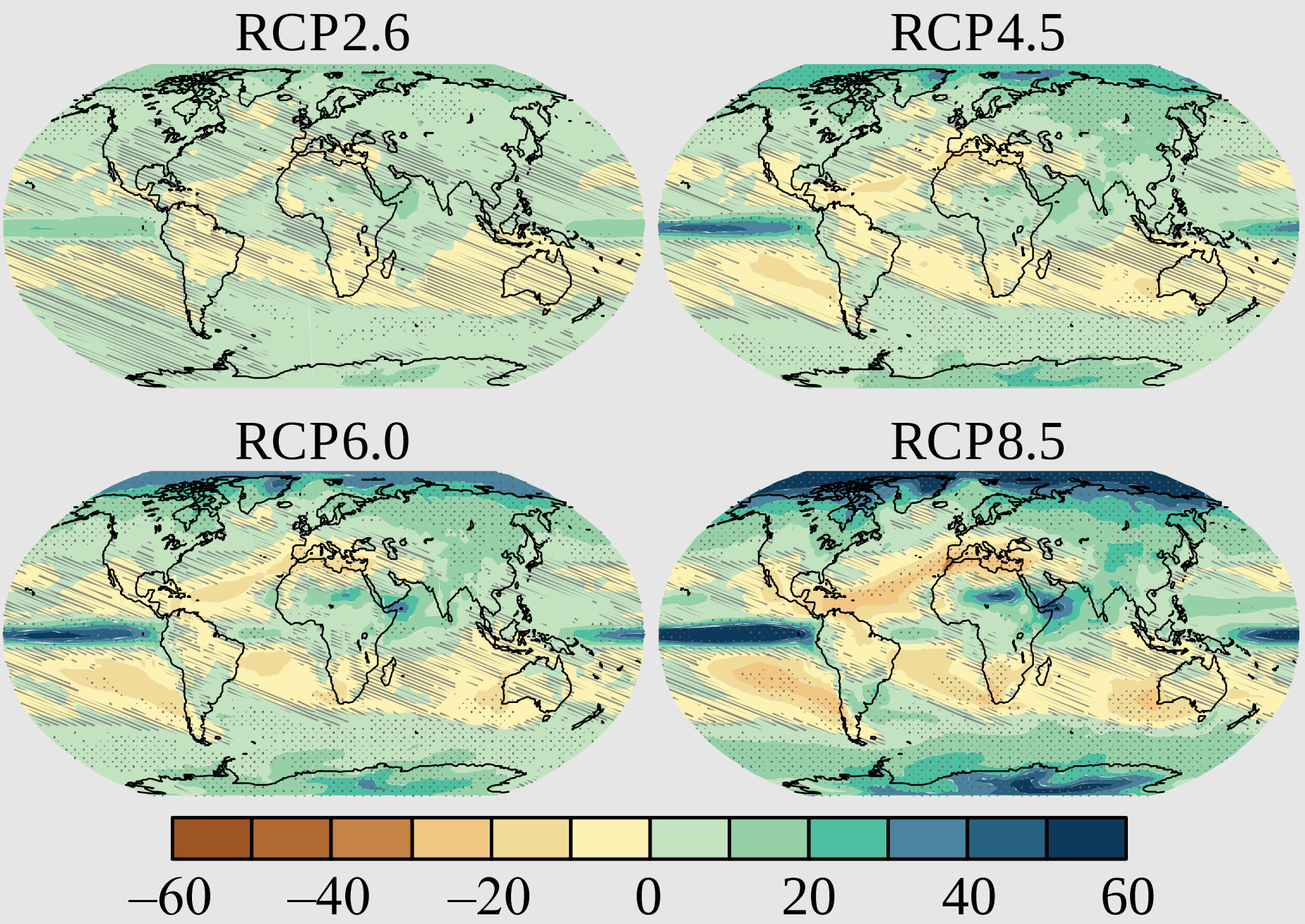
Sundarba, India

- The largest single block of tidal halophytic mangrove forest in the world.
- It became inscribed as a UNESCO world heritage site in 1997

Important habitat for the endangered Bengal tiger

Serves a crucial function as a protective flood barrier for the millions of inhabitants in and around Kolkata (Calcutta) against the result of cyclone activity.

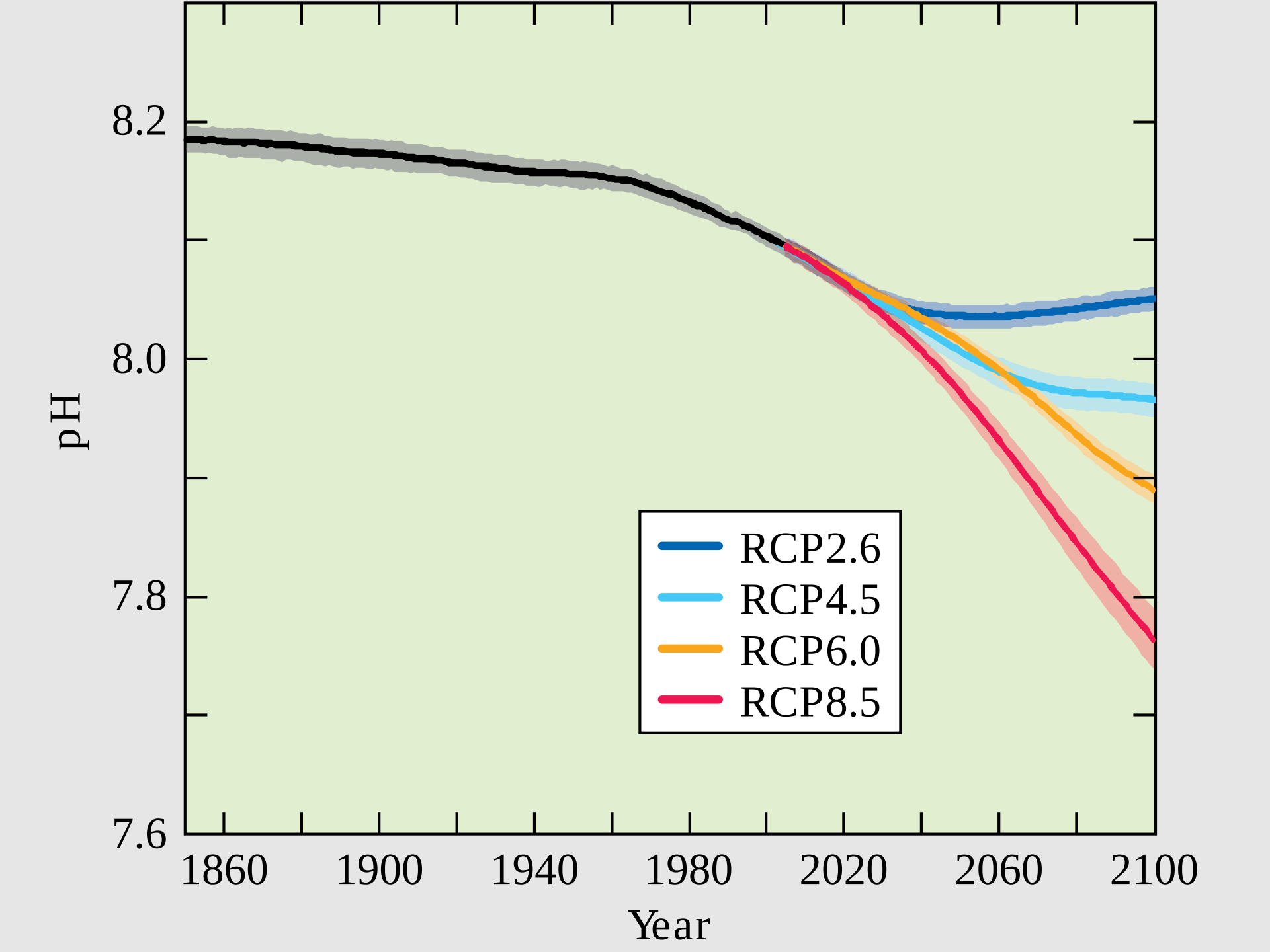
A 2007 report by UNESCO, "Case Studies on Climate Change and World Heritage" has stated that an anthropogenic 45-cm rise in sea level (likely by the end of the 21st century, according to the Intergovernmental Panel on Climate Change), combined with other forms of anthropogenic stress on the Sundarbans, could lead to the destruction of 75% of the Sundarbans mangroves


RCP2.6
RCP4.5
RCP6.0
RCP8.5
–60
–40
–20
0
20
40
60
Precipitation change from 1986-2005 to 2081-2100

Precipitation

Global precipitation should increase on average

- Poles and equatorial regions will become wetter
- Mid-latitudes will become drier
- Decreased snowpack in mountain ranges
  - Sierra Nevada Mountains may receive 30% to 90% less snow by 2100


8.2
8.0
7.8
7.6
pH
1860
1900
1940
1980
2020
2060
2100
Year
RCP2.6
RCP4.5
RCP6.0
RCP8.5

Ocean Acidification

Oceans will become more acidic

- CO_2 dissolves in the oceans and forms carbonic acid
- Will have a strong effect on sea life

Storms and Forest Fires

Major storms will increase in intensity.

- Larger storm surges will threaten coast lines

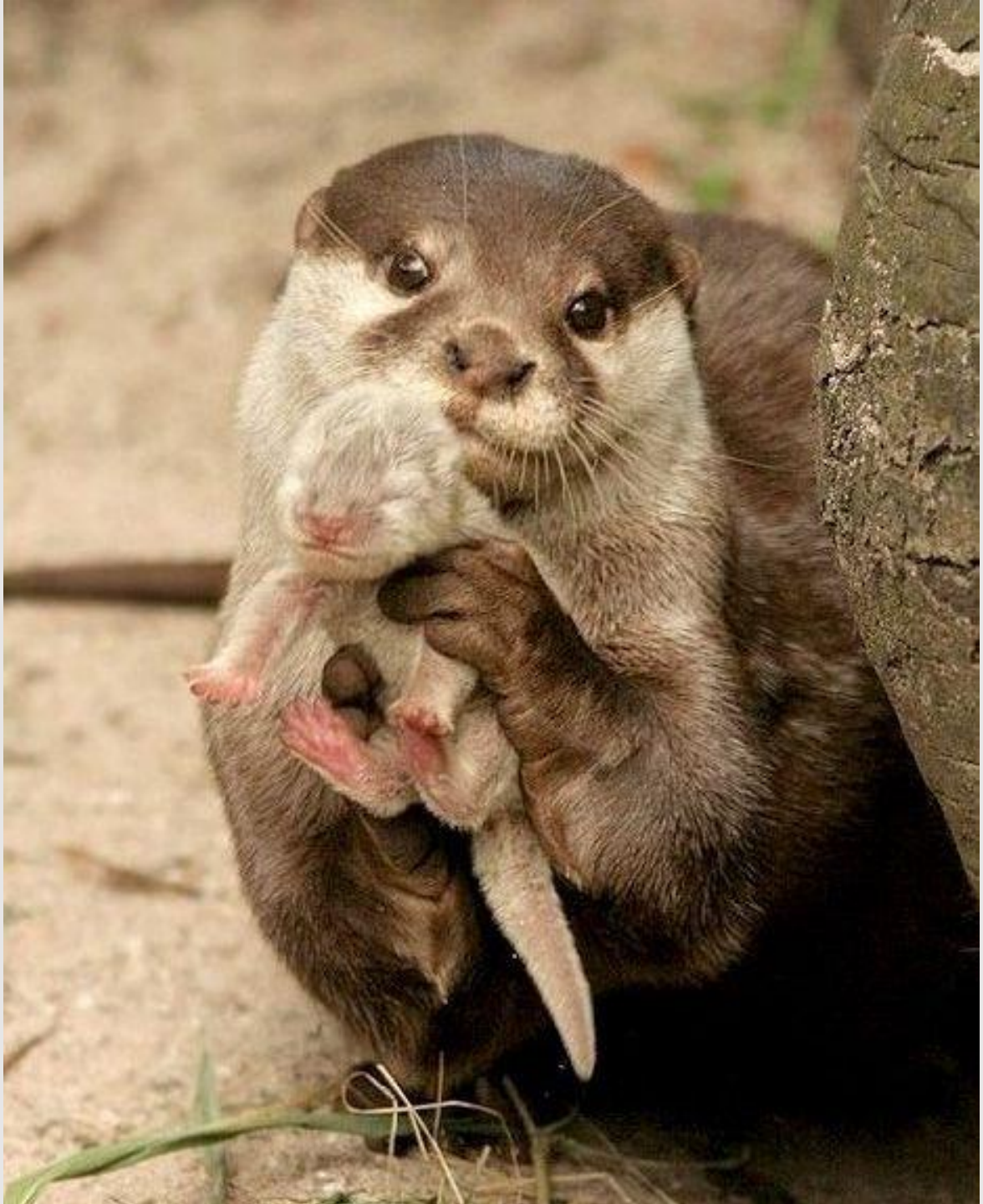
Forest Fires will become more frequent and more severe

- Trees are a carbon sink. Burning of trees will release CO_2 that may accelerate climate change

Warming Momentum

Earth will continue to warm for many decades after we curtail emissions

- GHGs are long lived. Concentrations will remain high without further additions
- CO_2 absorbed by oceans will dissipate slowly once emissions abate
- Positive feedback accelerates warming and will take time to reverse



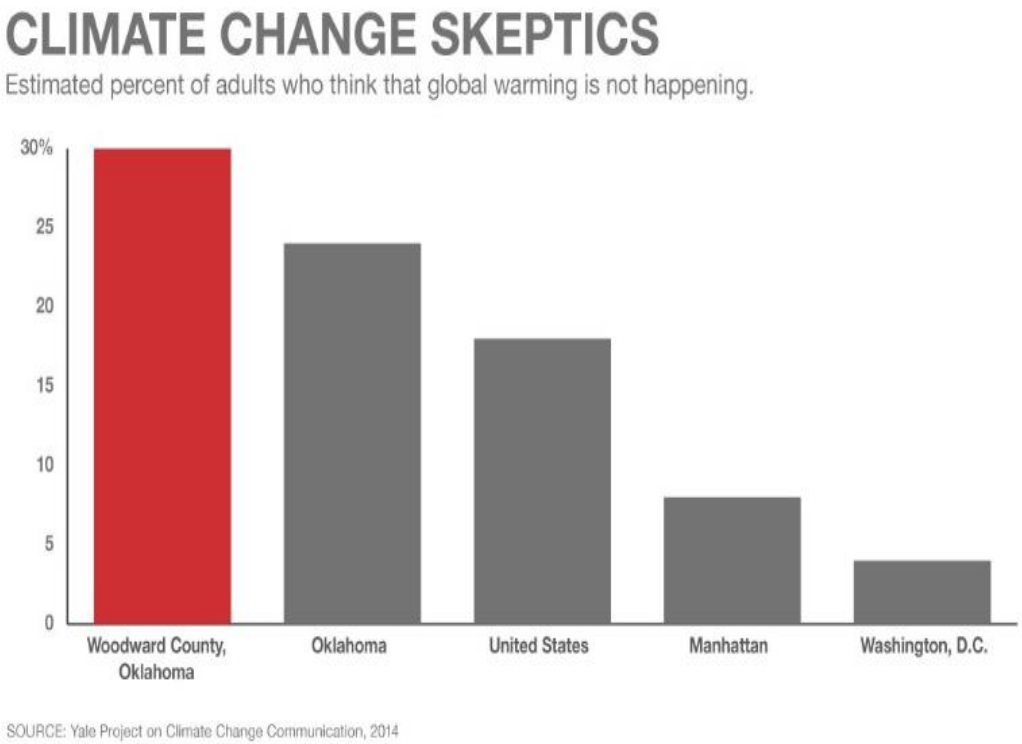
Woodward County, Oklahoma: Why do so many people here doubt climate change?

- Thanks Samuel Udo!

http://www.cnn.com/2015/08/03/opinions/sutter-climate-skeptics-woodward-oklahoma/index.html

This county ties with six others in the United States as having the **highest rate of climate deniers in the country (30%)**. Many citizens here think its is a **conspiracy or some type of propaganda by the government**. Most of climate change deniers had never even had a conversation about climate change.

I could recount several interactions like that from my week in Woodward County, Oklahoma, one of the most climate-skeptical counties in the United States. Thirty percent of the 21,000 people in Woodward County are estimated (using a statistical model based in national surveys) to believe that climate change isn't happening at all, according to the Yale Project on Climate Change Communication. The county ties with six others for the highest rate of climate skepticism in the country.



A larger chunk of people in Woodward County, 42%, are estimated to say maybe climate change is happening but we aren't causing it.

Those views, of course, aren't supported by science. Climate change is real, and we're contributing

Now Playing Opinion: Common ground...

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3.01%
APR
Calculate New Payment
30 Year Fixed 3.88% 3.88% APR
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What are greenhouse gases?

Greenhouse gases are NECESSARY for life on Earth.

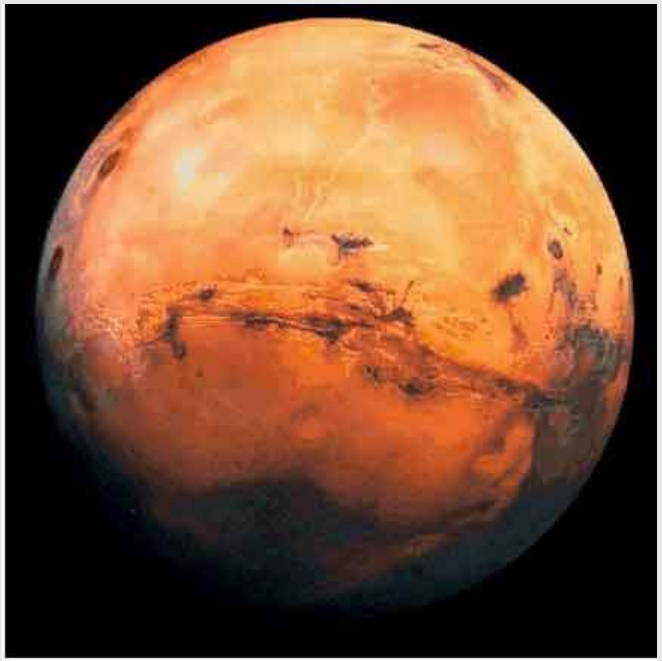
Without GHGs, the earth would be too cold to support life.

Without GHGs, Earth would be similar to Mars

Mars has a very thin atmosphere.

The EXTREMELY low concentration of GHGs means little heat. Temperatures can dip down to -120°C.

- The lowest recorded temperature in Antarctica was **–89.2 °C**



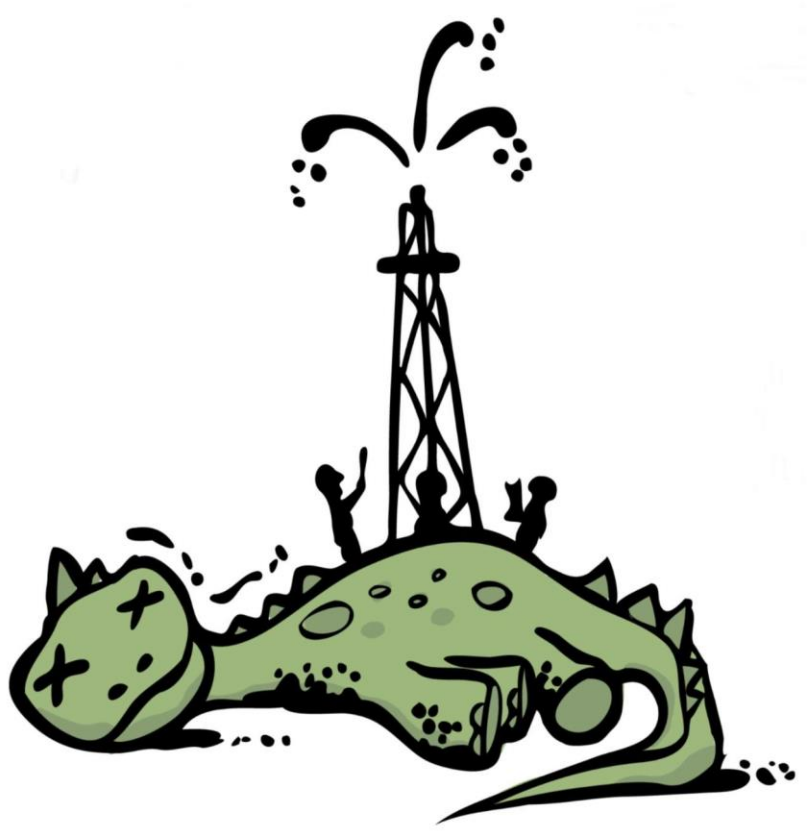
- Carbon dioxide (CO_2)
- Methane (CH_4)
- Tropospheric ozone (O_3)
- Nitrous oxide (N_2O)
- Chlorofluorocarbons (CFC)

Non-anthropogenic (non-human related):

- Water (H_2O)

CO_2

- Highest in concentration and effect
- Responsible for about 33.3% of global warming that derives from human activities
- Natural sources: part of **limestone and other sedimentary rocks**. Released by weathering
  - –Weathering of silicate rock is a sink
- Natural sinks: photosynthesis and large bodies of water

CO_2

Anthropogenic sources: burning fossil fuel and cement production