What Is Climate Change?

EES 2110

Introduction to Climate Change

Jonathan Gilligan

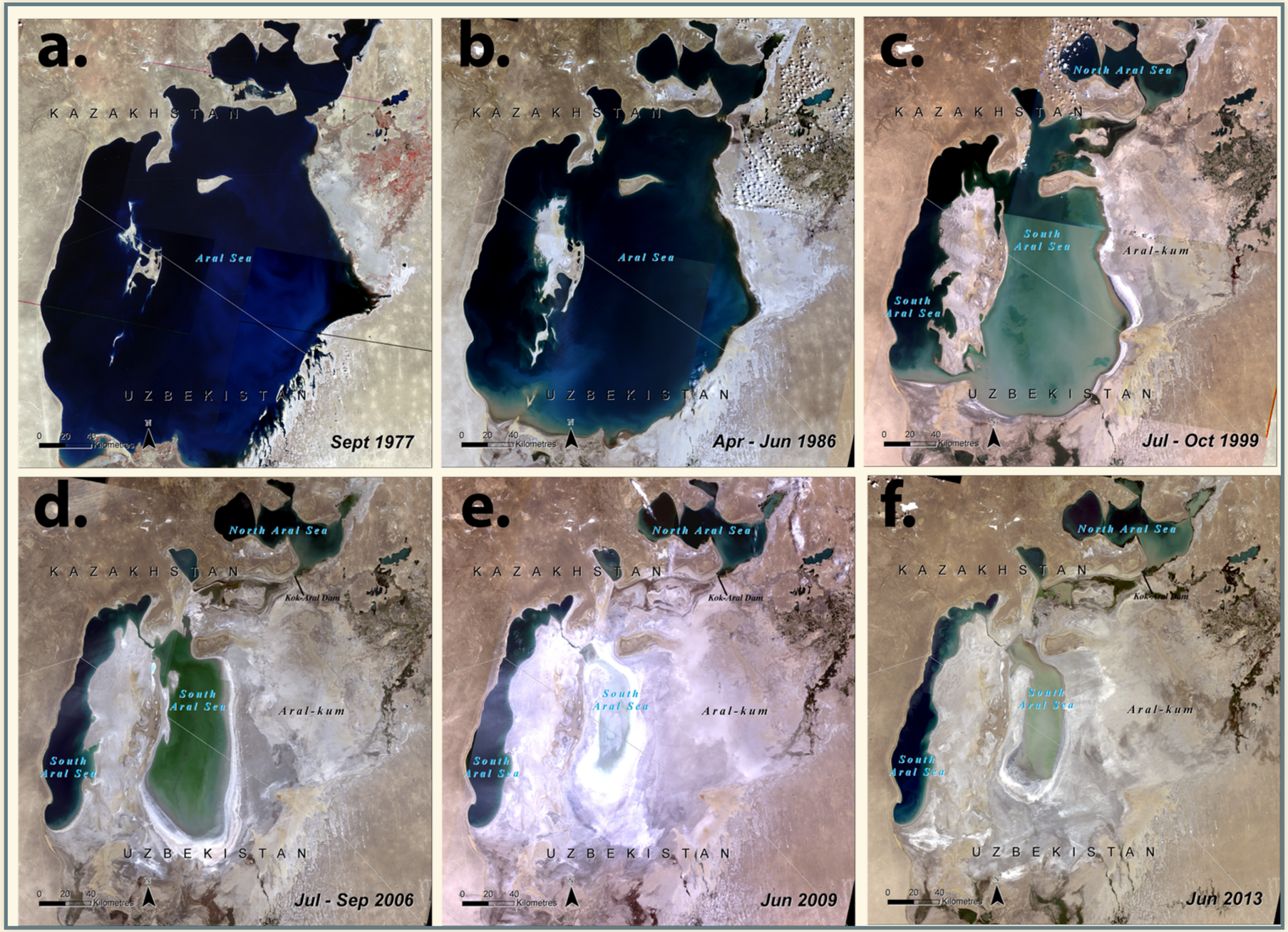
Class #2: Tuesday, January 11 2023

Housekeeping

- Remember when you email me:
  include “EES 2110” in your subject line.
- Office hours
  - Monday 10:00–11:00
  - Wednesday 1:30–2:30

  I’ll be in my office and you can drop in.
  - Or email to schedule a different time

Aral Sea


a.
KAZAKHSTAN
Aral Sea
UZBEKISTAN
0 20 40 Kilometres
Sept 1977
b.
KAZAKHSTAN
Aral Sea
UZBEKISTAN
0 20 40 Kilometres
Apr - Jun 1986
c.
North Aral Sea
KAZAKHSTAN
South Aral Sea
Aral-kum
South Aral Sea
UZBEKISTAN
0 20 40 Kilometres
Jul - Oct 1999
d.
North Aral Sea
KAZAKHSTAN
Kok-Aral Dam
South Aral Sea
Aral-kum
South Aral Sea
UZBEKISTAN
0 20 40 Kilometres
Jul - Sep 2006
e.
North Aral Sea
KAZAKHSTAN
Kok-Aral Dam
South Aral Sea
Aral-kum
South Aral Sea
UZBEKISTAN
0 20 40 Kilometres
Jun 2009
f.
North Aral Sea
KAZAKHSTAN
Kok-Aral Dam
South Aral Sea
Aral-kum
South Aral Sea
UZBEKISTAN
0 20 40 Kilometres
Jun 2013

Questions from Reading?

Important Concepts:

Important Concepts:

- What kinds of things can cause the global temperature to change?
  - Energy Balance:
    - Temperature is steady when $\text{Heat}_{\text{in}} = \text{Heat}_{\text{out}}$.
  - What happens when $\text{Heat}_{\text{in}} > \text{Heat}_{\text{out}}$?
  - What kinds of things can cause Heat_{in} to change?
  - What kinds of things can cause Heat_{out} to change?

Temperature Change

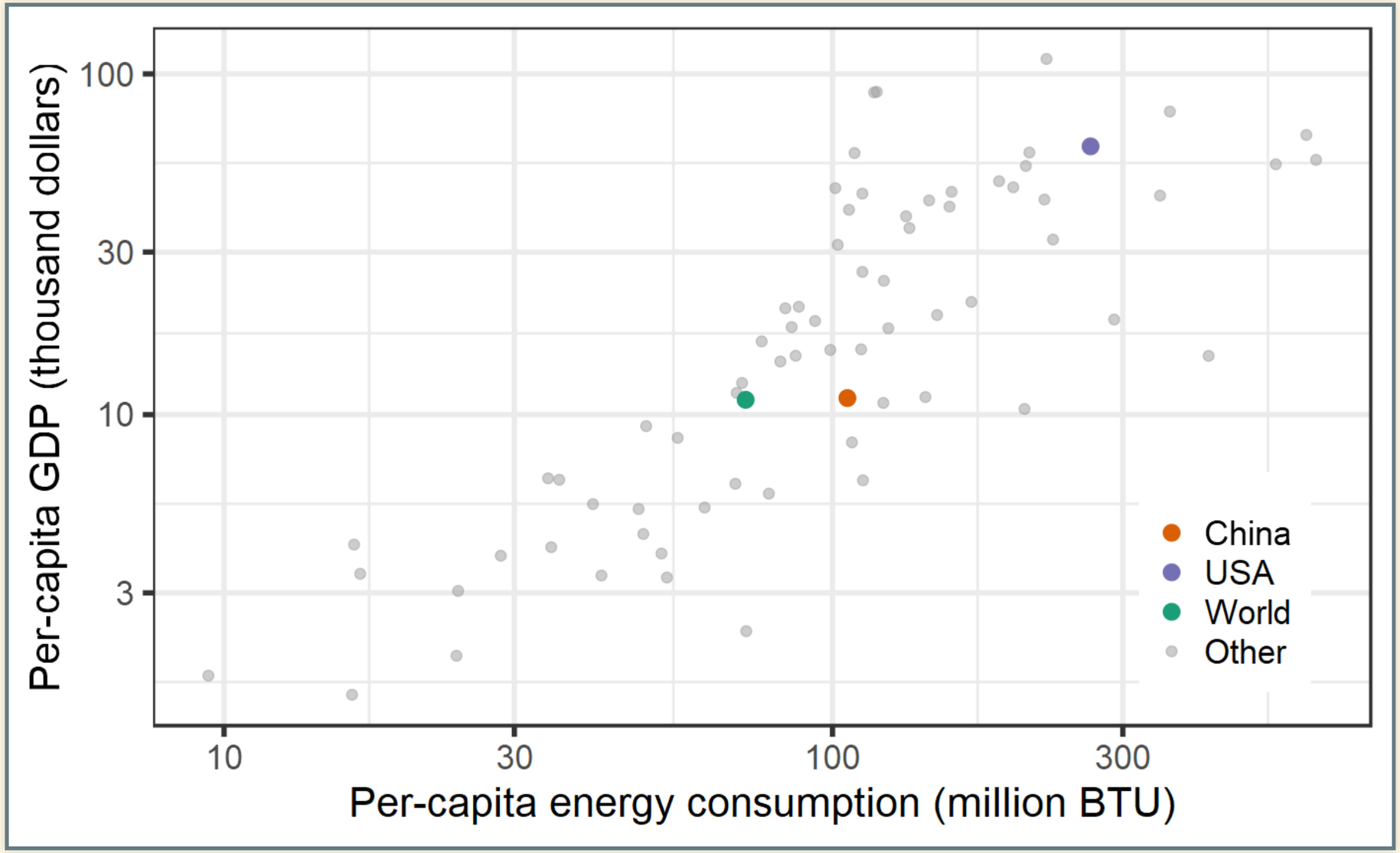
- How much has earth warmed in the last century or so?
  - About 1.2°C (2.2°F)
- If CO_2 emissions keep rising on their current path, how much do scientists expect it to warm in the next century?
  - Somewhere around 2–4.5°C (3.5–8°F)
- What is the seasonal temperature change in Nashville (winter to summer)?
  - Around 23°C (42°F): 47°F in January, 89°F in August.
- What is the average daily temperature range in Nashville (night to day)?
  - Around 11°C (20°F)
    - **So why do people worry about global warming?**

Predictions

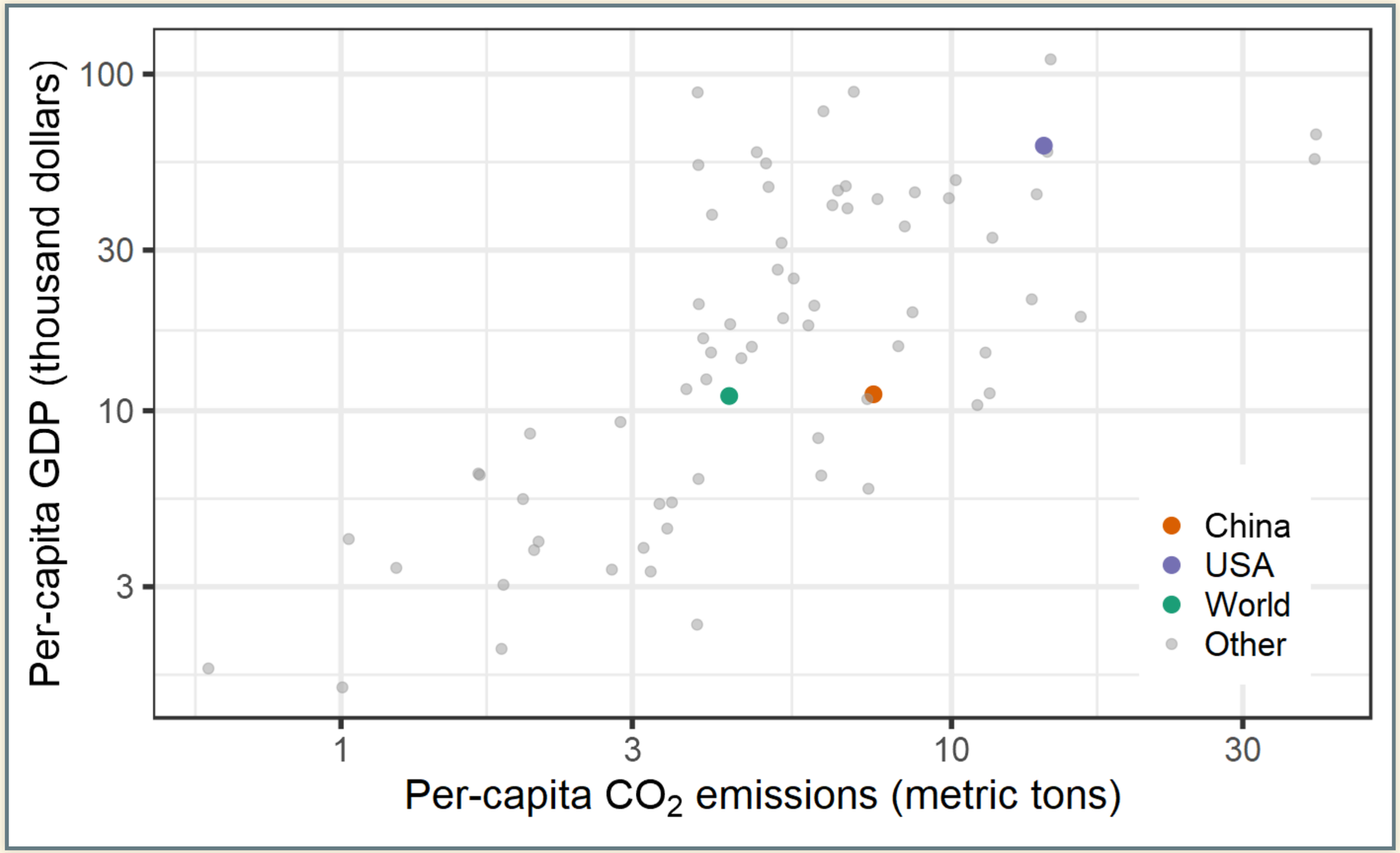
- Meteorologists can’t predict whether it will rain three weeks from today with any confidence.
- So how can I trust predictions about the climate 100 years from now?

Economy-Energy-Environment

Wealth & Energy Use



Wealth & CO_2 Emissions



US Emissions

- 5 billion metric tons CO_2 per year total
- 14 metric tons CO_2 per person per year
- 23 pounds carbon per person per day

Economics, Policy, Climate

- Why don’t markets manage greenhouse gas emissions well?
  - Pollution is an **externality**
- How does Nordhaus propose to fix this problem?
  - Ronald H. Coase (1920–2013):
    - Solve externality problems by assigning property rights
      - Cap-and-trade: Permits
      - Emissions tax: Put price on emissions

Ronald H. Coase

Economics and Vulnerability

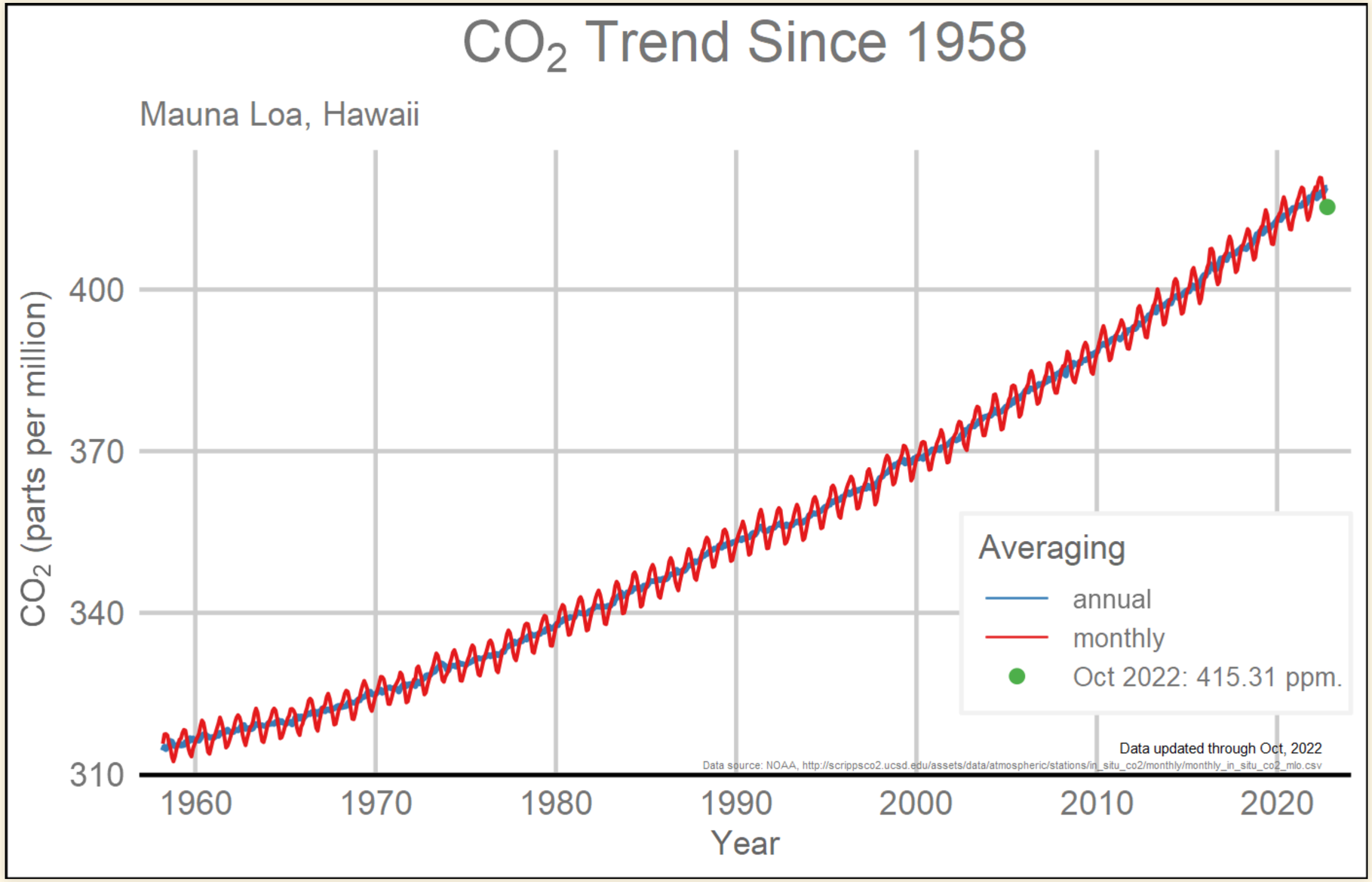
- For an economist, what are the big dangers associated with climate change?
  - **Managed** vs. **unmanaged**, **unmanageable** resources

Think, Pair, Share (5 minutes)

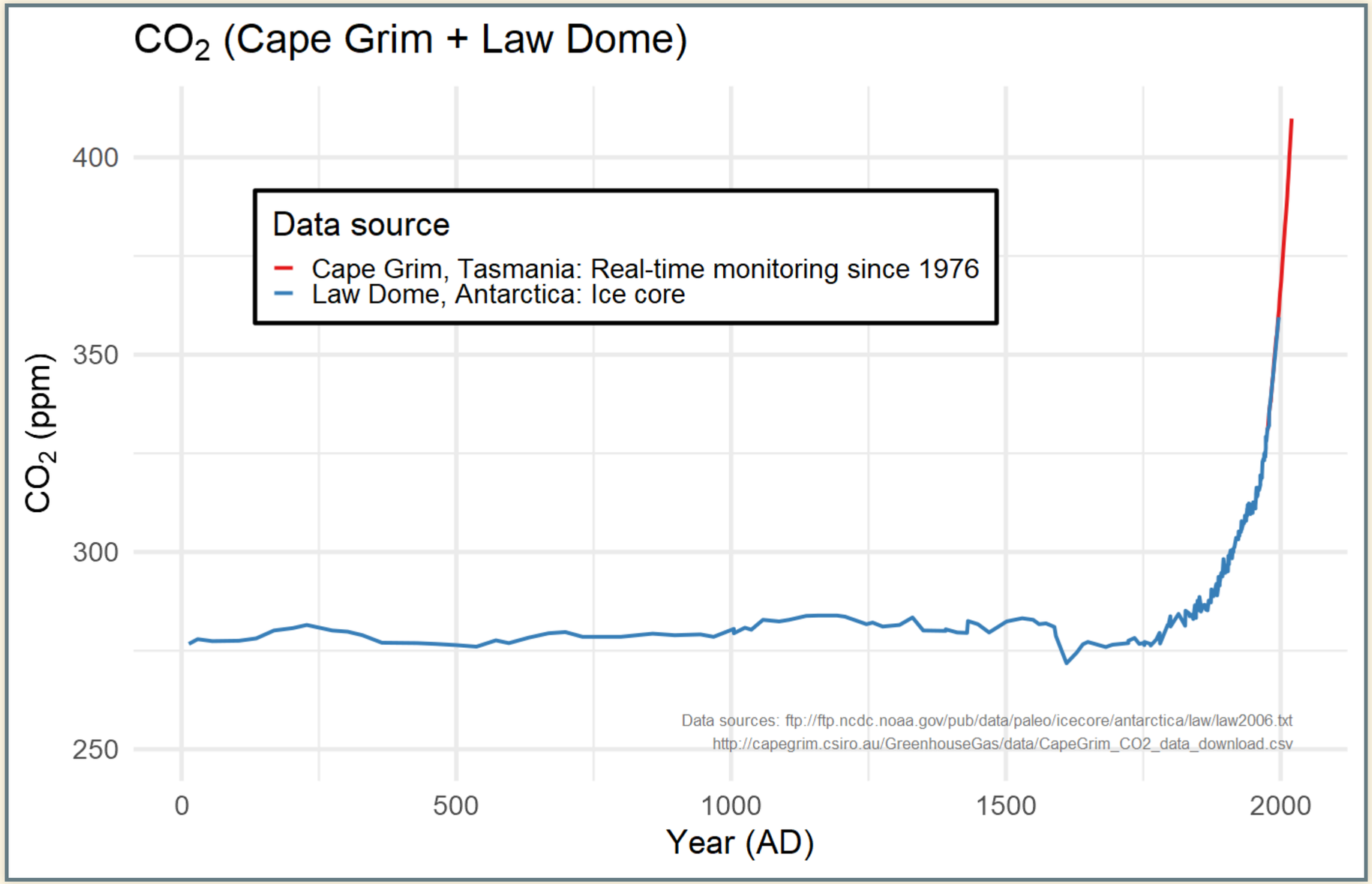
- Can you think of examples of **managed**, **unmanaged**, and **unmanageable** resources?
- How would you respond to climate change differently for the 3 kinds of resources?

Carbon Dioxide and Temperature

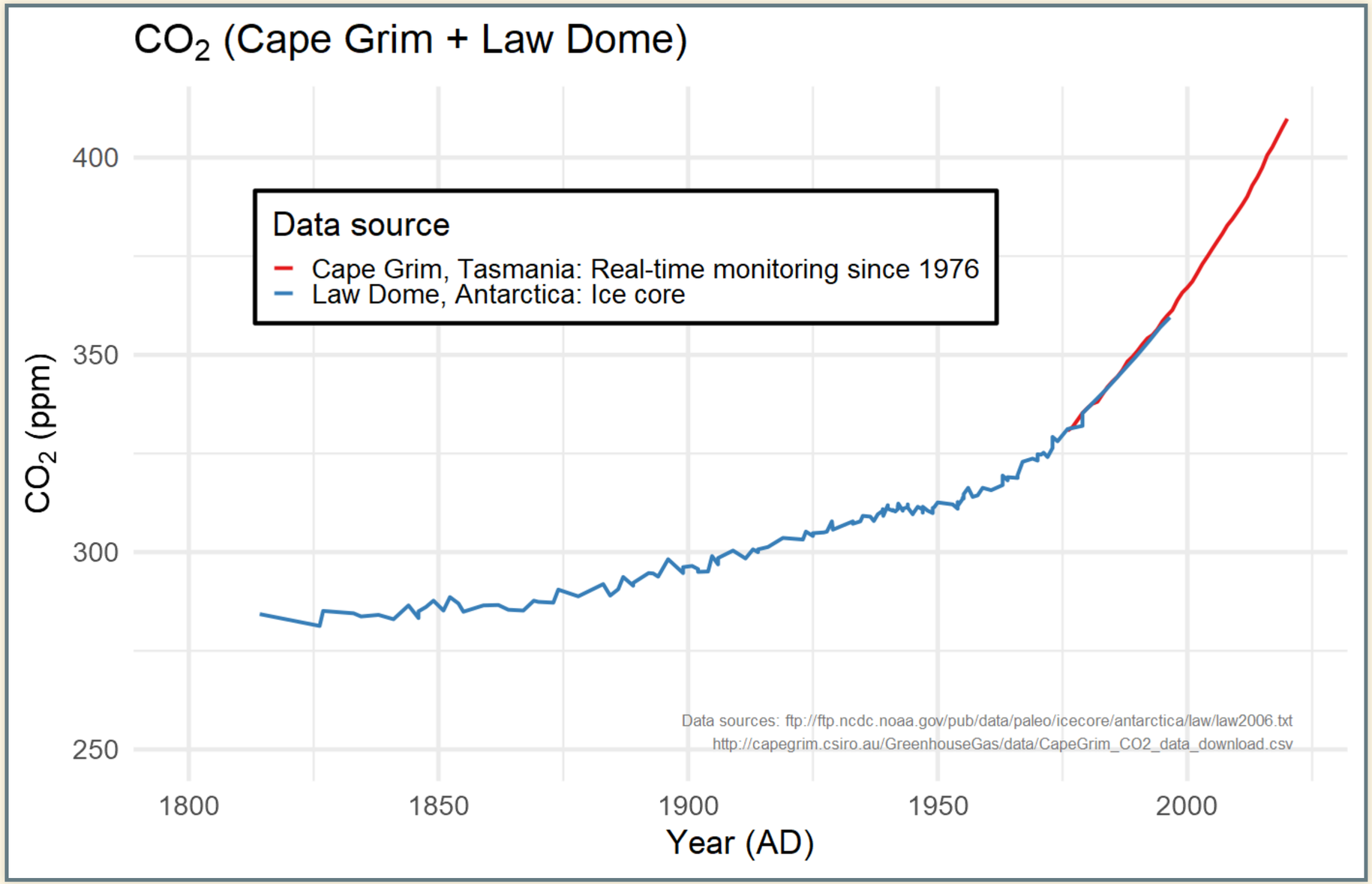
Carbon Dioxide in the Atmosphere



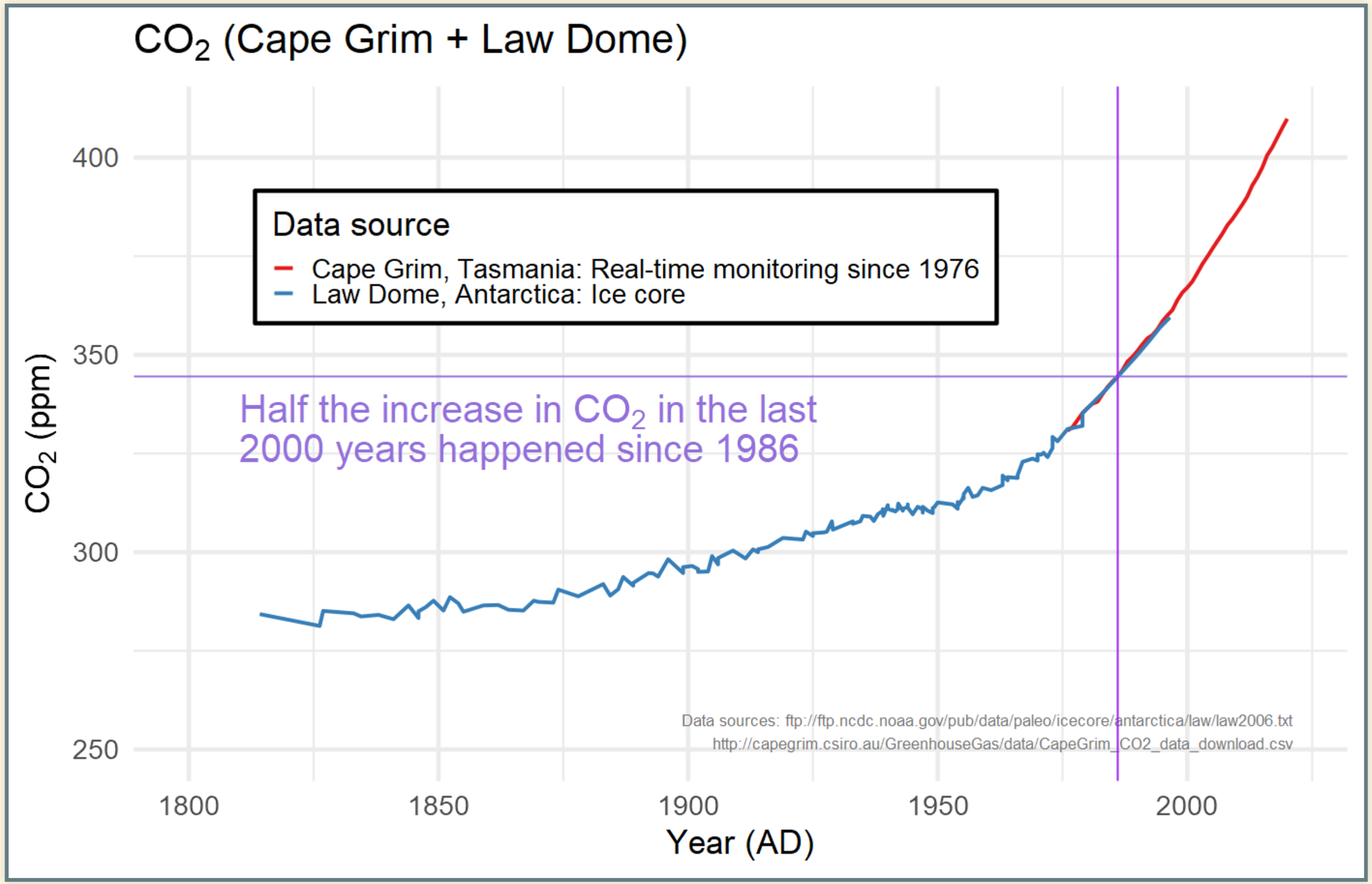
2000 Years of CO_2



Since 1800…


CO2 (Cape Grim + Law Dome)
Data source
Cape Grim, Tasmania: Real-time monitoring since 1976
Law Dome, Antarctica: Ice core
400
350
300
250
CO2 (ppm)
1800
1850
1900
1950
2000
Year (AD)
Data sources: ftp://ftp.ncdc.noaa.gov/pub/data/paleo/icecore/antarctica/law/law2006.txt
http://capegrim.csiro.au/GreenhouseGas/data/CapeGrim_CO2_data_download.csv

Since 1800…


CO_2 (Cape Grim + Law Dome)
Data source
Cape Grim, Tasmania: Real-time monitoring since 1976
Law Dome, Antarctica: Ice core
Half the increase in CO_2 in the last 2000 years happened since 1986
Data sources: ftp://ftp.ncdc.noaa.gov/pub/data/paleo/icecore/antarctica/law/law2006.txt
http://capegrim.csiro.au/GreenhouseGas/data/CapeGrim_CO2_data_download.csv
CO_2 (ppm)
400
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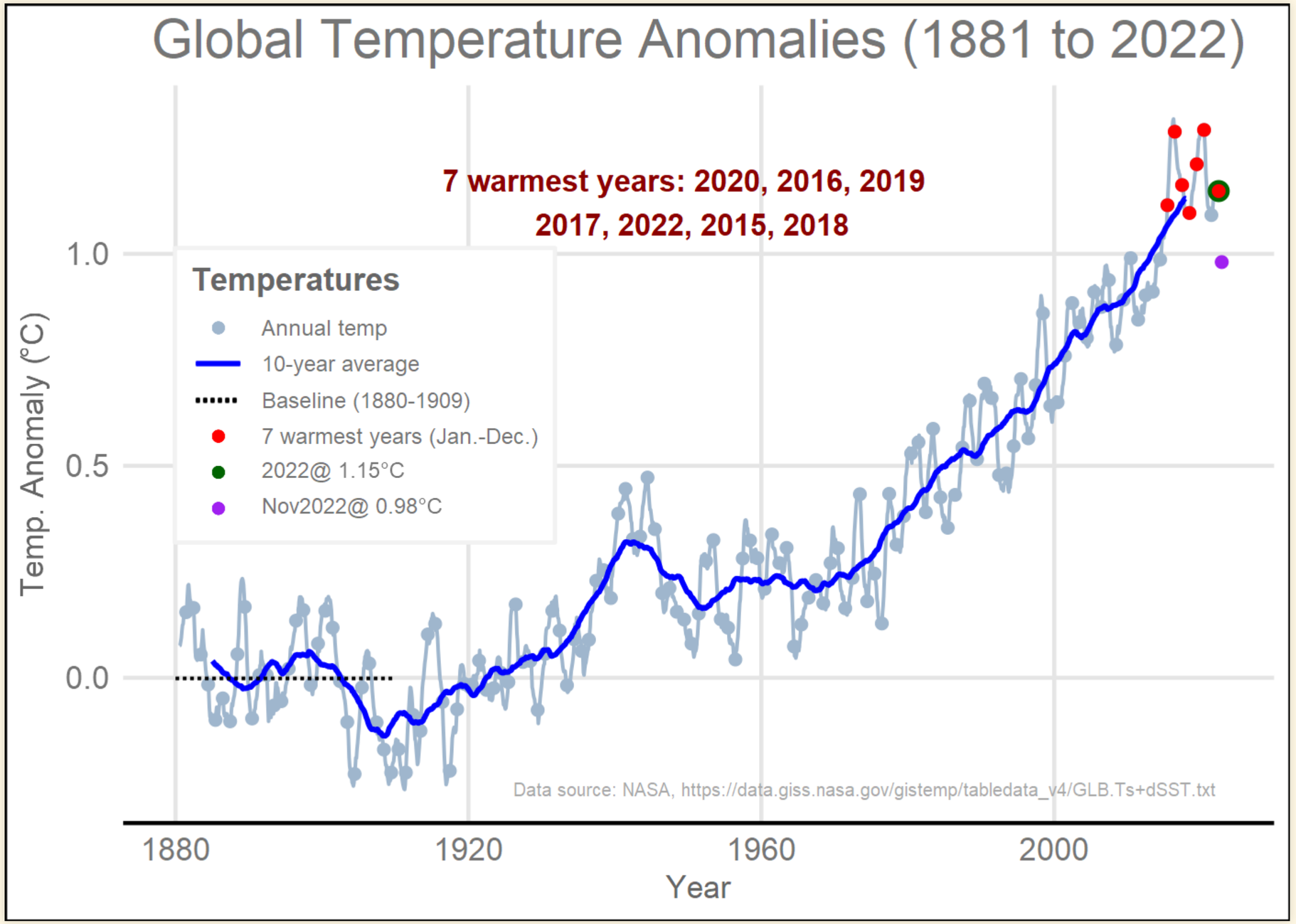
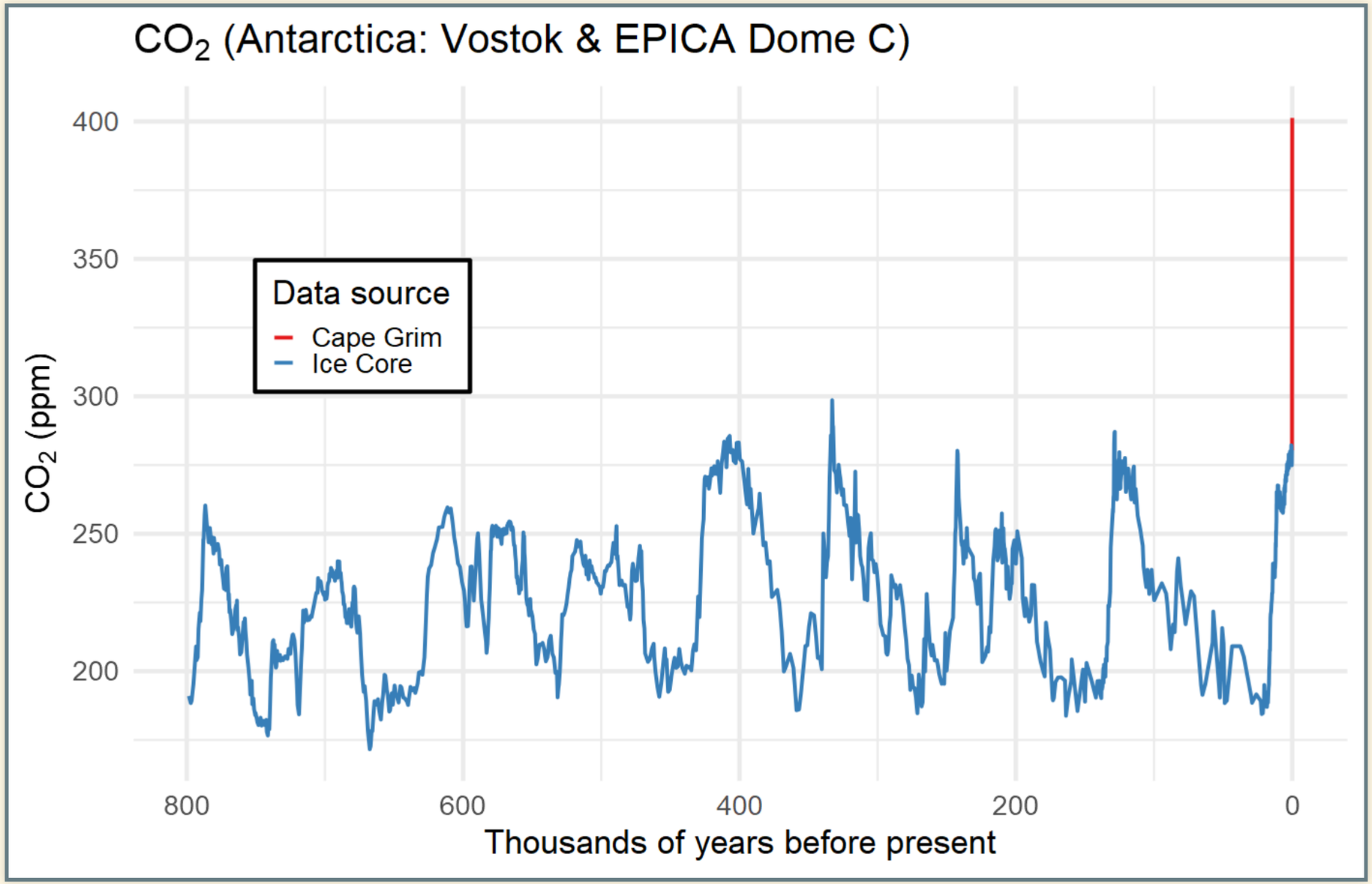
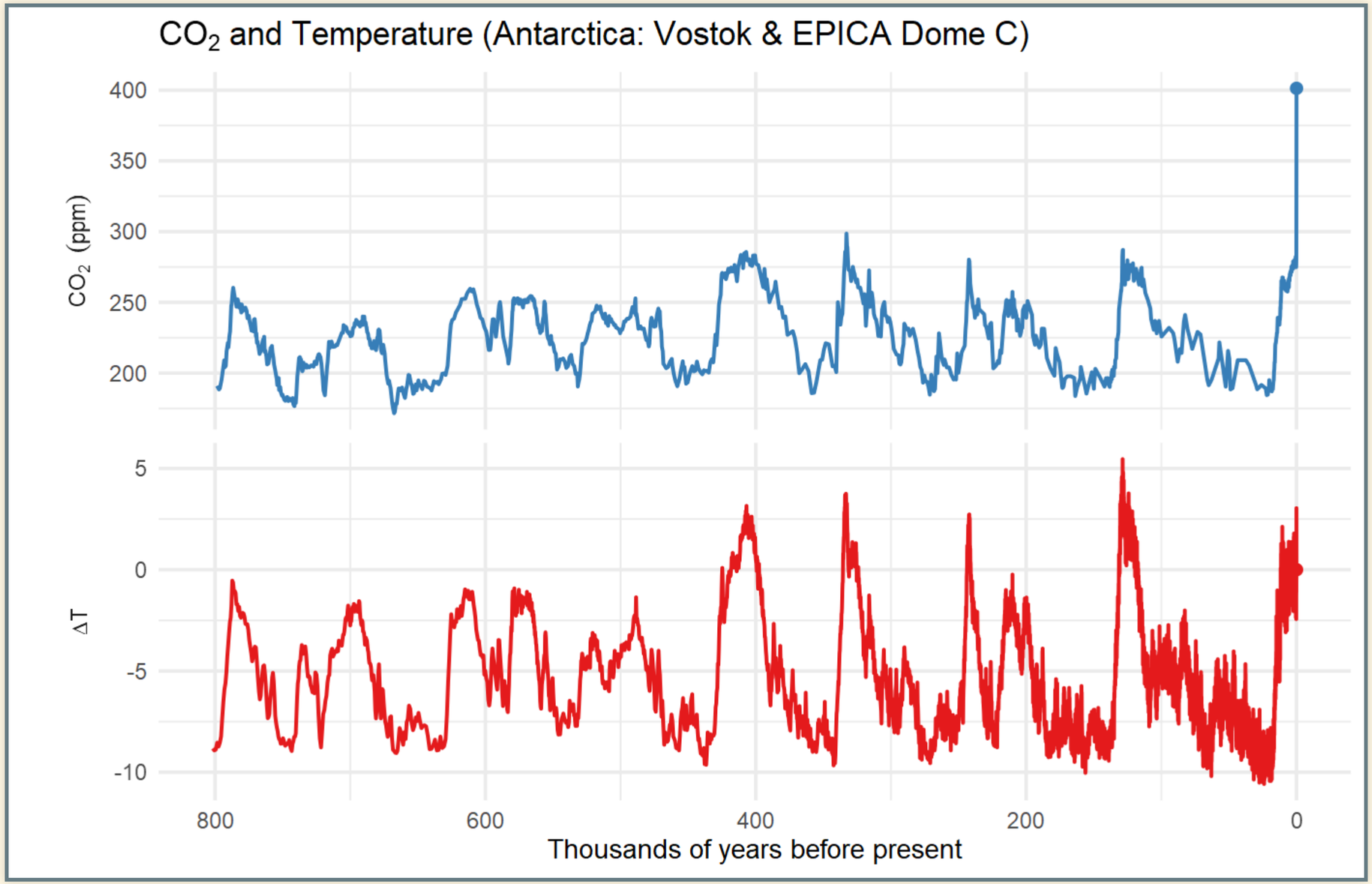

Global Temperature Anomalies (1881 to 2022)
7 warmest years: 2020, 2016, 2019
2017, 2022, 2015, 2018
Temperatures
Annual temp
10-year average
Baseline (1880-1909)
7 warmest years (Jan.-Dec.)
2022@ 1.15°C
Nov2022@ 0.98°C
Temp. Anomaly (°C)
1.0
0.5
0.0
1880
1920
1960
2000
Year
Data source: NASA, https://data.giss.nasa.gov/gistemp/tabledata_v4/GLB.Ts+dSST.txt

What Earth’s History Tells Us

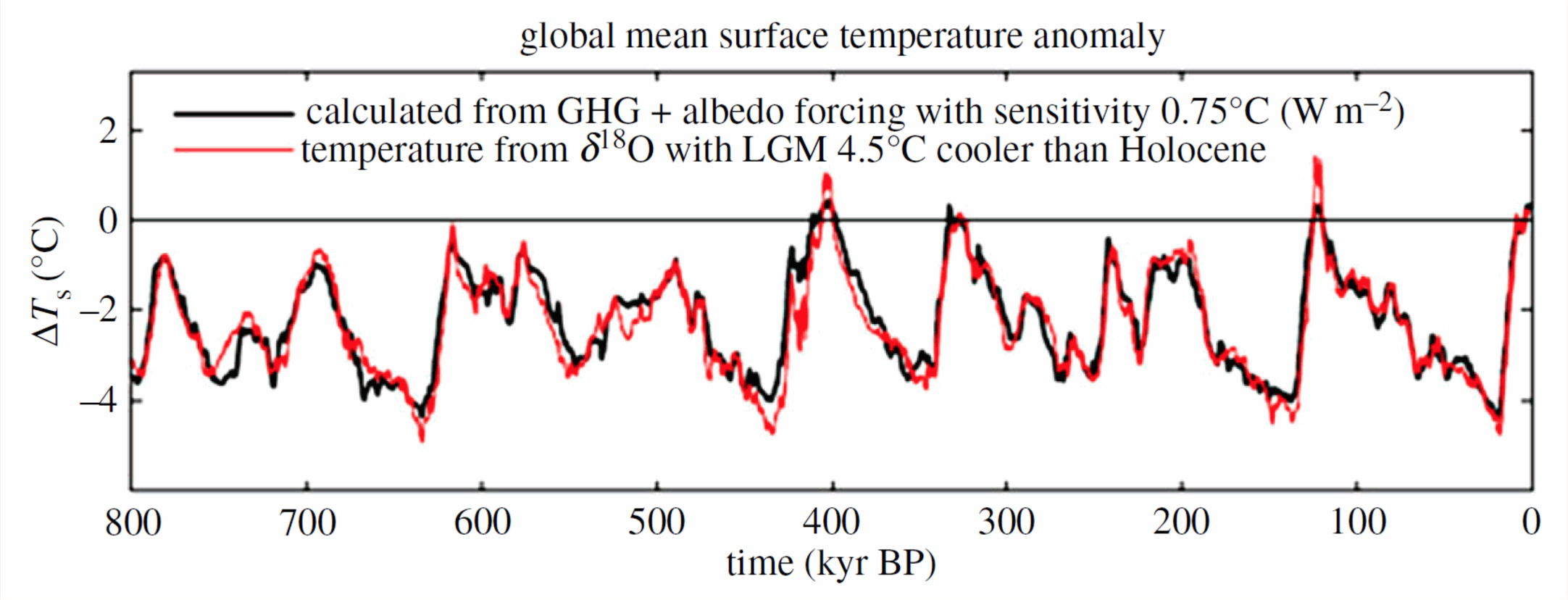
800,000 years of CO_2



800,000 years of CO_2 and Temperature



Using Past Climates to Test Theory



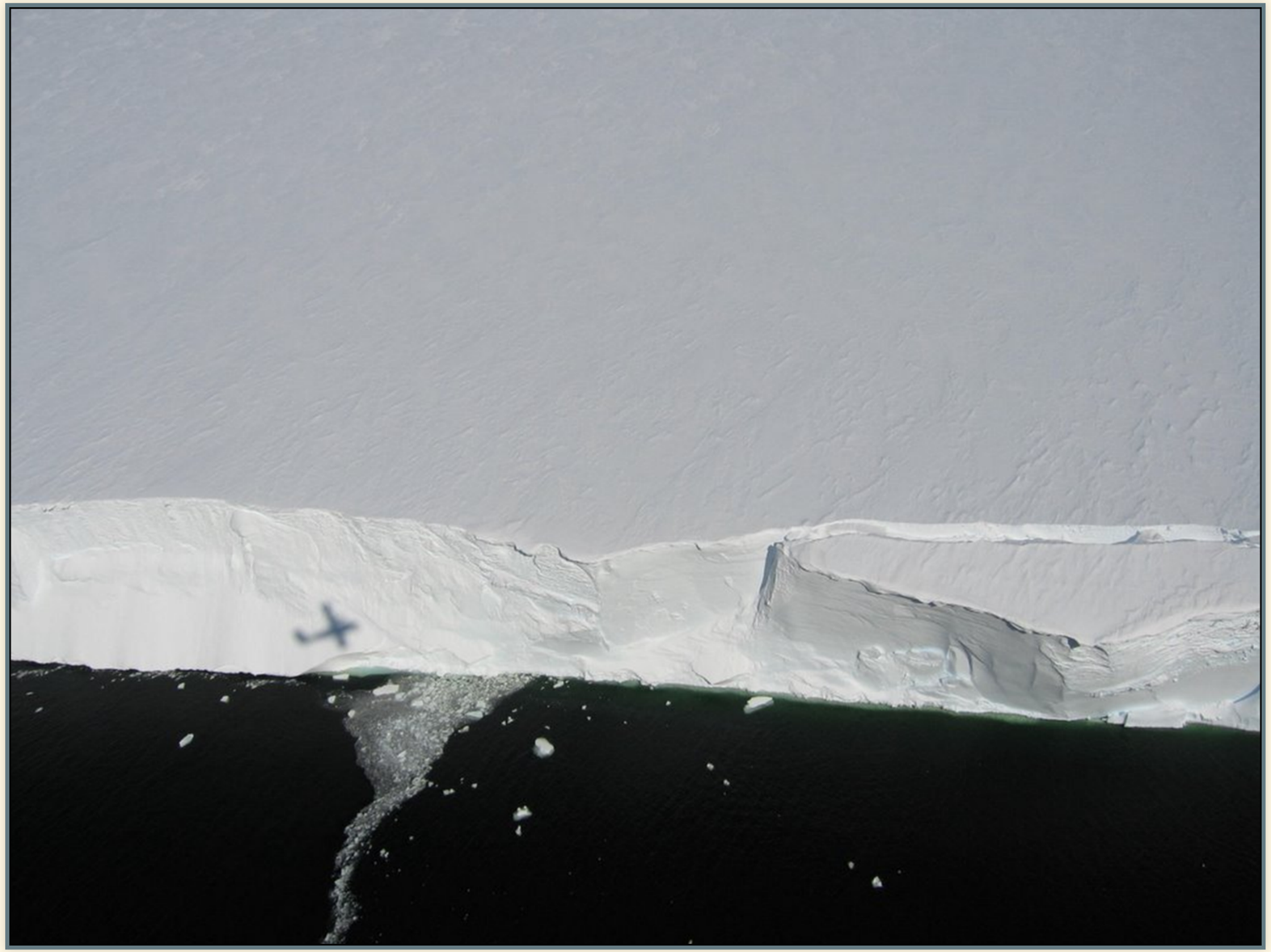
Source: J. Hansen *et al.*, Phil. Trans. Roy. Soc. A **371**, 20120394 (2013).

Tipping Points

Tipping Points

- Consider a wooden stick
- Bend it a little
  - When you let it go, it springs back to its original shape
- Bend it too far
  - It snaps
  - When you let it go, it does not return to its original shape

Amplification of Climate Change



Climate Tipping Points

- Unknown, uncertain, but dangerous
- We may have crossed a tipping point in sea-level rise
  - West Antarctic ice sheet may be past saving
- Less likely:
  - Runaway warming
    - Temperature rises
    - Biomass in Arctic tundra thaws and decays
    - Releases methane & CO_2
    - Further warming
- Climate tipping points:
  - We don’t know if they exist
  - We don’t know where they are
  - How do we make policy for those risks?