# Climate Change Mental Models

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# Misperceptions of Feedback

- People's intuitive understanding of complex system dynamics is poor.
- Performance degraded by dynamic complexity:
  - Lags
  - Accumulations (stocks and flows)
  - Feedbacks
  - Nonlinearities

- These difficulties are pervasive, robust & resistant to formal training in STEM (Science, Technology, Engineering and Mathematics).
- All these elements pervasive in climate change

Sterman, J. (2008) Science 322: 532-533, 24 Oct.
Sterman, J. and L. Booth Sweeney (2007). Climatic Change 80(3-4): 213-238.

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# Risk Communication on Climate: Mental Models and Mass Balance

Public confusion about the urgency of reductions in greenhouse gas emissions results from a basic misconception.

John D. Sterman

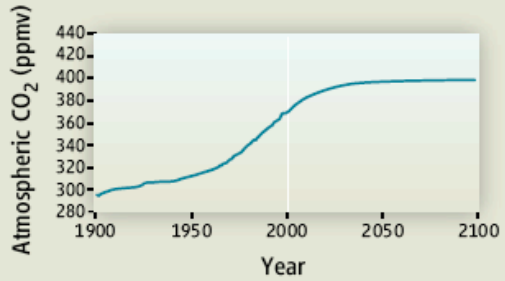
Sterman, J. (2008) *Science* ***322*****:** 532-533 *(24 Oct).*

The strong scientific consensus on the causes and risks of climate change stands in stark contrast to widespread confusion and complacency among the public (*1*, *2*). Why does this gulf exist, and why does it matter? Policies to manage complex natural and technical systems should be based on the best available scientific knowledge, and the Intergovernmental Panel on Climate Change (IPCC) provides rigorously vetted information to policy-makers. In democracies, however, the beliefs of the public, not only those of experts, affect government policy.

Effective risk communication is grounded in deep understanding of the mental models of policy-makers and citizens (*3*). What, then, are the principal mental models shaping people's beliefs about climate change? Studies show an apparent contradiction: Majorities in the United States and other nations have heard of climate change and say they support action to address it, yet climate change ranks far behind the economy, war, and terrorism among people's greatest concerns, and large majorities oppose policies that would cut greenhouse gas (GHG) emissions by raising fossil fuel prices (*1*, *2*).

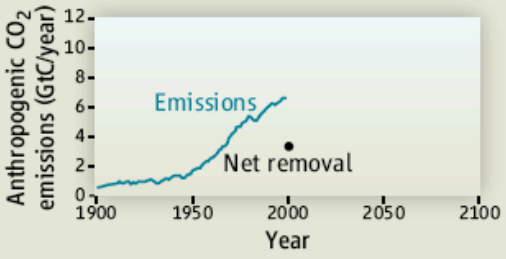
More telling, a 2007 survey found a majority of U.S. respondents (54%) advocated a "wait-and-see" or "go slow" approach to emissions reductions. Larger majorities favored wait-and-see or go slow in Russia,

Consider a scenario in which the concentration of $CO_2$ in the atmosphere gradually rises to 400 ppm, about 8% higher than the level in 2000, then stabilizes by the year 2100, as shown here:




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.




**The climate stabilization task.** Subjects were first given an excerpt from the IPCC SPM explicitly describing the accumulation of $CO_2$ in the atmosphere [see (*2*)].

standing of stocks and flows—the concept of accumulation. Accumulation is pervasive in everyday experience: Our bathtubs accumulate the inflow of water through the faucet less the outflow through the drain, our bank accounts accumulate deposits less withdrawals, and we all struggle to control our weight by managing the inflows and outflows of calories through diet and exercise. Yet, despite their ubiquity, research shows that people have difficulty relating the flows into and out of a stock to the level of the stock, even in simple, familiar contexts such as bank accounts and bathtubs. Instead, people often assess system dynamics using a pattern-matching heuristic, assuming that the output of a system should "look like"—be positively correlated with—its inputs (*12*, *13*).

Although sometimes useful, correlational reasoning fails in systems with important accumulations. Since 1950, the U.S. federal budget deficit and national debt have risen dramatically and are highly correlated ($r = 0.84$, $P < 0.0001$). Correlational reasoning predicts that cutting the deficit would also cut the debt. However, because the national debt is a stock that accumulates the deficit, it keeps rising even if the deficit falls; debt falls only if the government runs a surplus.

Poor understanding of accumulation leads to serious errors in reasoning about climate change (see charts, left, and on page 533).

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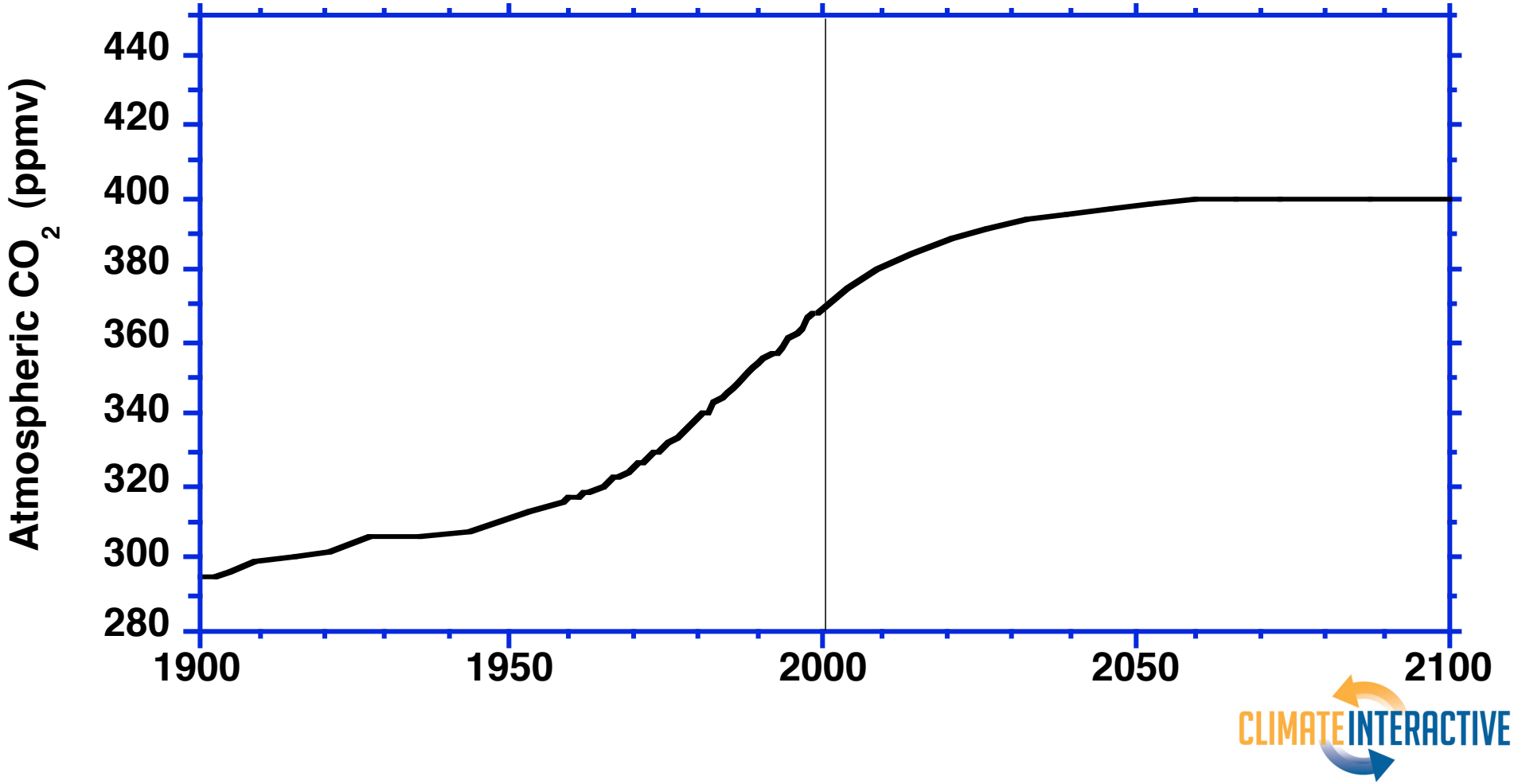


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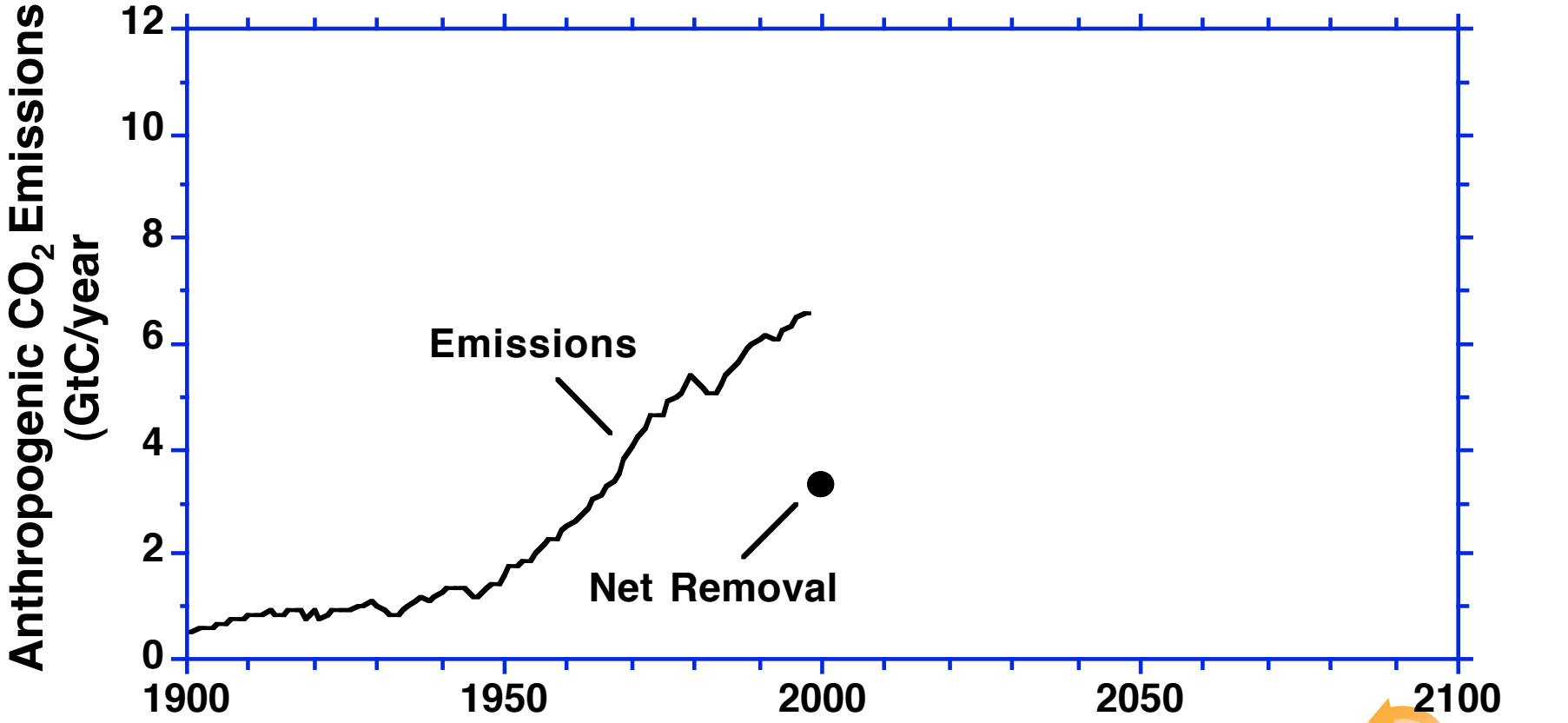
# Estimate $CO_2$ Emissions and Removal

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.

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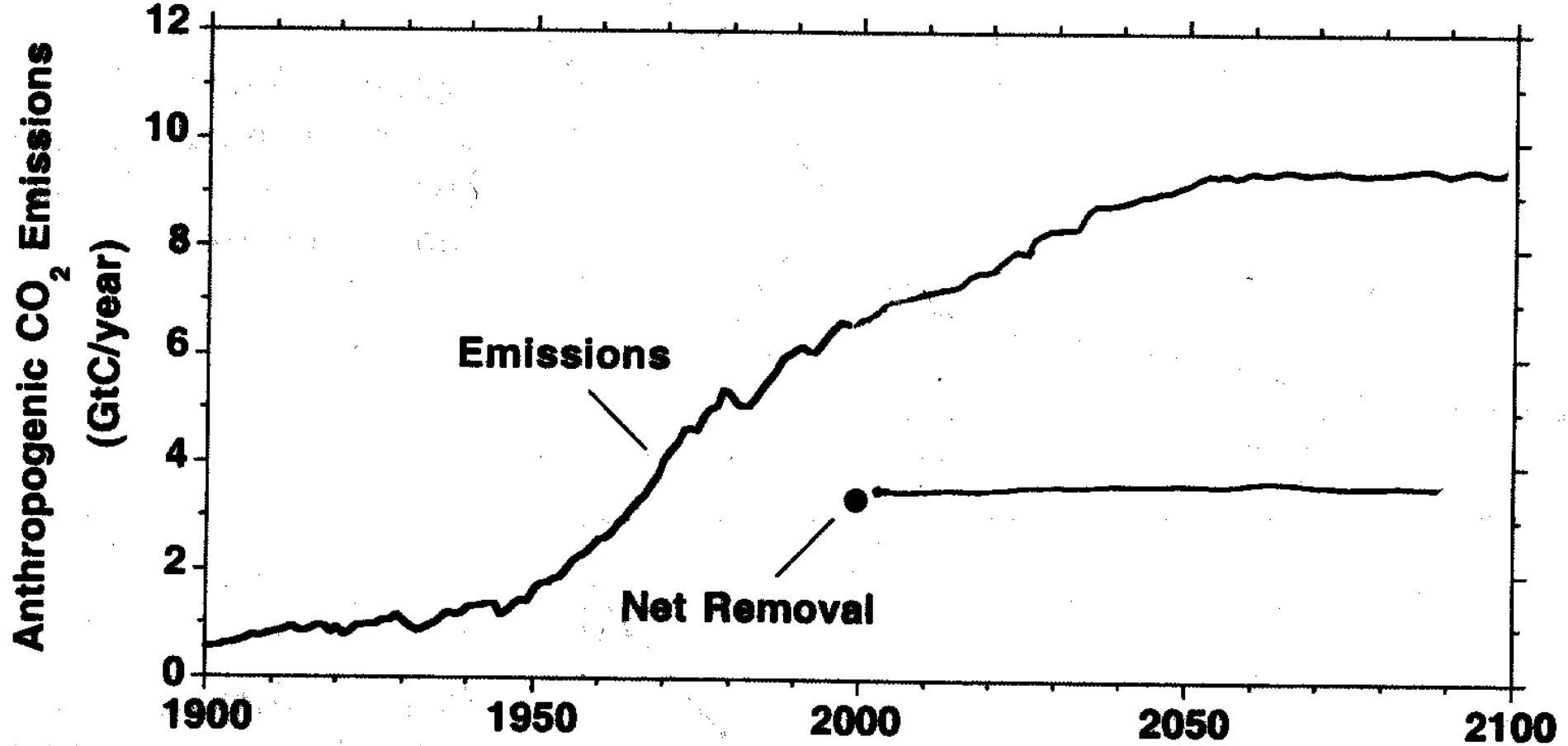
# Typical Response




Rise in Atmospheric $CO_2$ implies
↑ $CO_2$ ↓ Net Removal or both.
Also, the info provided suggests direct
Relationship between temperature & $CO_2$.
So higher $CO_2$, higher T

# Mass Balance?

- *84%* violate conservation of mass
- *75%* violate equilibrium condition that stable atmospheric $CO_2$ → Emissions = Removal
- *63%* assert atmospheric $CO_2$ can be stabilized while E > R

**Subjects: MIT Graduate Students**

Sterman, J. and L. Booth Sweeney (2007). Understanding Public Complacency About Climate Change: Adults' Mental Models of Climate Change Violate Conservation of Matter. *Climatic Change* ***80(3-4):*** 213-238.

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# Policymaker Mental Models

"Currently, in the UNFCCC negotiation process, the concrete environmental consequences of the various positions are not clear to all of us.

There is a dangerous void of understanding of the short and long term impacts of the espoused … unwillingness to act on behalf of the Parties."

– Christiana Figueres, UNFCCC negotiator for Costa Rica

# Climate Interactive Mission

"Climate Interactive is building a community that creates, shares, and uses credible models, accessible simulations, and related media in order to improve the way leaders and citizens around the world think about the climate.

Our purpose is to get these simulations and insights into the world as accessible products so they can be tweaked, enhanced, translated, distributed and used to power change around the world."



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# Our Approach

- Provide a means to speed up the learning by providing instant feedback
  - Interactive materials and simulators
- Open access materials
  - Climate models, course materials that have been used around the world, museum exhibits, etc.
- Scientifically rigorous and reviewed
  - Independent panel reviewed main simulators

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# Available Resources

- Online simulators
  - Climate change lag, importance of global approach, “bathtub” lessons
- Classroom World Climate negotiation exercise (supported by simulation)
- ClimateScoreboard.org
  - Web widget showing the effectiveness of proposed country actions, if fully implemented

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# DEMOS

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# What's Next?

- Would love to work with you to develop K-12 tools and lessons
- Target new platforms for lessons (iPad, phones?)
- We're creating a low-carbon economy simulator to help people understand the delays in infrastructure investments of clean technologies

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# Thank you

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