Uncertainty about Future Climates

EES 3310/5310

Global Climate Change

Jonathan Gilligan

Class #20: Friday, March 4 2022

Review of Fallacies

Categories of Fallacies: FLICC

- People who reject climate science mostly use five categories of fallacies:
  - **F**ake experts
  - **L**ogical fallacies
  - **I**mpossible expectations
  - **C**herry picking
  - **C**onspiracy theories

Innoculation Theory

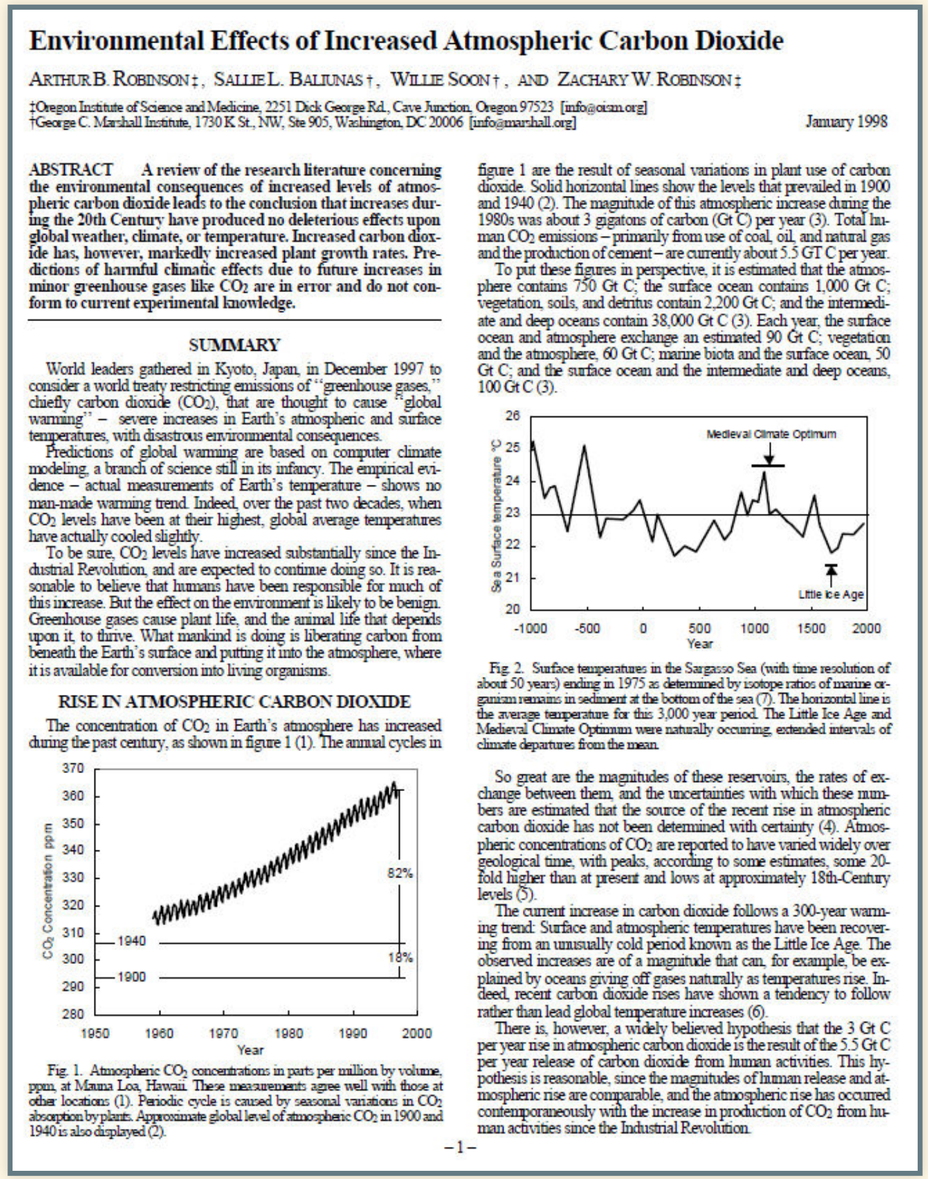
- Based on psychological research
- Similar to vaccination against disease
- Presenting a weakened form of misinformation helps people recognize and resist propaganda
- Two elements:
  - Warn people about misinformation
  - Explain how the misinformation is wrong
- Facts vs. Logic
  - Facts can help you refute a single fallacy
  - Understanding the logic of fallacies helps you refute entire categories of misinformation

Fake Experts Fallacies

In an experiment when participants are taught to see the Fake Expert fallacy in a tobacco ad, they were much less likely to be fooled by climate misinformation that used the Fake Expert fallacy.

Oregon Institute of Science and Medicine

- Sounds fancy.
  - It's one room in a farmhouse at the end of a road in rural Oregon.
  - In 1998: 2 people: Arthur B. Robinson and his 21-year-old son
- Circulated a document printed on glossy paper, typeset to look like an article from *Proceedings of the National Academy of Sciences*
  - Claimed to prove that CO_2 does not affect the climate
- Arthur Robinson also says that nuclear radiation is good for you
  - And he has collected over 14,000 vials of human urine that he claims will extend his life and let him overthrow the "medical-industrial-government complex."



Environmental Effects of Increased Atmospheric Carbon Dioxide

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January 1998

ABSTRACT **A review of the research literature concerning the environmental consequences of increased levels of atmospheric carbon dioxide leads to the conclusion that increases during the 20th Century have produced no deleterious effects upon global weather, climate, or temperature. Increased carbon dioxide has, however, markedly increased plant growth rates. Predictions of harmful climatic effects due to future increases in minor greenhouse gases like CO_2 are in error and do not conform to current experimental knowledge.**

SUMMARY

World leaders gathered in Kyoto, Japan, in December 1997 to consider a world treaty restricting emissions of "greenhouse gases," chiefly carbon dioxide (CO_2), that are thought to cause "global warming" – severe increases in Earth's atmospheric and surface temperatures, with disastrous environmental consequences.

Predictions of global warming are based on computer climate modeling, a branch of science still in its infancy. The empirical evidence – actual measurements of Earth's temperature – shows no man-made warming trend. Indeed, over the past two decades, when CO_2 levels have been at their highest, global average temperatures have actually cooled slightly.

To be sure, CO_2 levels have increased substantially since the Industrial Revolution, and are expected to continue doing so. It is reasonable to believe that humans have been responsible for much of this increase. But the effect on the environment is likely to be benign. Greenhouse gases cause plant life, and the animal life that depends upon it, to thrive. What mankind is doing is liberating carbon from beneath the Earth's surface and putting it into the atmosphere, where it is available for conversion into living organisms.

RISE IN ATMOSPHERIC CARBON DIOXIDE

The concentration of CO_2 in Earth's atmosphere has increased during the past century, as shown in figure 1 (1). The annual cycles in figure 1 are the result of seasonal variations in plant use of carbon dioxide. Solid horizontal lines show the levels that prevailed in 1900 and 1940 (2). The magnitude of this atmospheric increase during the 1980s was about 3 gigatons of carbon (Gt C) per year (3). Total human CO_2 emissions – primarily from use of coal, oil, and natural gas and the production of cement – are currently about 5.5 GT C per year.

To put these figures in perspective, it is estimated that the atmosphere contains 750 Gt C; the surface ocean contains 1,000 Gt C; vegetation, soils, and detritus contain 2,200 Gt C; and the intermediate and deep oceans contain 38,000 Gt C (3). Each year, the surface ocean and atmosphere exchange an estimated 90 Gt C; vegetation and the atmosphere, 60 Gt C; marine biota and the surface ocean, 50 Gt C; and the surface ocean and the intermediate and deep oceans, 100 Gt C (3).

Fig 2. Surface temperatures in the Sargasso Sea (with time resolution of about 50 years) ending in 1975 as determined by isotope ratios of marine organism remains in sediment at the bottom of the sea (7). The horizontal line is the average temperature for this 3,000 year period. The Little Ice Age and Medieval Climate Optimum were naturally occurring, extended intervals of climate departures from the mean.

Fig. 1. Atmospheric CO_2 concentrations in parts per million by volume, ppm, at Mauna Loa, Hawaii. These measurements agree well with those at other locations (1). Periodic cycle is caused by seasonal variations in CO_2 absorption by plants. Approximate global level of atmospheric CO_2 in 1900 and 1940 is also displayed (2).

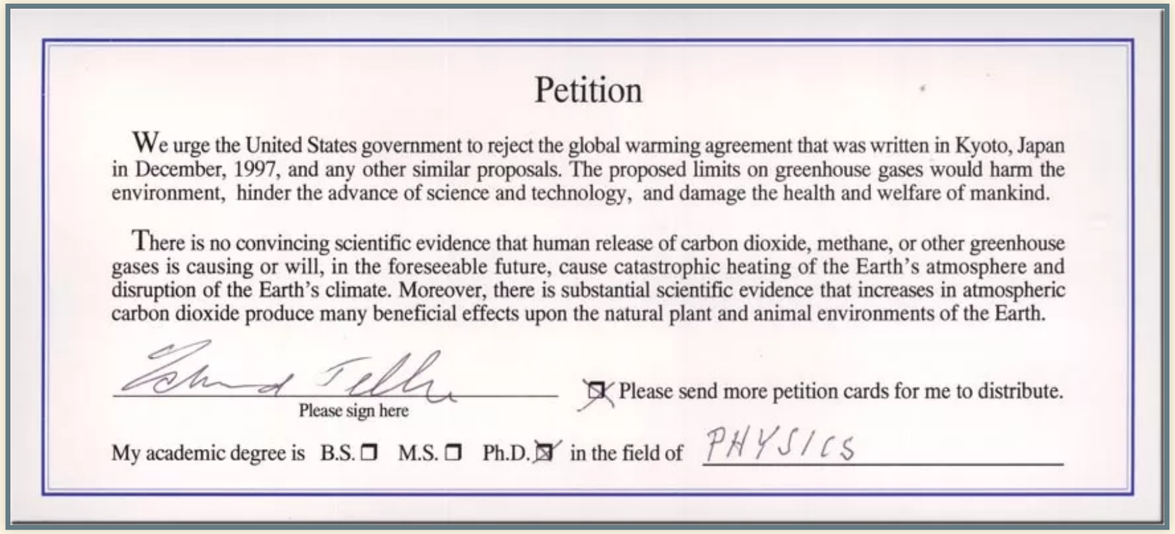
So great are the magnitudes of these reservoirs, the rates of exchange between them, and the uncertainties with which these numbers are estimated that the source of the recent rise in atmospheric carbon dioxide has not been determined with certainty (4). Atmospheric concentrations of CO_2 are reported to have varied widely over geological time, with peaks, according to some estimates, some 20-fold higher than at present and lows at approximately 18th-Century levels (5).

The current increase in carbon dioxide follows a 300-year warming trend: Surface and atmospheric temperatures have been recovering from an unusually cold period known as the Little Ice Age. The observed increases are of a magnitude that can, for example, be explained by oceans giving off gases naturally as temperatures rise. Indeed, recent carbon dioxide rises have shown a tendency to follow rather than lead global temperature increases (6).

There is, however, a widely believed hypothesis that the 3 Gt C per year rise in atmospheric carbon dioxide is the result of the 5.5 Gt C per year release of carbon dioxide from human activities. This hypothesis is reasonable, since the magnitudes of human release and atmospheric rise are comparable, and the atmospheric rise has occurred contemporaneously with the increase in production of CO_2 from human activities since the Industrial Revolution.

Oregon Petition

- Asked readers to sign a petition saying that greenhouse gases do not affect the climate.
- They claim that 31,487 scientists have signed the petition
  - No attempt to verify identities or credentials
  - Signatories include:
    - Characters from Star Wars
    - Characters from the TV show M*A*S*H
    - Michael J. Fox and Ginger Spice
  - Credentials included over 1,000 veterinarians
    - Almost none had any expertise in climate science.
- Several members of Congress cited the petition



Petition

We urge the United States government to reject the global warming agreement that was written in Kyoto, Japan in December, 1997, and any other similar proposals. The proposed limits on greenhouse gases would harm the environment, hinder the advance of science and technology, and damage the health and welfare of mankind.

There is no convincing scientific evidence that human release of carbon dioxide, methane, or other greenhouse gases is causing or will, in the foreseeable future, cause catastrophic heating of the Earth's atmosphere and disruption of the Earth's climate. Moreover, there is substantial scientific evidence that increases in atmospheric carbon dioxide produce many beneficial effects upon the natural plant and animal environments of the Earth.

Edward Teller
Please sign here

☒ Please send more petition cards for me to distribute.

My academic degree is B.S. ☐ M.S. ☐ Ph.D. ☒ in the field of PHYSICS

Cherry-Picking Fallacy

Pielke and Nordhaus

Pielke and Nordhaus

Pielke:

Although some scientists believe that there may be “tipping points” … no one knows if or when there might be a threshold effect.

Nordhaus:

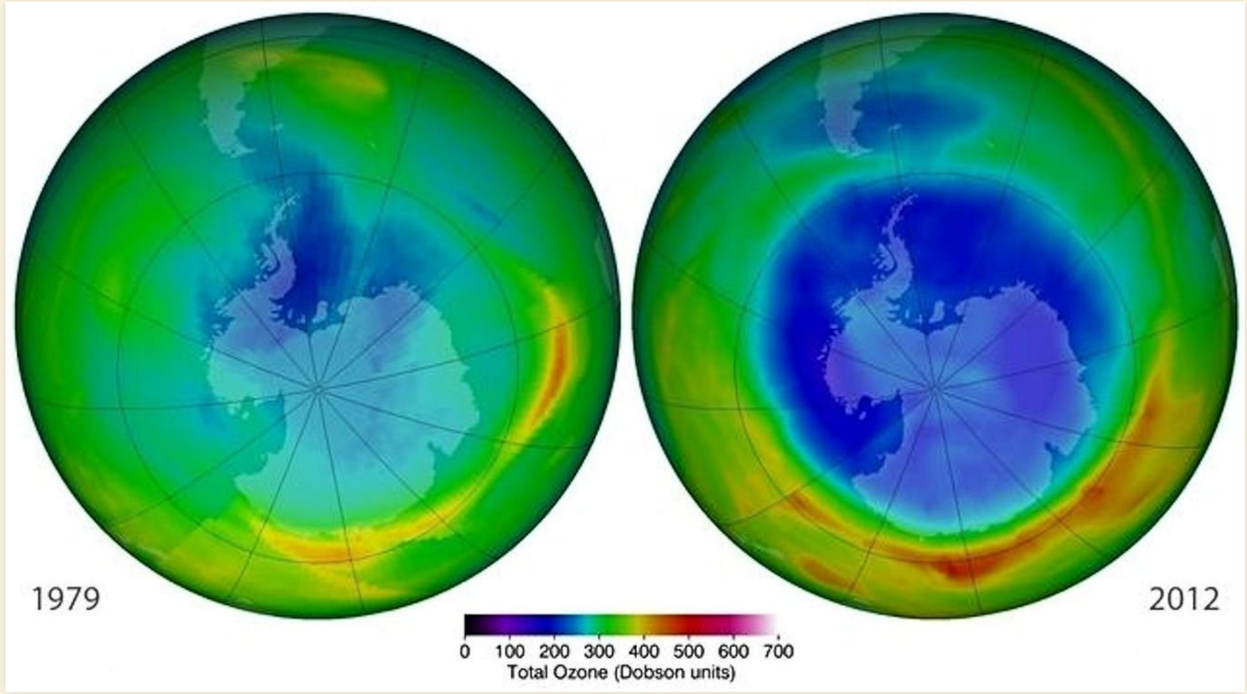
Humans are in effect spinning the roulette wheel when we inject CO_2 and other gases into the atmosphere. The balls may land in the favorable black pockets or in the unfavorable red pockets, or possibly in the dangerous zero or double-zero pockets.

Stratospheric Ozone

- Ozone is a naturally occurring molecule in the stratosphere
  - From 15–35 km altitude
- Blocks harmful ultraviolet (extreme shortwave) radiation
  - Disrupts DNA and proteins in the lens of the eye
  - Causes skin cancer
  - Causes blindness from cataracts
- Scientists have measured ozone from the ground since the 1920s
  - Useful for understanding winds and weather

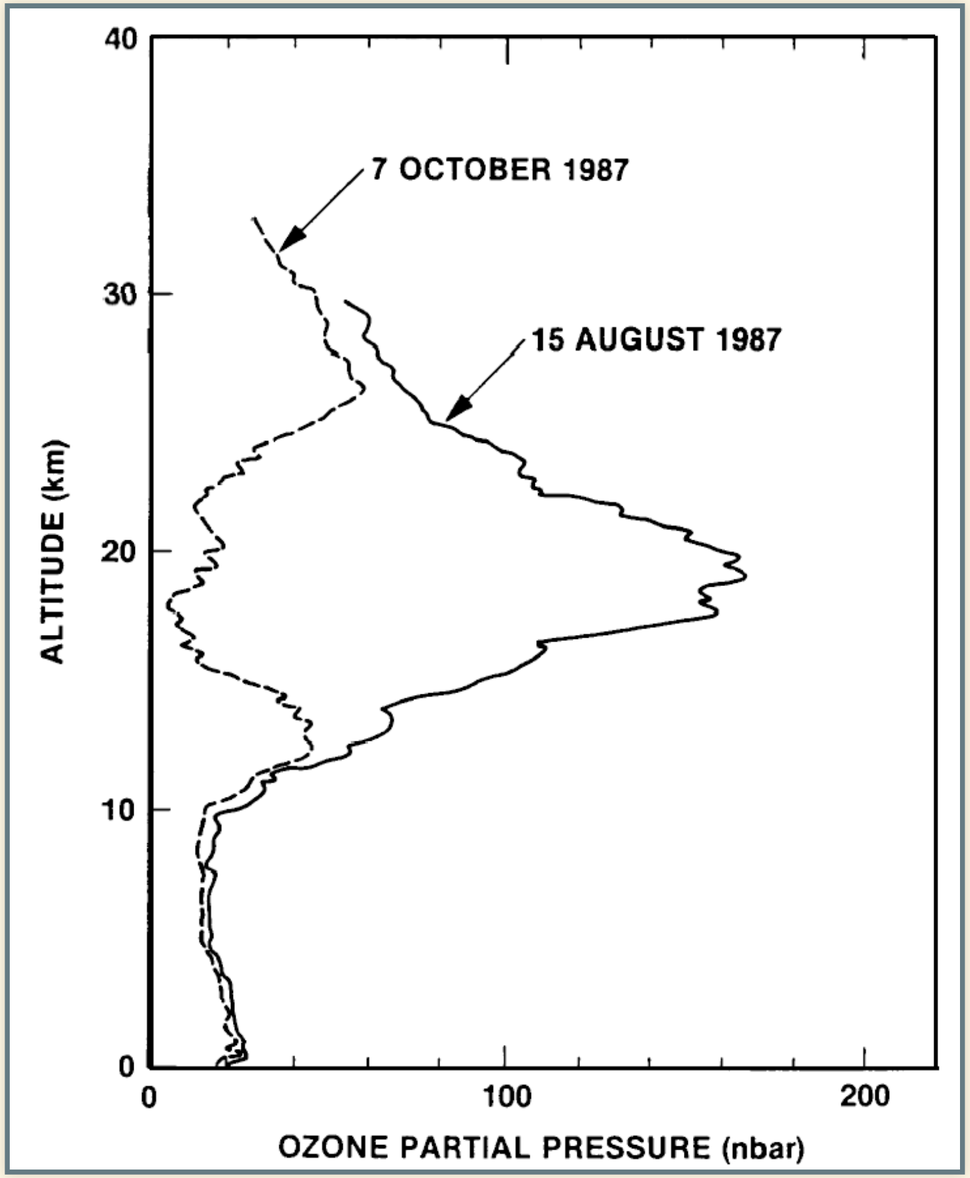
Stratospheric Ozone Depletion

- 1974: Scientific prediction:
  - Chlorofluorocarbon chemicals will destroy ozone
  - Scientists believed ozone destruction would be gradual
- September 1980: Scientists in Antarctica see ozone go to zero in a matter of days
- 1985: Announcement: Discovery of a giant hole in the ozone layer over Antarctica every spring
- Tipping point:
  - Stratospheric chlorine < 2 parts per billion: No ozone hole
  - Stratospheric chlorine > 2 parts per billion: Ozone hole appears

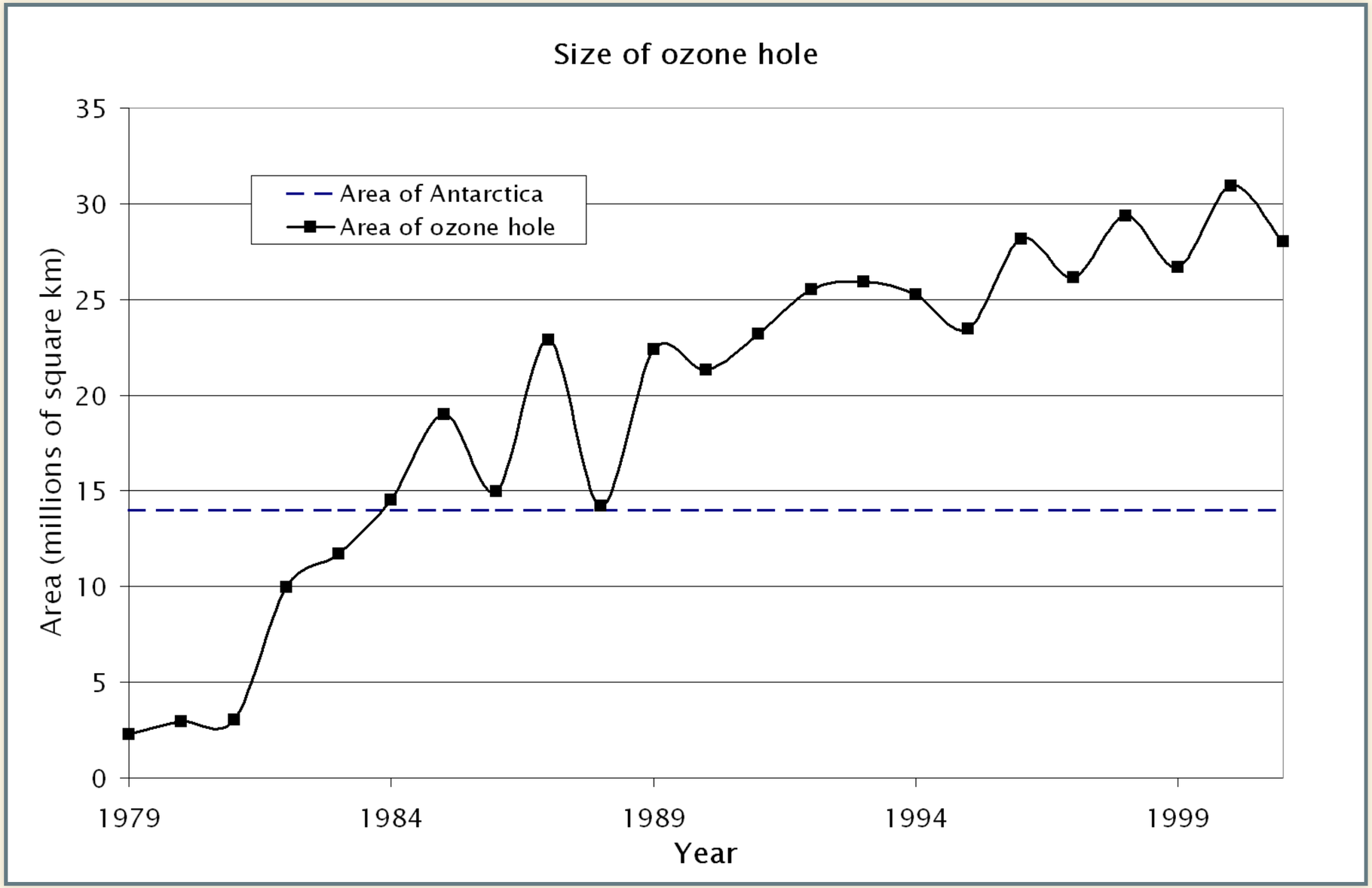


Discovery of the Ozone Hole

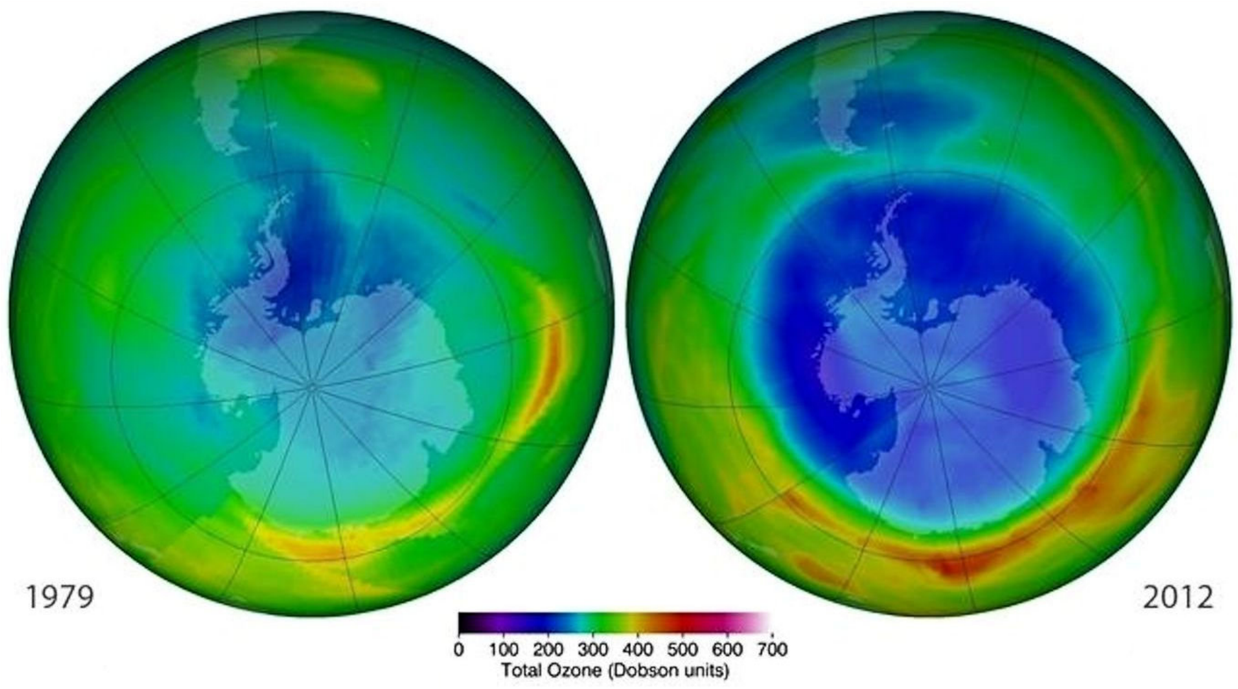
- Halley Bay Antarctica
  - British meteorological station
  - Measured ozone every month from 1958
- Antarctic Winter
  - June–September
  - No sun for months
- September 1980
  - Shortly after the sun rose, ozone disappeared
  - Ozone returned a few months later
  - Station head Joe Farman thought his instrument must be broken
    - Ordered a new instrument from England
    - The next September both instruments saw ozone disappear
  - 1984: Farman reports ozone hole
    - NASA had launched Total Ozone Mapping Spectrometer in 1979
      - Why hadn’t it seen an ozone hole
    - NASA had programmed the computers to ignore crazy low ozone values



Growth of Ozone Hole

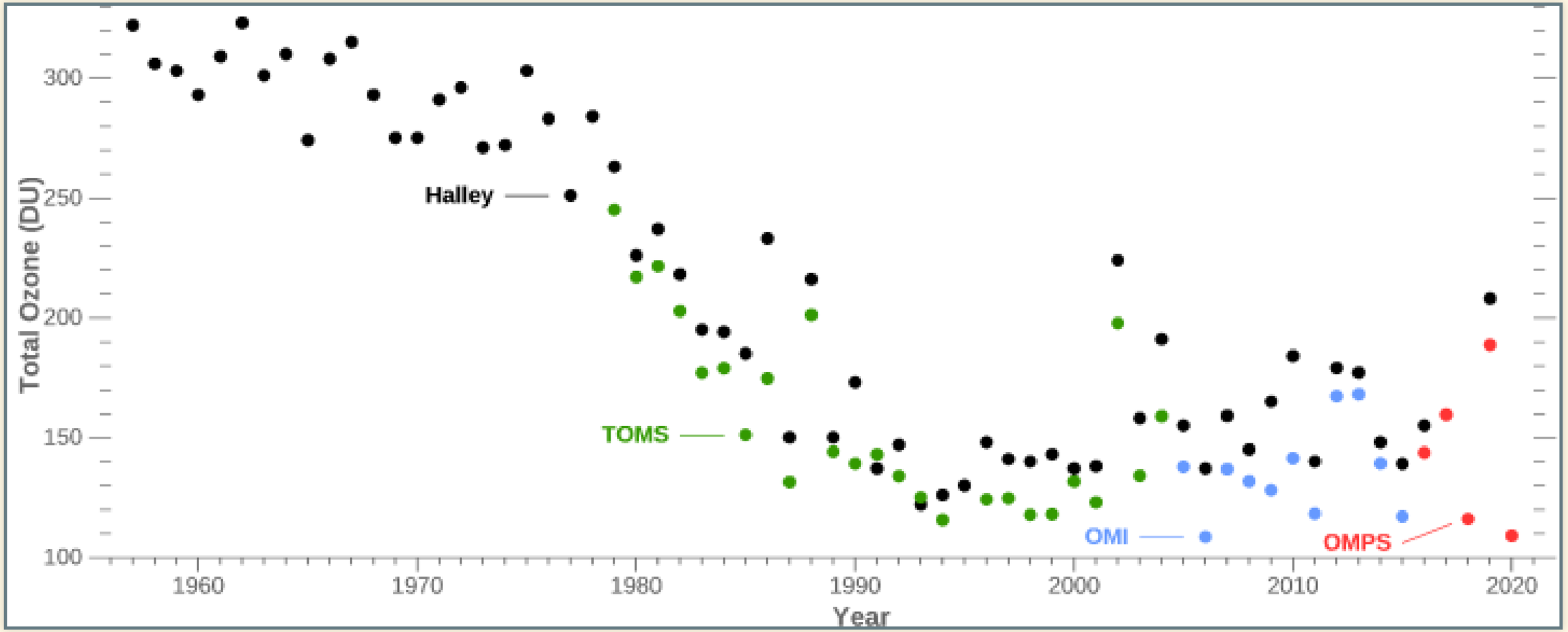


Ozone Policy

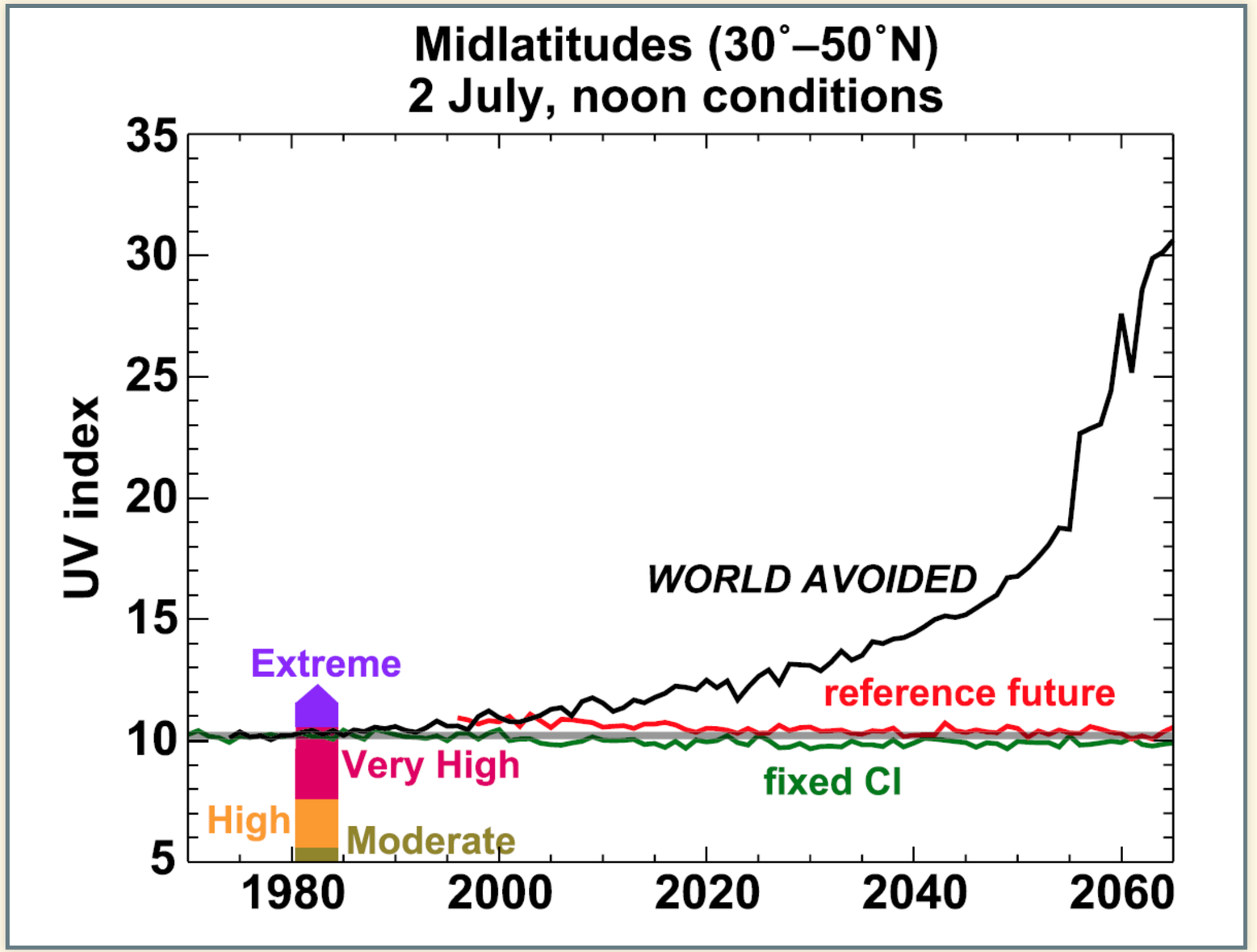


- 1970s: Significant scientific uncertainty
- Decision to take action without waiting for certainty
- Discovery of hole: tipping point
- Flexible policy (renegotiate details every two years)

History of Ozone over Halley Bay



Success: Avoided Futures



Important Note:

- The ozone hole is completely different from global warming
- Caused by chemical reactions with chlorine atoms
- However:
  - CFC chemicals that destroy ozone are also powerful greenhouse gases
  - Ozone depletion is temperature-sensitive
    - Hole over Antarctica because of very cold stratosphere (much colder than arctic)
    - Global warming cools stratosphere
    - If we had not stopped production of CFC chemicals An ozone hole might have started over arctic too.

Goals for Climate Policy

Goals for Climate Policy

- Limit temperature rise?
- Limit greenhouse gas concentrations?
- Focus only on CO_2?
- Focus broadly on all kinds of climate change (natural and human)?
- What do Pielke and Nordhaus say about these questions?
- What do you think?
- Pielke:

> *"A narrow focus on carbon dioxide is double-edged: it gives priority to a very important aspect …, but it can obscure the fact that … climate change involves so much more."*

Scientific Uncertainty

- How does scientific uncertainty affect policy?
- Should we wait for more certainty before acting?
- What do Pielke and Nordhaus say?
- What do you think?

- Nordhaus:

  “A sensible policy would pay an insurance premium to avoid playing the roulette wheel.”

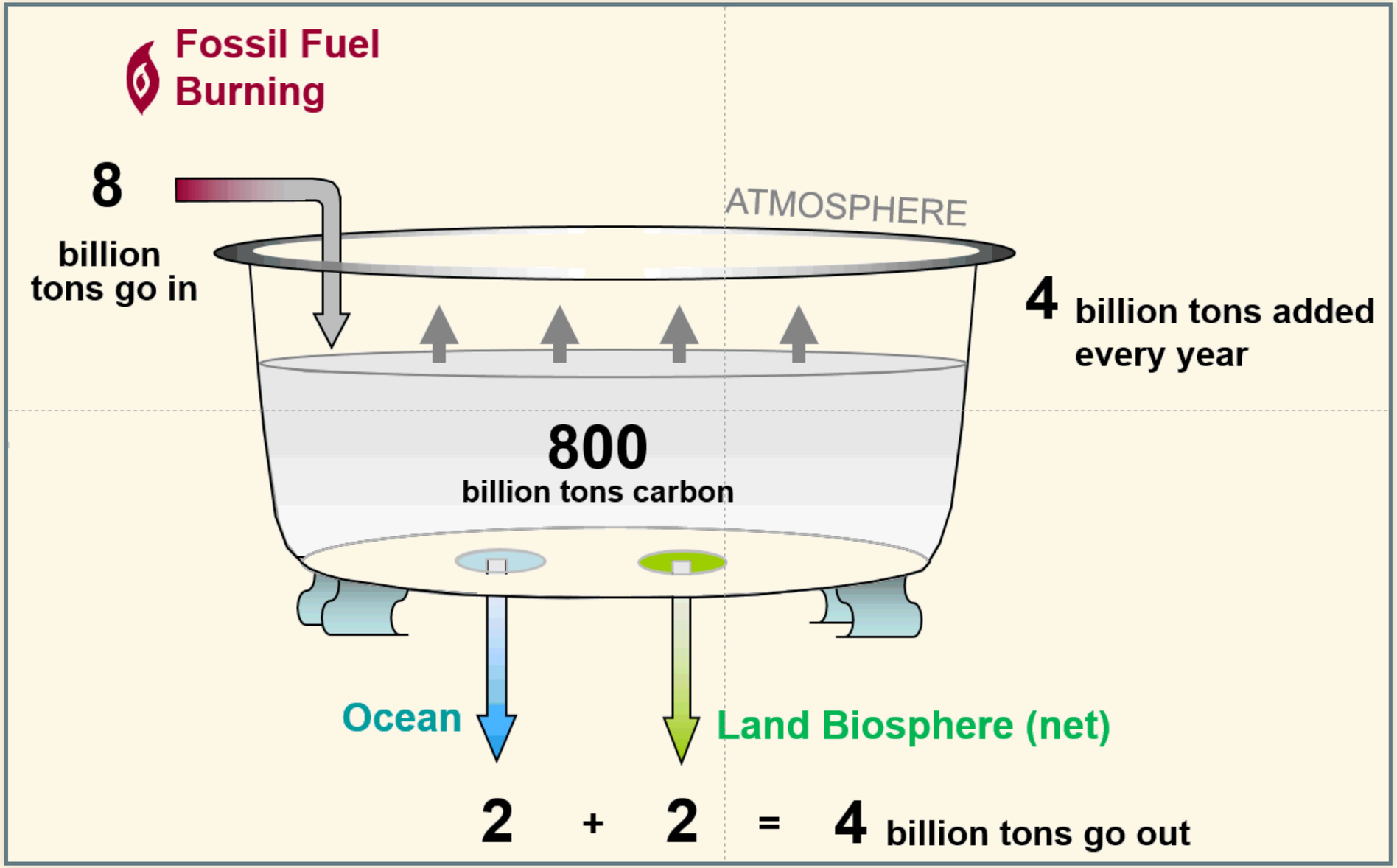
  “The cost of delaying action for 50 years … is [estimated] as $6.5 trillion.”

- Pielke:

  “Policy makers routinely make decisions … with a similar (or even less well-developed) state of understanding.”

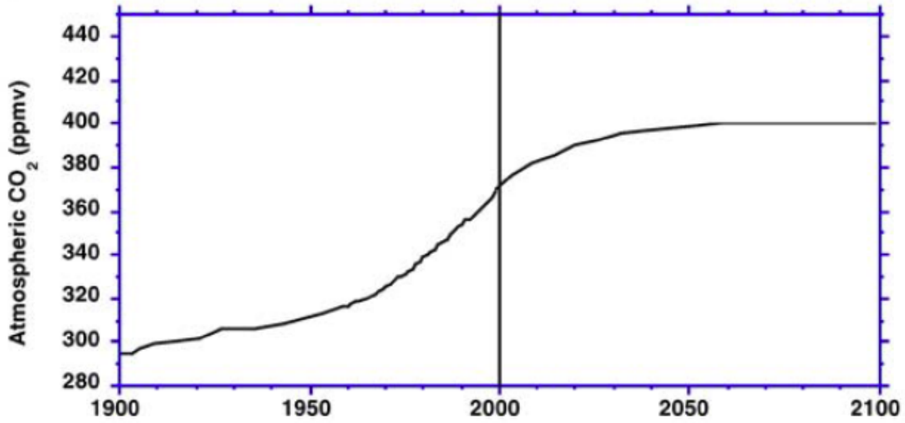
Bathtub model

Bathtub model

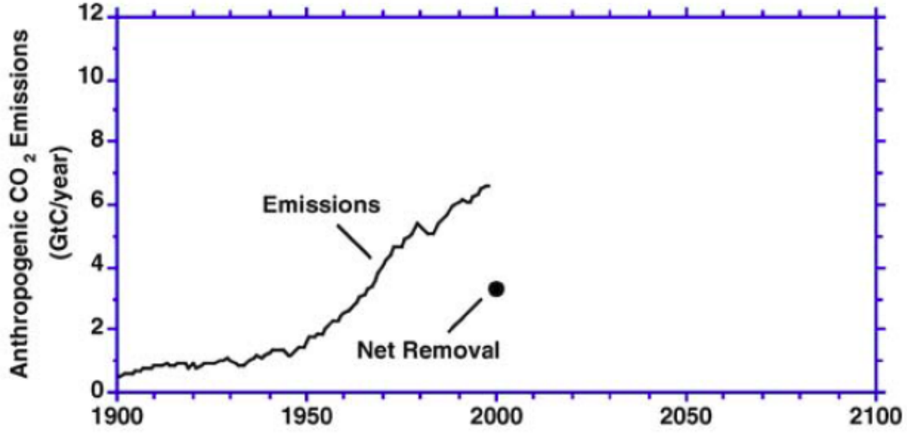


Bathtub model

Now consider a scenario in which the concentration of CO_2 in the atmosphere gradually rises to 400 ppm, about 8% higher than the level today, then stabilizes by the year 2100, as shown here:

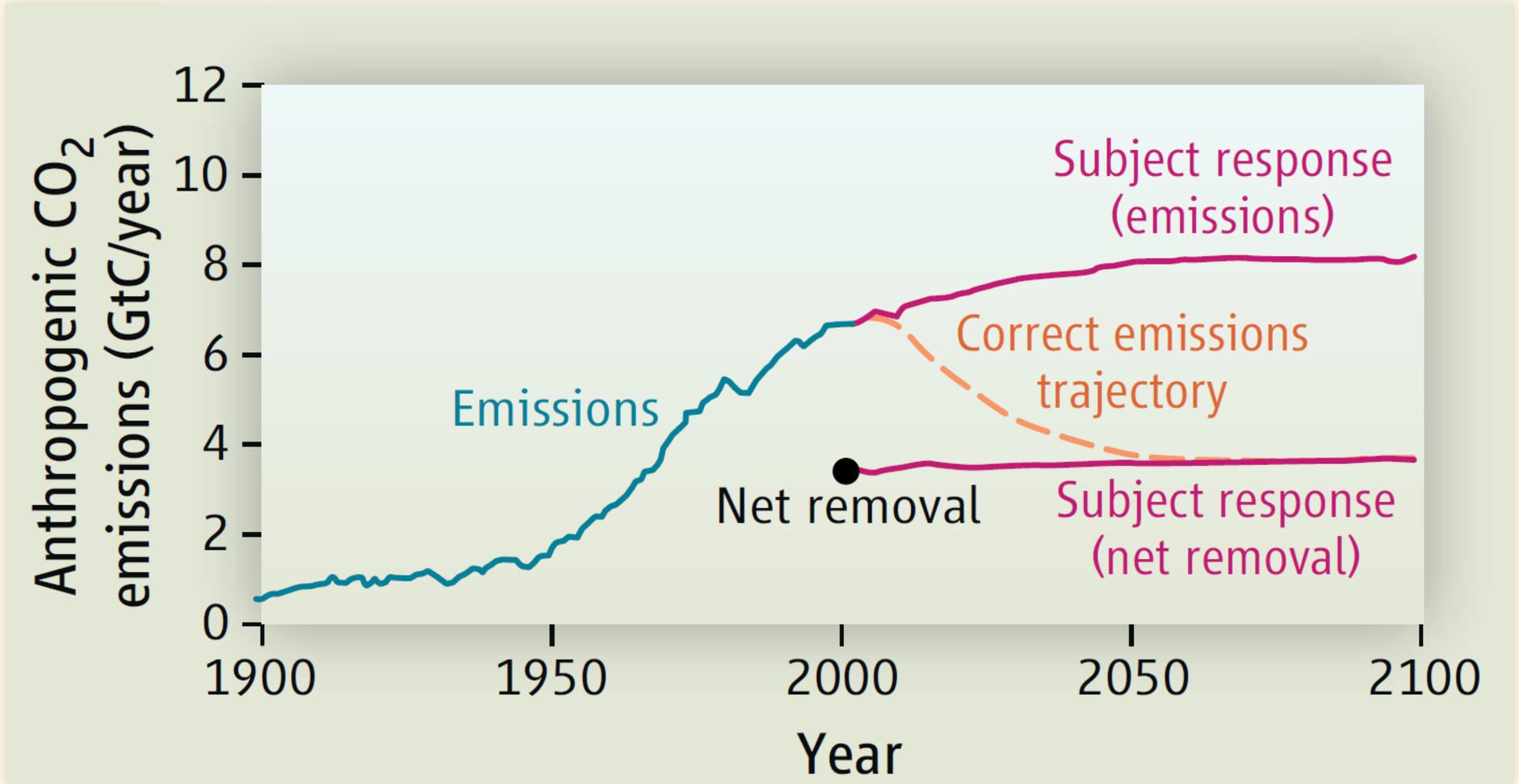


1. The graph below shows anthropogenic CO_2 emissions from 1900-2000, and current net removal of CO_2 from the atmosphere by natural processes. Sketch:
   a. Your estimate of likely future net CO_2 removal, given the scenario above.
   b. Your estimate of likely future anthropogenic CO_2 emissions, given the scenario above.



J.D. Sterman, Science **322**, 532 (2008).

Bathtub model



J.D. Sterman, Science **322**, 532 (2008).

- 212 MIT MBA and graduate students.
- 60% majored in science or engineering