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# Insights from Building and Using ICAMs

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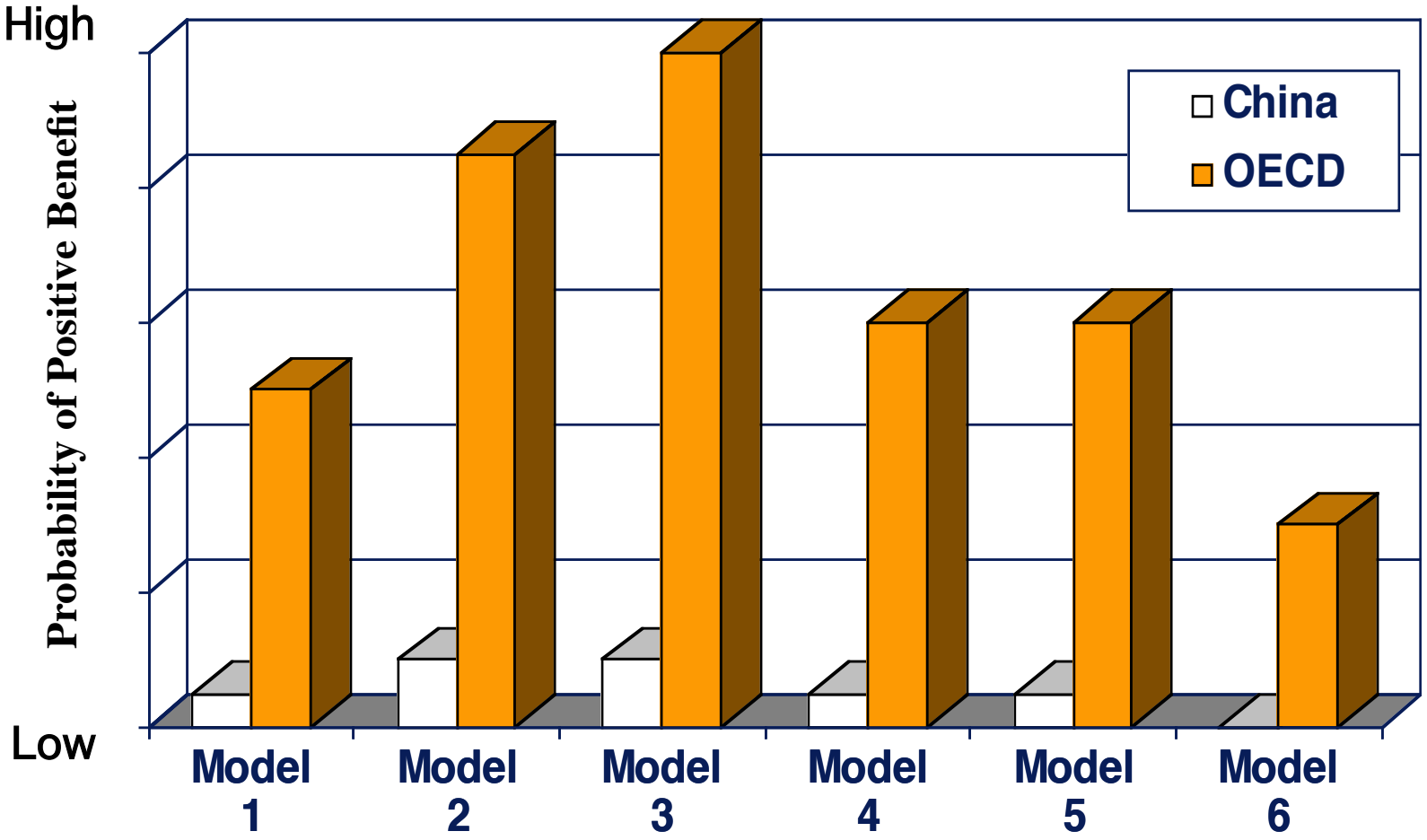
# Those of you…

…who have been regular attendees at Snowmass have heard Granger give  talks about why we stopped building integrated assessment models in which he argues that when we did an adequate job of treating both coefficient and model uncertainty we found:

- We could get any answer depending on plausible assumptions about the structure of the model.
- Rarely was any policy optimal for all regions.
- Rarely were any results stochastically dominant.

Rather than have Granger repeat any of his previous slides we decided it would be more interesting to have me give my own take on our experience.

# Implications of the model structure study
(ICAM-2)




Snowmass 1995

# Overall

- It is heroic to build IAs.
- Explicit incorporation of uncertainties focuses the research effort on issues where value of information is highest.
- We need to know a great deal more about the human dimensions of the problem.

# ICAM 1991-2000

**1991-1992:**
This problem is fraught with first and higher order uncertainties what can we learn by modeling it?

**1992: ICAM-0**
L&D frame the problem as a tension between science uncertainty & subjective perspectives.

**1992: ICAM-1**
M&D develop first process model, There are 2 regions Mitigation, adaptation, & geo

**1995: ICAM-2**
With 6 regions, four fuels, aerosols and adaptation is treated ous process

**1999: ICAM-3**
12 regions, health and ecological change, artificial agents representing cognitive and implementation ics. Can be used to assess and stability etc.

**2000+: Personal & Local DA tools**
Information & analysis frameworks aimed at personal and local decision-making

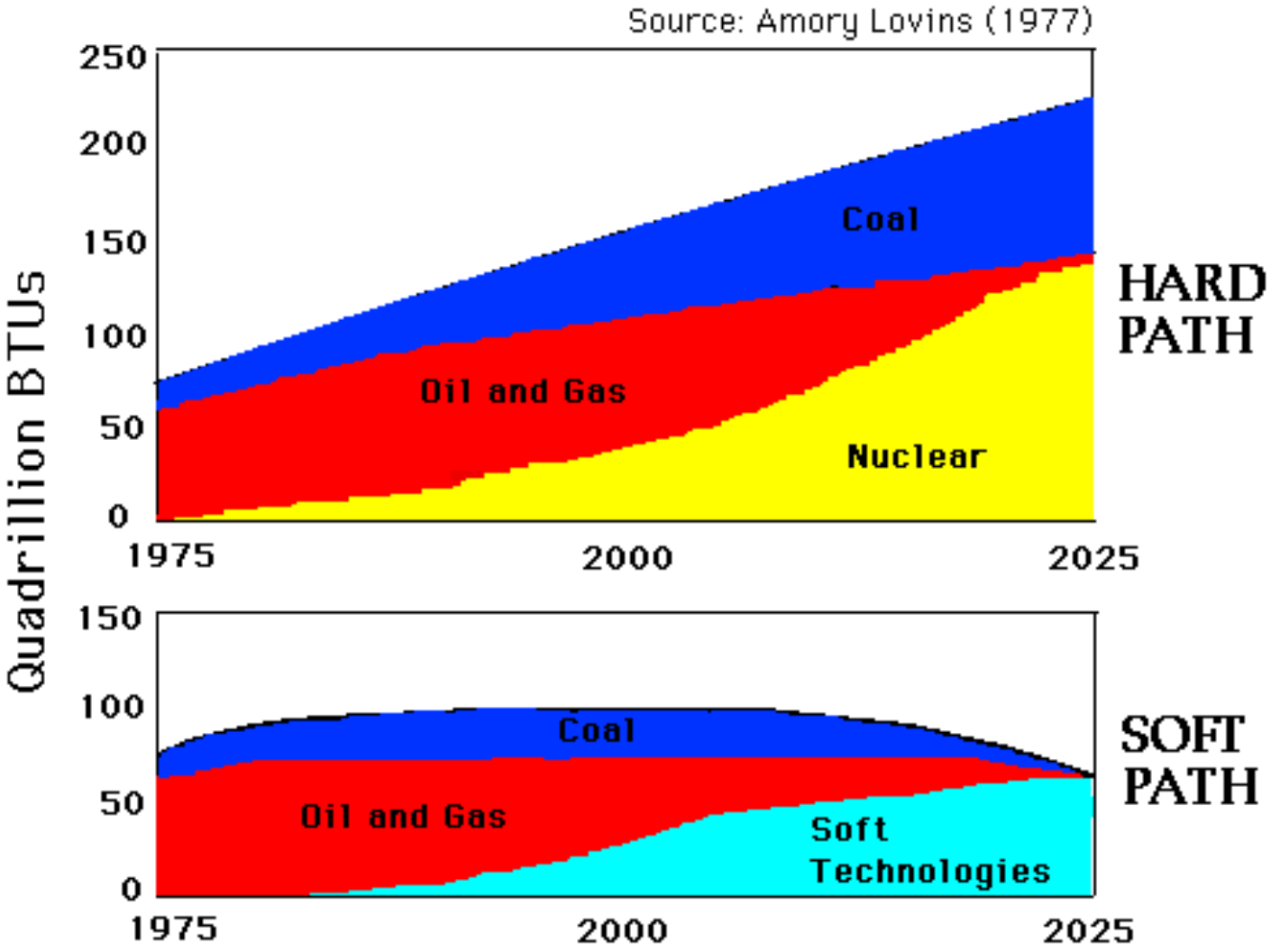
# Lessons learned

- Drivers:
  - Demographics, education, dependency ratios and economic growth are critical in the long-term – they need to be linked (what will give?)
- Mitigation:
  - Endogenous technical change is not just a matter of economics (how to model it?)
- Adaptation:
  - Bad initial conditions, and
  - Stochasticity of extreme events, and
  - Regulations are strong determinants of the loss/gain function.
- Geo-engineering
  - Cheap but of unknown risk

# Along the way we learned …

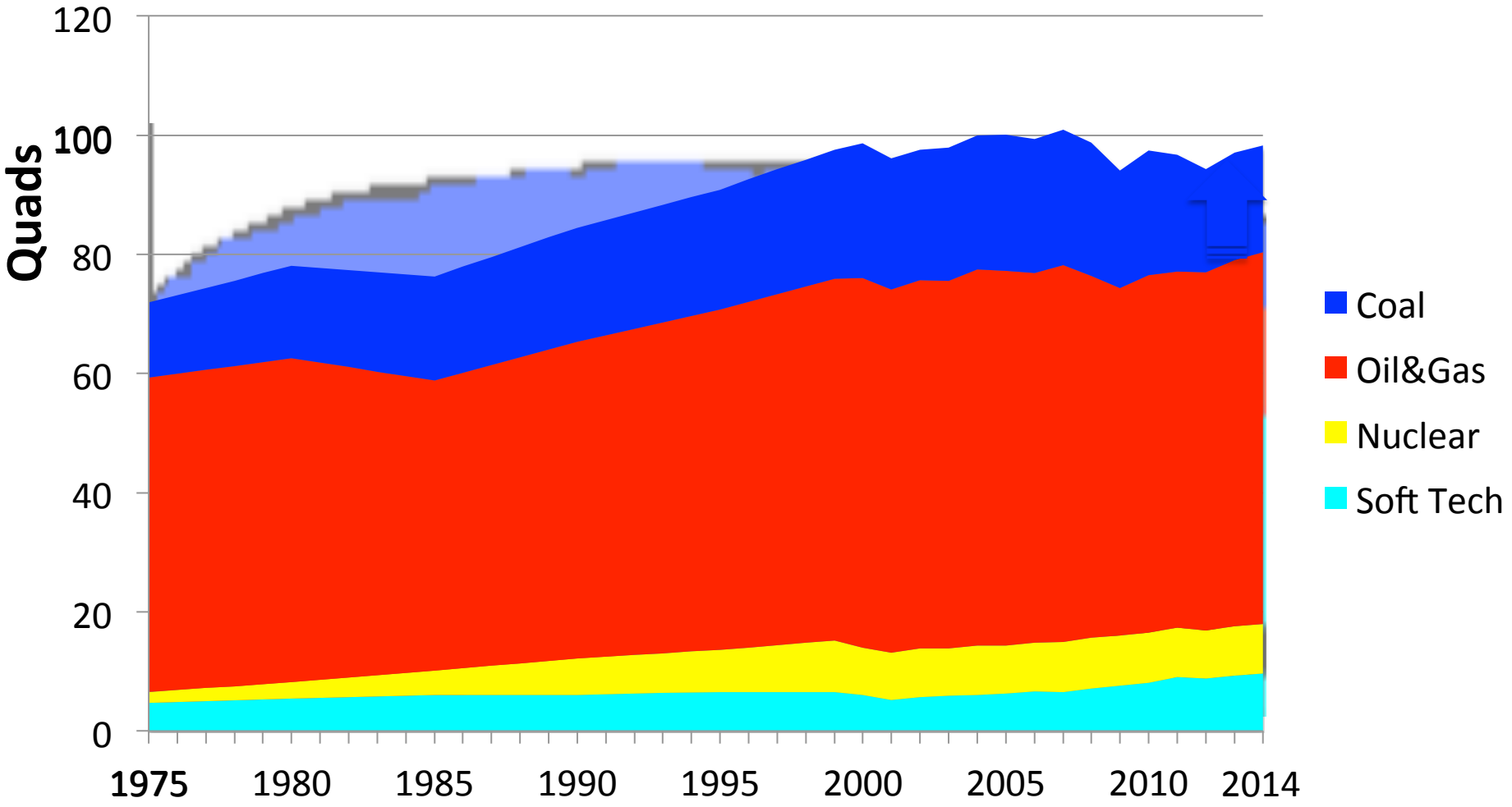
- There are no constraints among the drivers of the models (demographics, economic growth, …)
- When we did construct empirically informed, internally consistent, links between the key drivers of the model, we were unable to follow IPCC trajectories!
- While EMF and IPCC can bring scrutiny to the collective enterprise, they also lead to, perhaps, too much clustering of “expertise.”

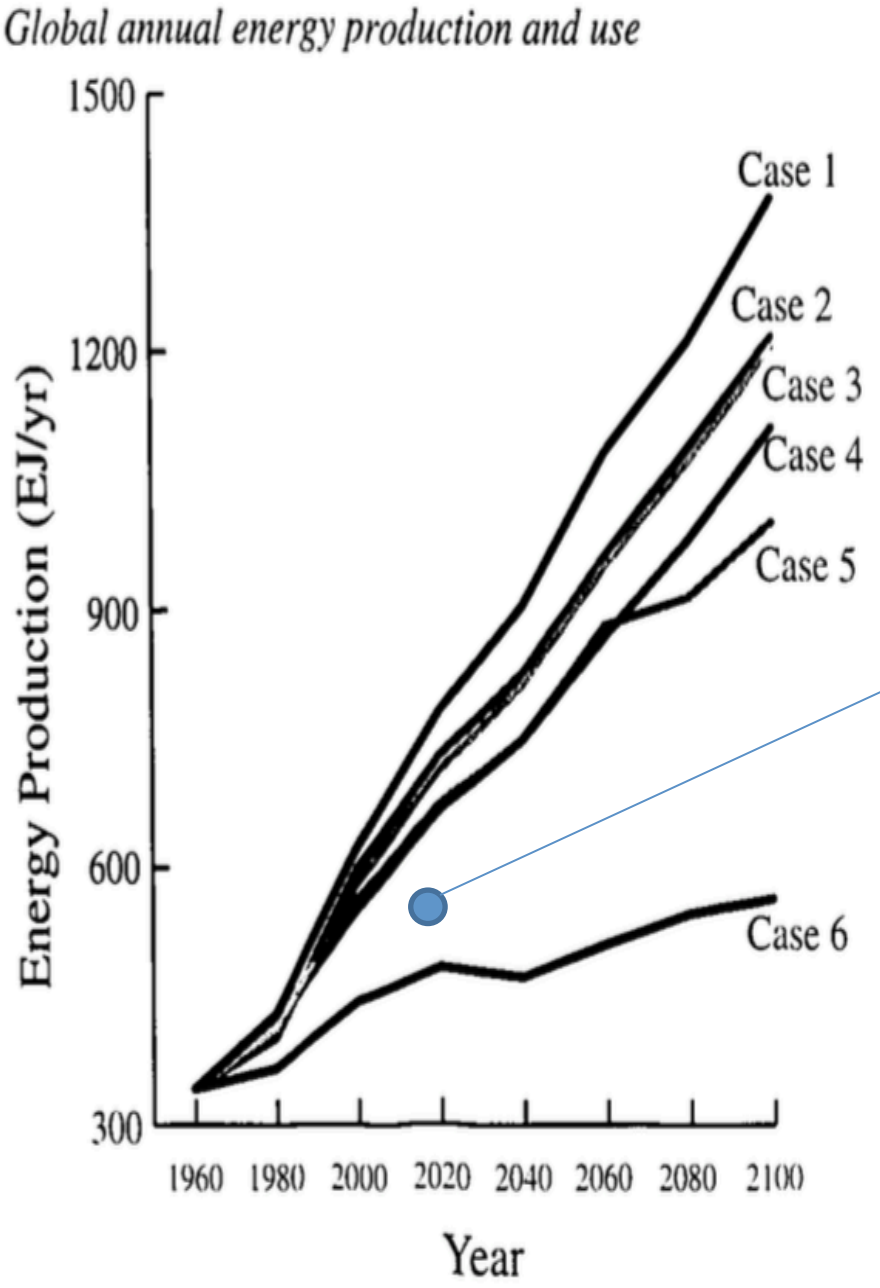
# Wanting something to be so *cf.* what it actually is



# US Energy Consumption by source:

## Right TPE but wrong composition

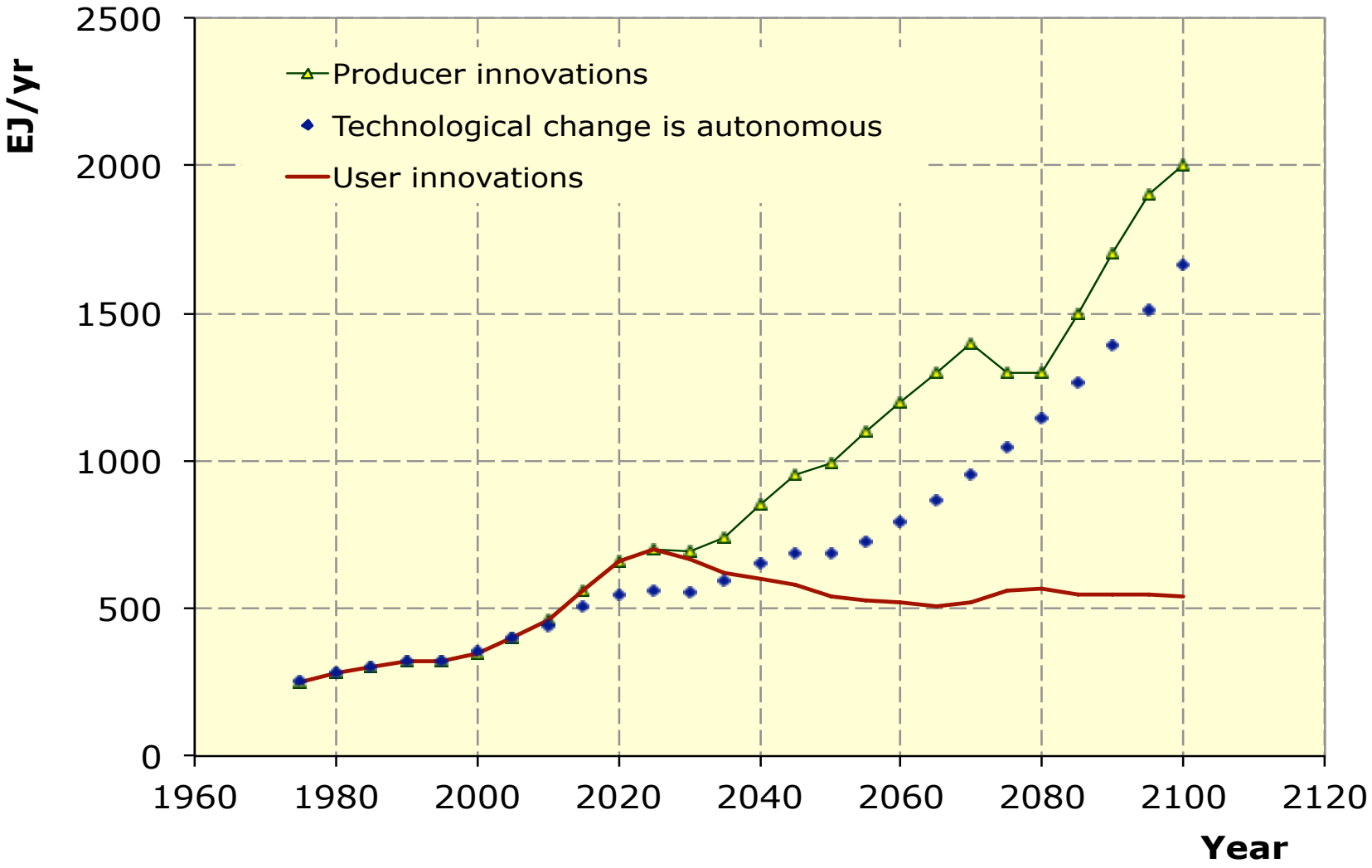





**2015 TPES:** 541 EJ

Figure 9.3.2: Global annual primary energy production and use for six cases constructed by IPCC WGIIa

# Energy trajectories & innovation




Snowmass 1996

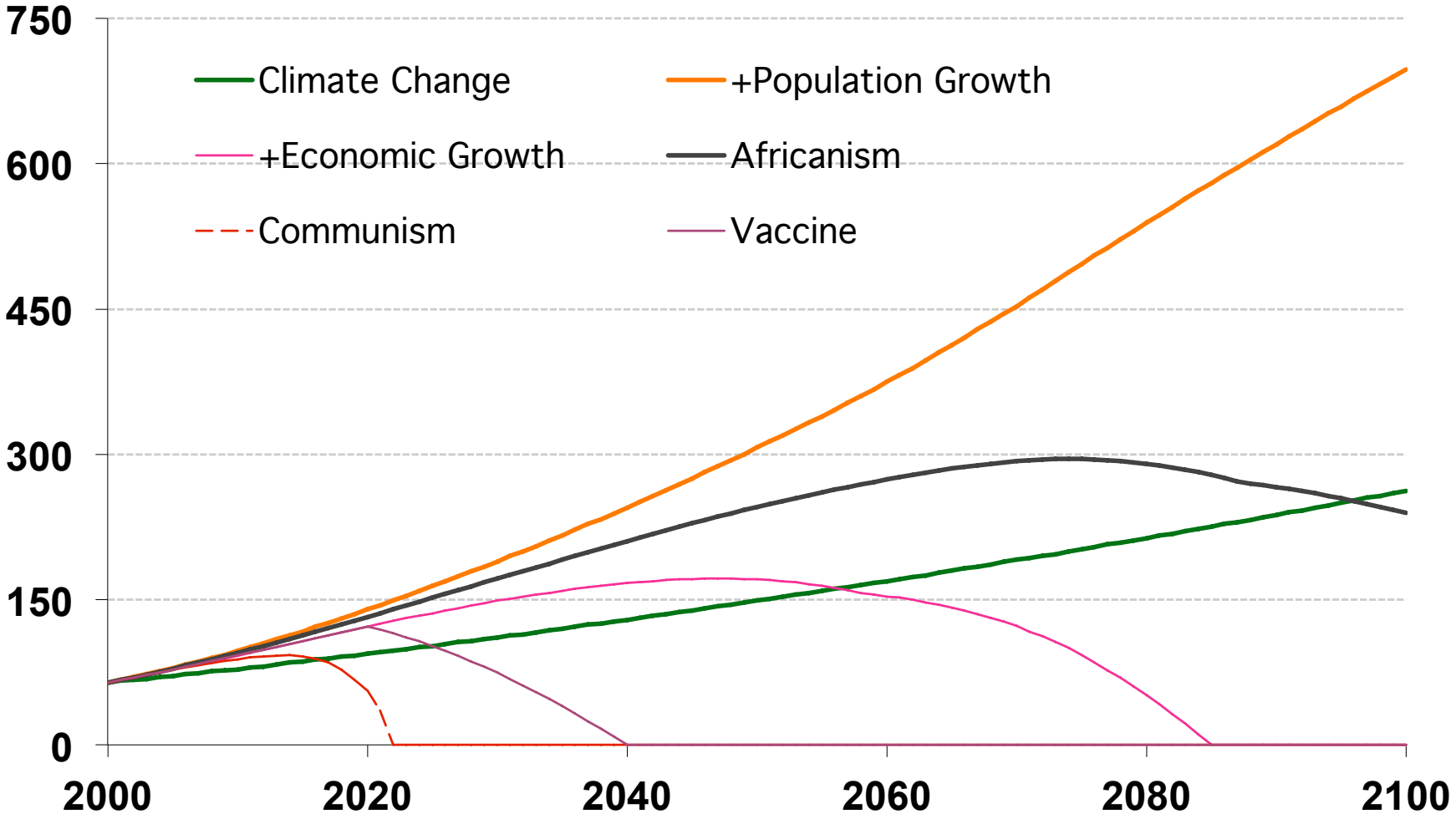
# We never did do an energy expert elicitation but, …

- Energy markets are a far cry from how they are modelled in IAMs.
- EROI matters a great deal in what is supplied when and,
- C-transition requires realistic treatment of:
  - financial flows;
  - where tech is made; &
  - non-economic momentum of transition

# Currency & Impact

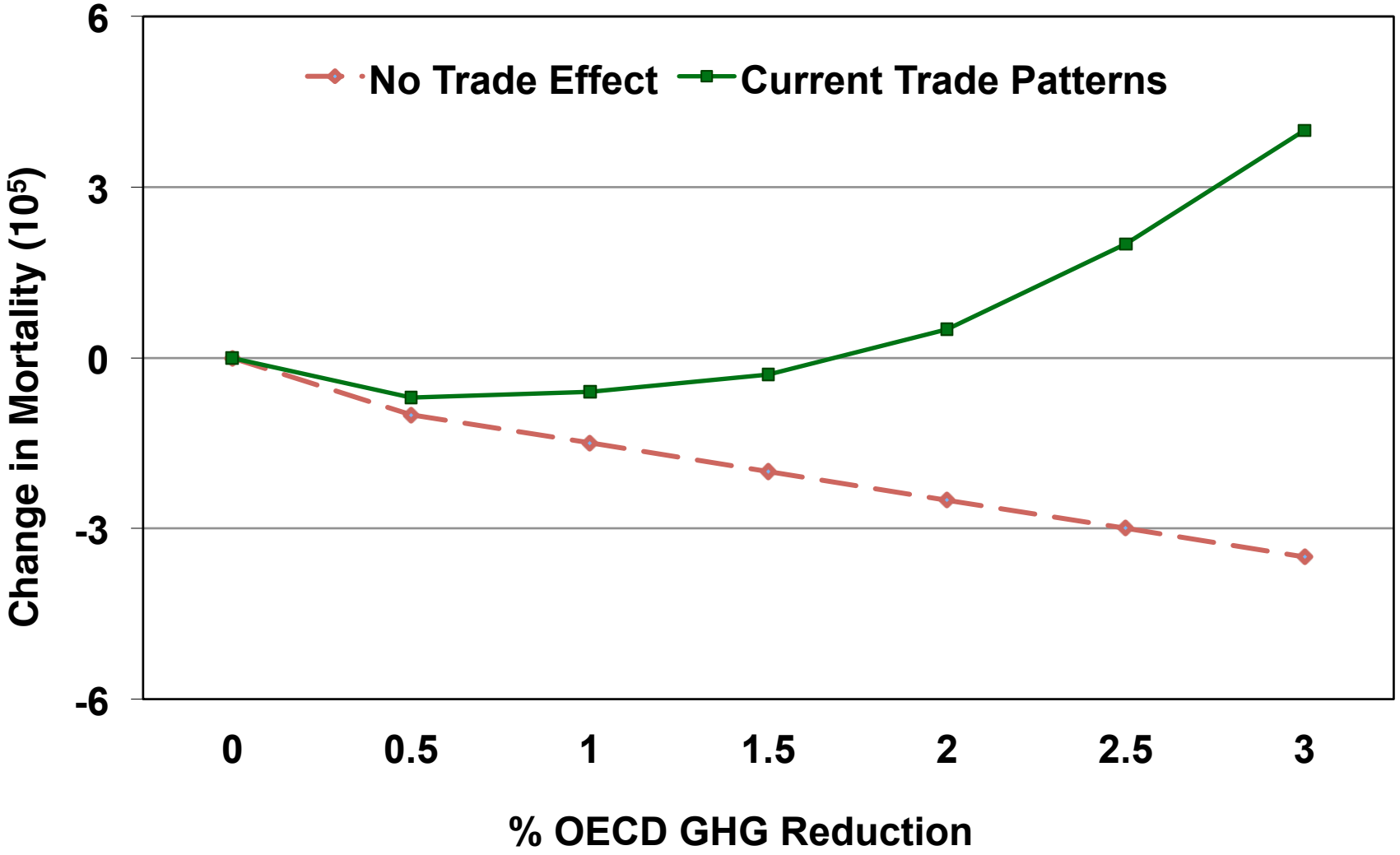
- Modelling approach and focus:
  - We were shunned for including uncertainties.
  - Experts pooh-poohed reduced form models.
  - Inclusion of adaptation did not endear us to ENGOs.
  - Consideration of geo-engineering was a further black mark.
- Having a complex model led to:
  - Few adoptions; and,
  - We learned a great deal, but it was/remains difficult to share insights.

# Revisiting climate change & malaria mortality increases ($10^3$)




Source: Tol & Dowlatabadi (2001)

# Trade & Altruism




Source: Tol & Dowlatabadi (2001)

# Micro-motives, Macro-behaviour?

- The process of detection, attribution, choice and action at the individual level. Possible differences between:
  - Domain experts
  - Informed individuals
  - Less informed individuals
- The processes shaping group actions from the individual components above.
  - Responding to slow secular processes
  - Responding to extreme events
  - Choosing between different priorities (social, economic, environmental)

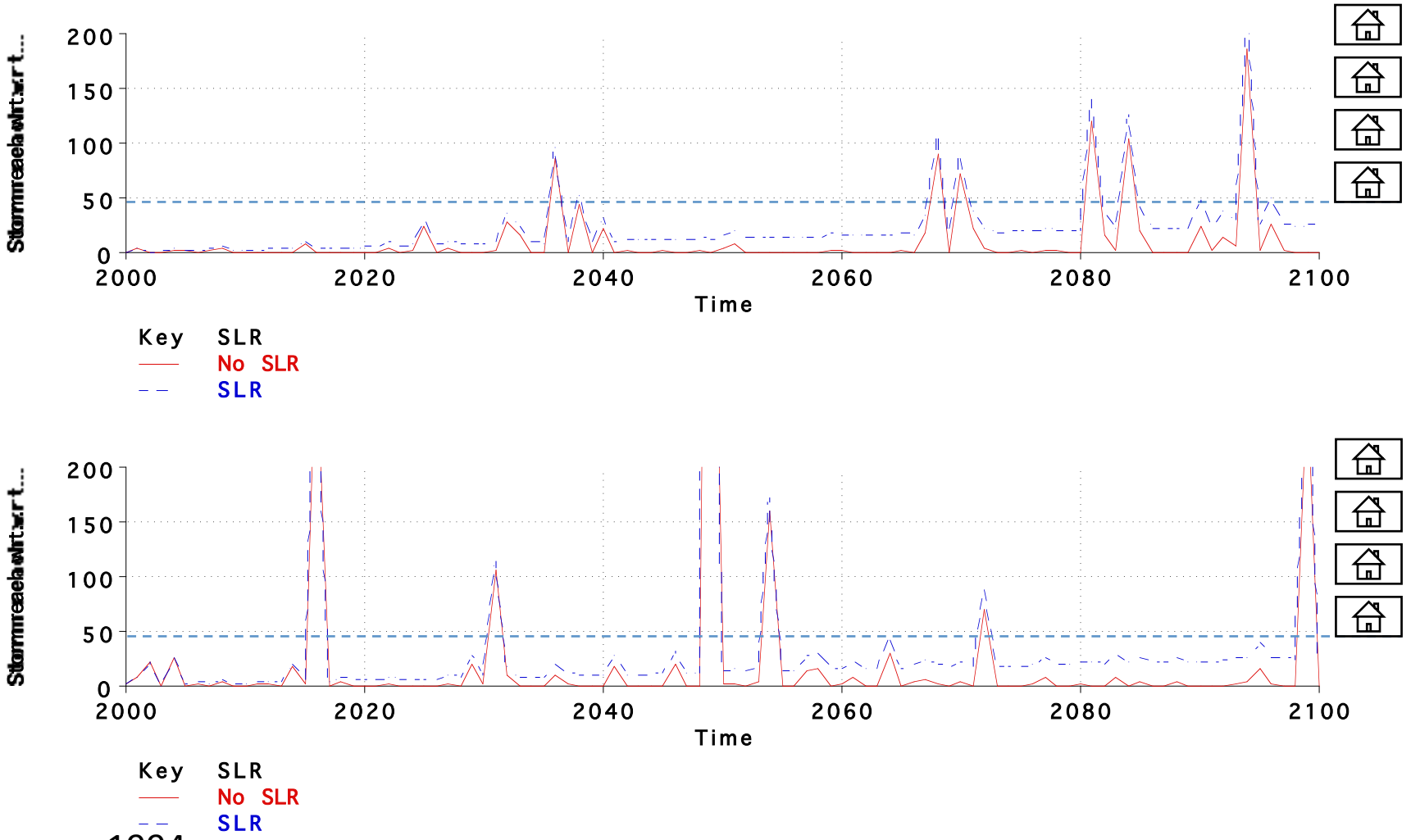
# Understanding demographic change

- Dynamics and drivers of demographic change
  - Urbanization
  - Access to public health services
  - Female participation in formal work force
  - Standard of living
- Implications of demographic change, such as an older population:
  - Social implications of such demographic change (e.g., in terms of technological innovation and diffusion).
  - Implications of longevity in how change is experienced, its impact and willingness to adapt.
  - Implications for intergenerational decision-making.

# Impacts and Adaptation

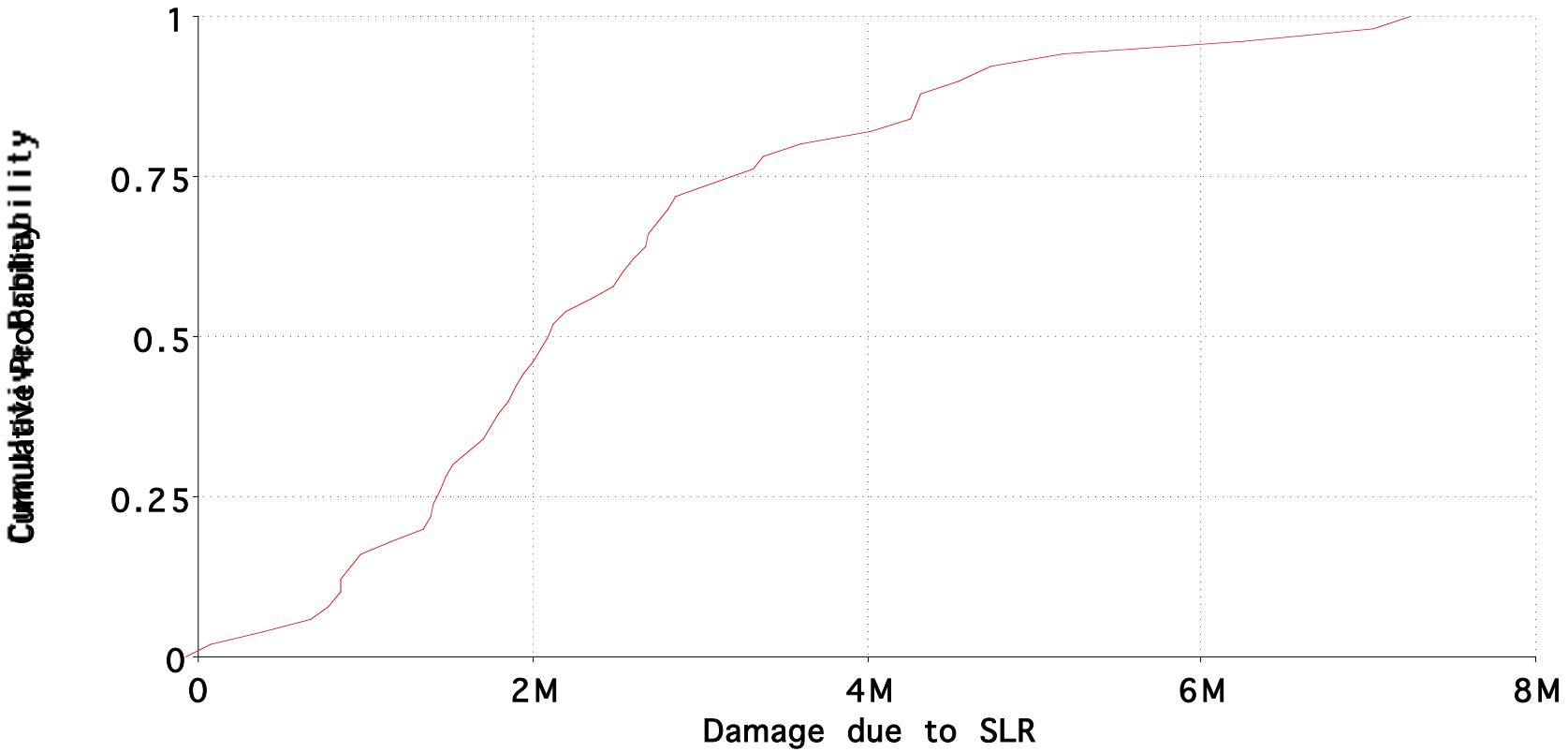
- Impacts and adaptation
  - Responses to secular change.
  - Responses in stochastic environments.
  - The dynamics of adaptation (market or non-market) with poor foresight (or under extreme conditions).
- Implications of our approach to impact assessment:
  - Cognitive aspects of impact perception.
  - Memory and discounting.
  - Adaptation to climate change in a second-best world.

# Storm surges with and without SLR



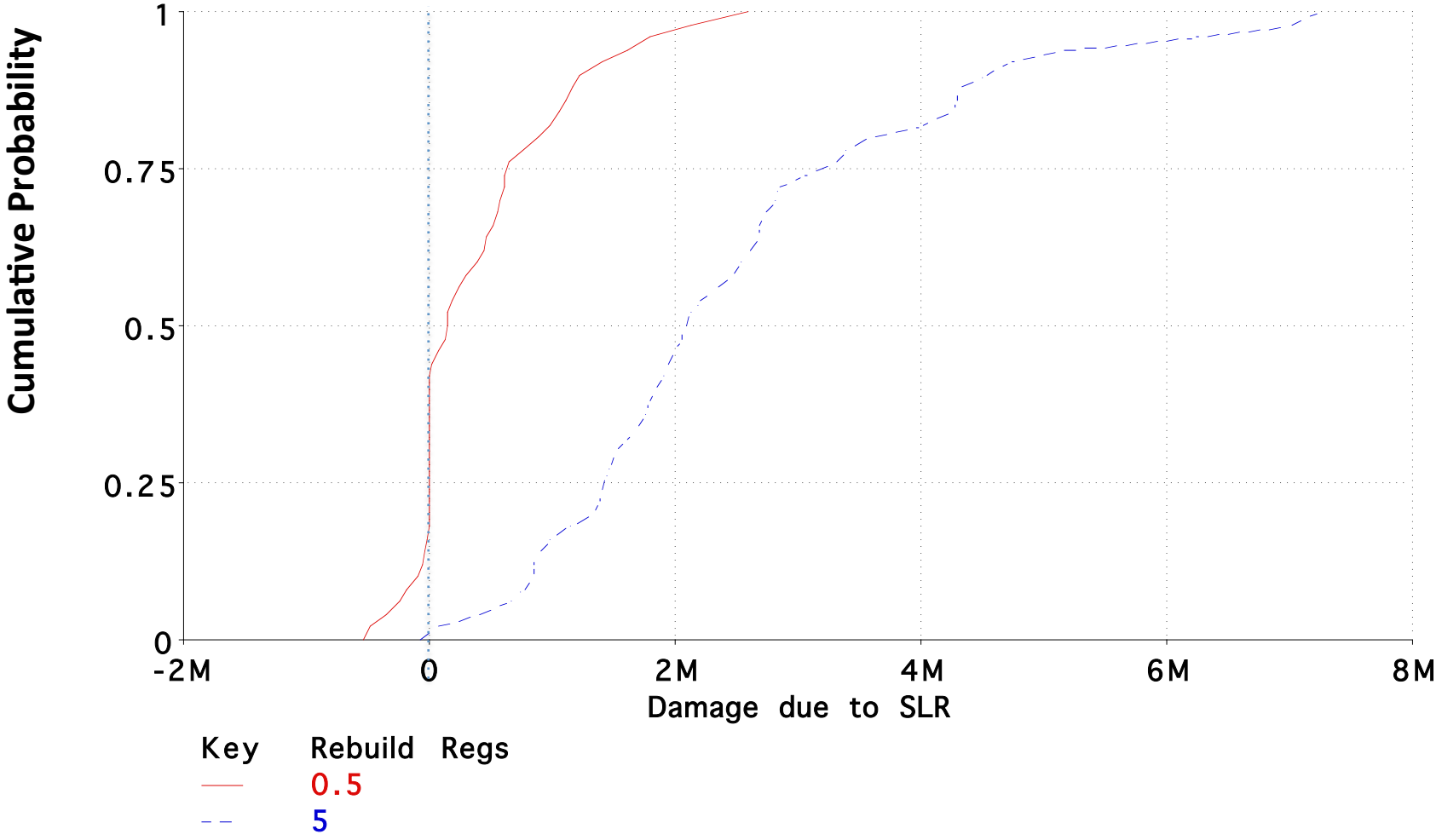

Snowmass 1994

# Damage due to SLR




Snowmass 1994

# Regulations & impacts

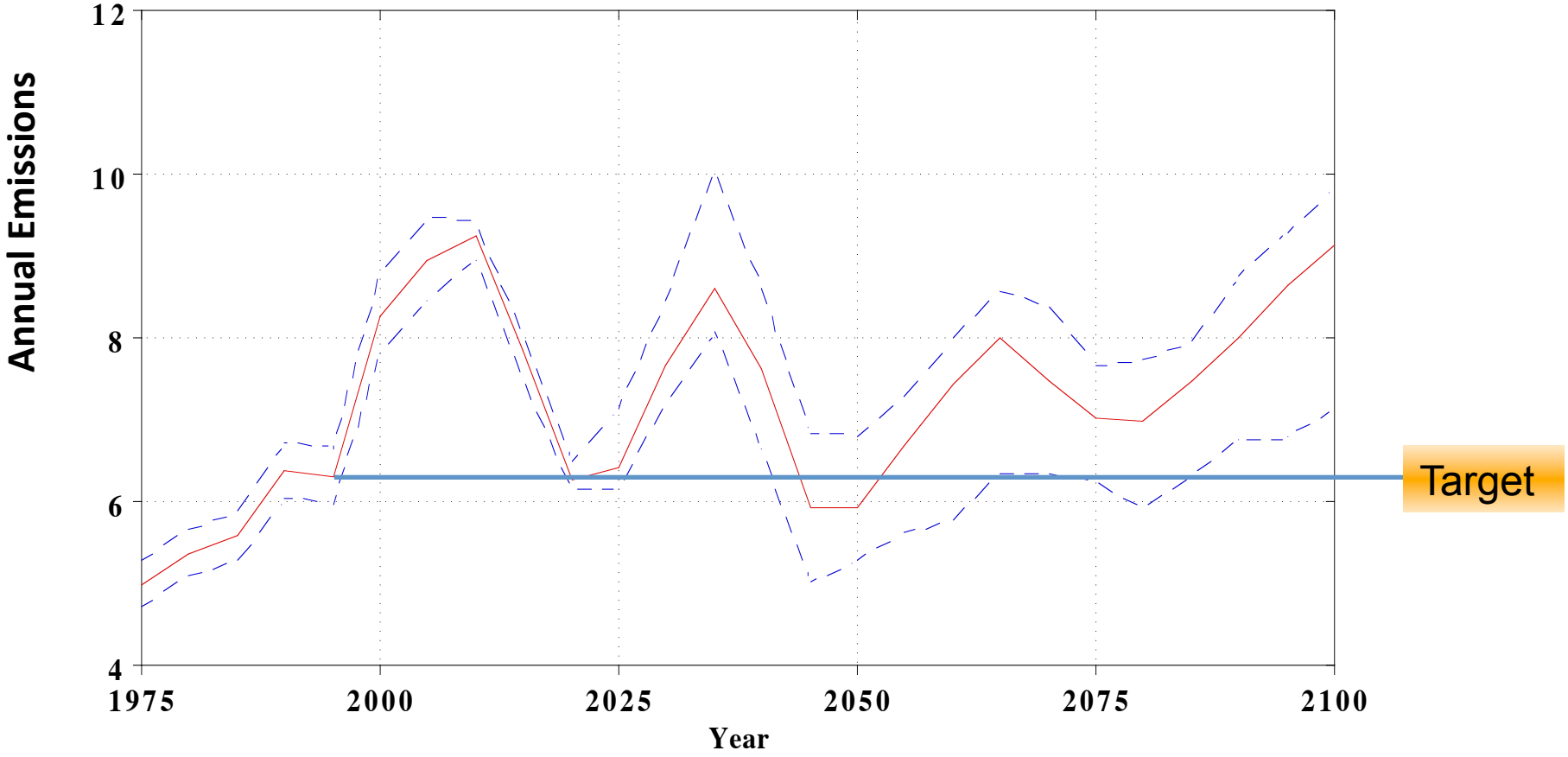



Snowmass 1994

# Intervention

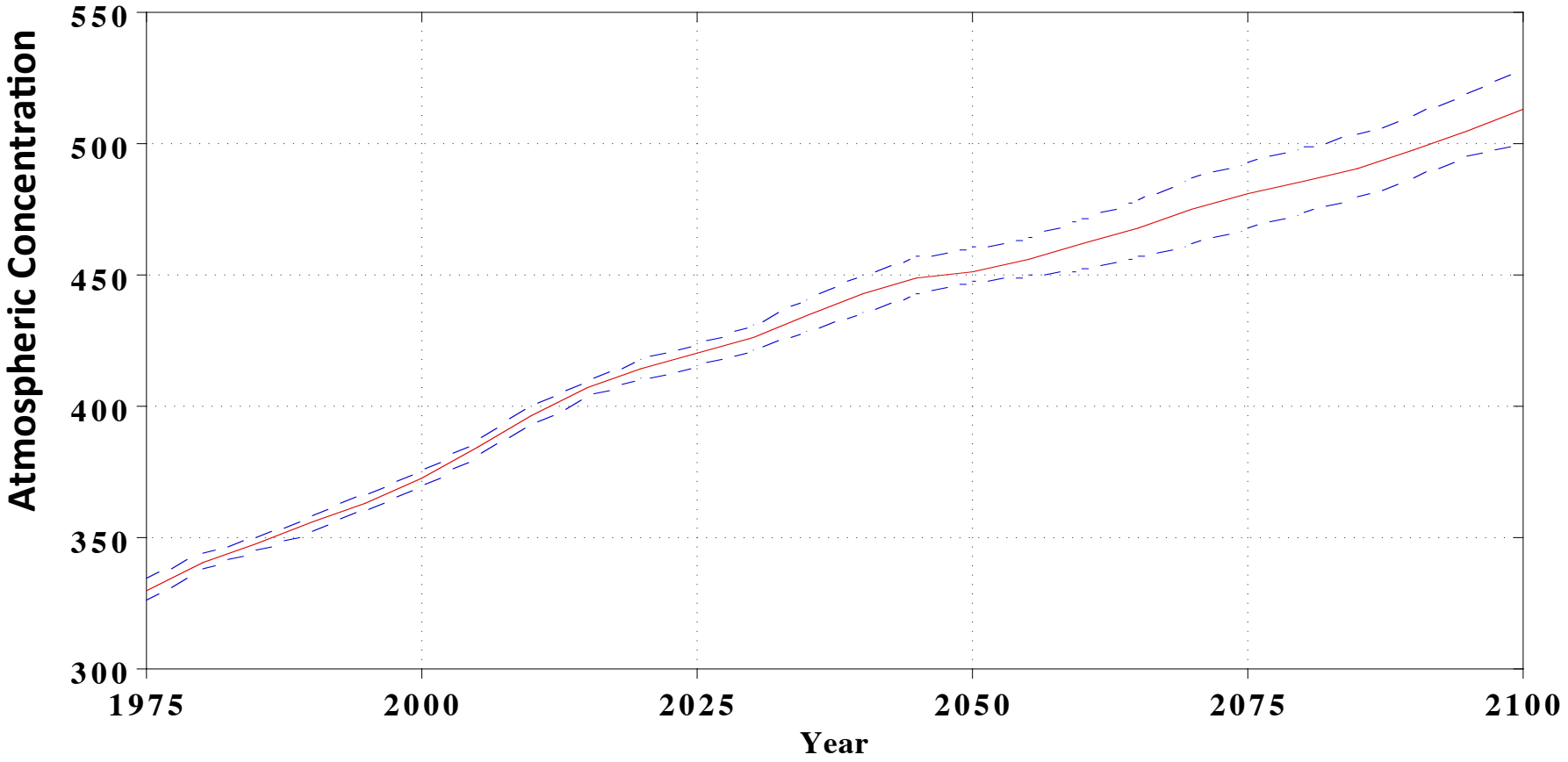
- Issues in representation of intervention:
  - Definition of desirable policy outcomes.
  - Characterization of policy as a goal rather than a constraint.
  - Equity and policy design.
- Implications of our approach to representation of intervention strategies and their dynamics:
  - Exploration of pathologies in various policy designs.
  - Identification of policy designs more suited to the characteristics of human detection and implementation processes.
  - Analysis of the dynamics of long-term change and stability of policies (i.e., impact of evolving knowledge, evolving preferences and public resolve) aimed at addressing such issues.

# How well can agents meet a global $CO_2$ emissions target of 6.4 GT?




Snowmass 1997

# What will be the path of $CO_2$ concentration?




Snowmass 1997

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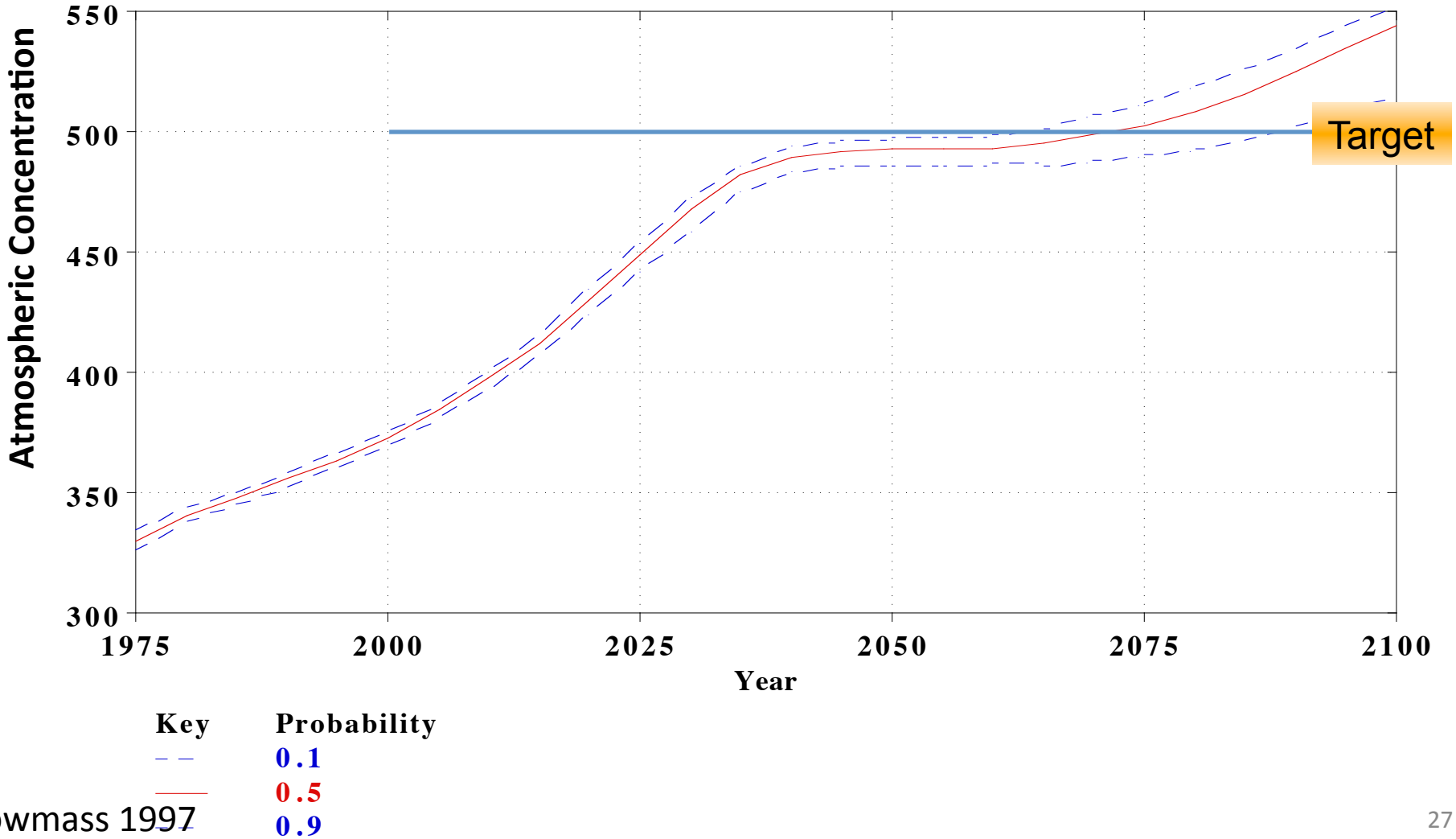
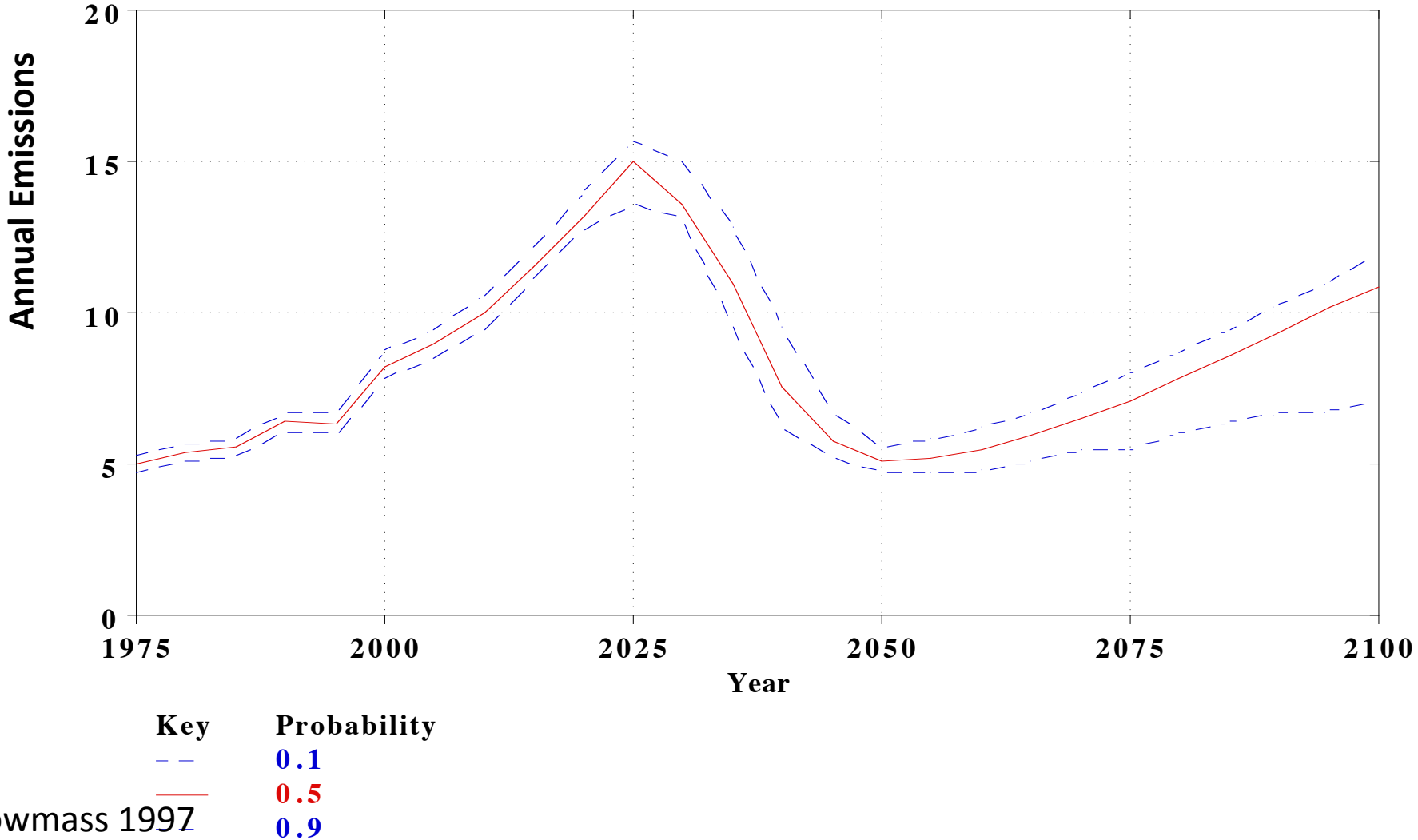


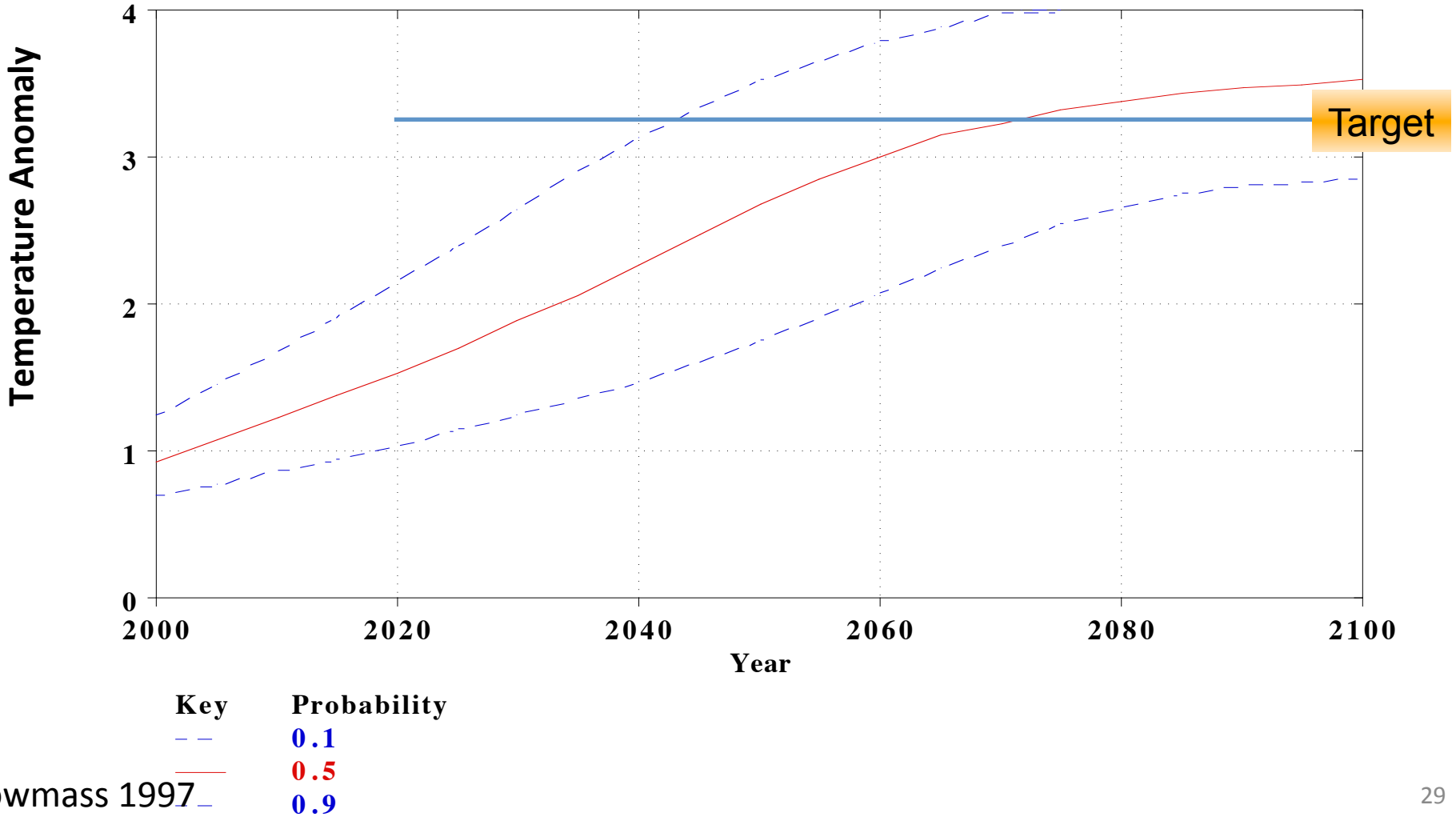

Snowmass 1997

# What is their emissions path to the $CO_2$ concentration target?



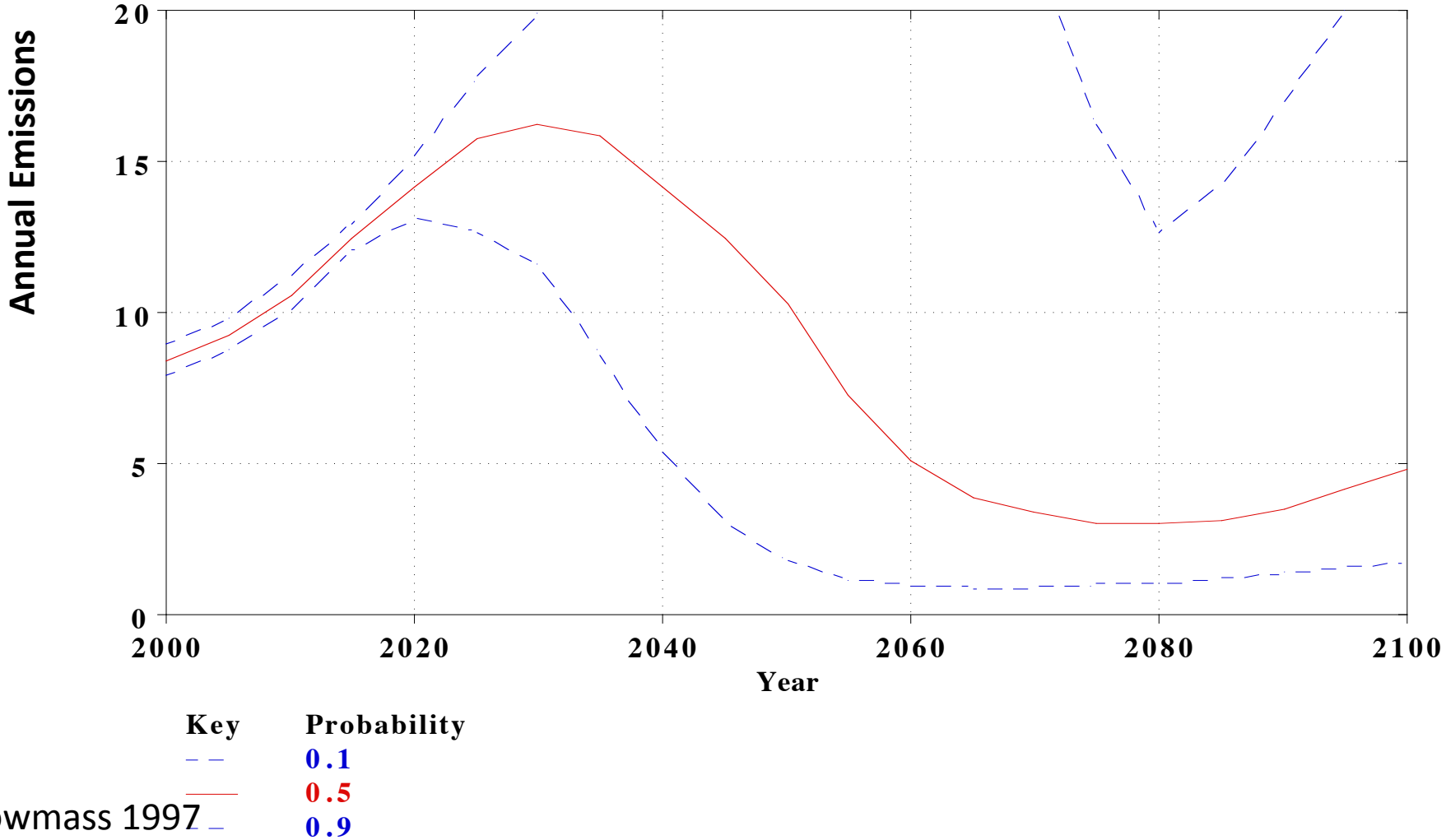

Snowmass 1997

# How well can agents meet a global ΔT target?




Snowmass 1997

# What is their emissions path to the ΔT target?




Snowmass 1997

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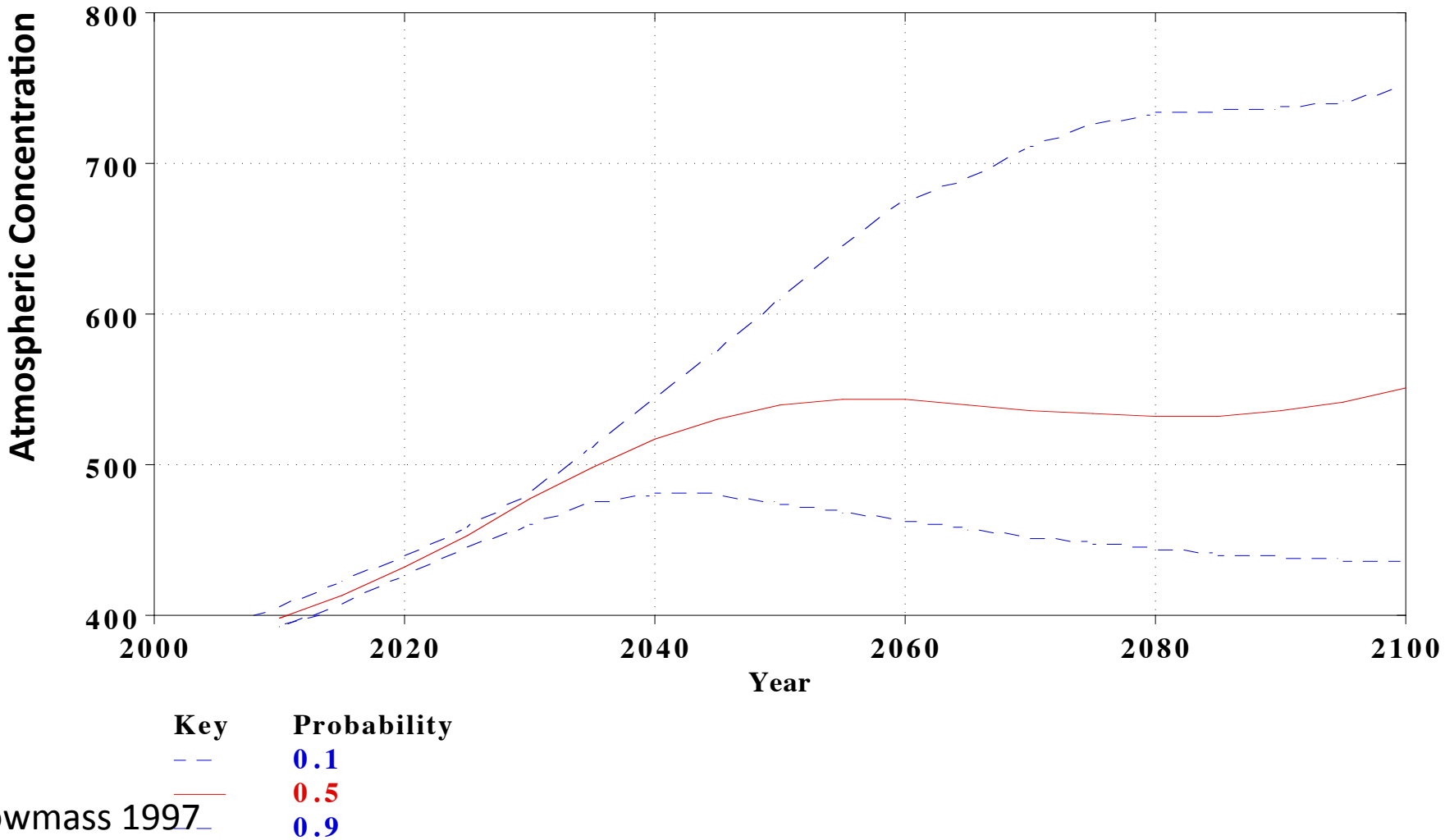


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# Summary of findings 2000 to 2050

| | TARGET INDICATOR | | |
|---|---|---|---|
| | **Emissions** | **Concentration** | **Temperature** |
| Target met? | ±50% | ±5% | ±50% |
| Control Path | volatile & tight | smooth & tight | smooth & dispersed |

- Meeting the target with high confidence is good.
- Tight control paths are good. They suggest that despite irreducible uncertainties, the control path is well delineated.
- Smooth control paths are good. Volatility in signaling is socio-economically inefficient and politically undesirable.

# Summary

- We learned a few things
- Not sure if we succeeded in persuading other IAM developers of the value of the work
- So, for the past 15 years we have been trying to understand and help decision-makers at the ground level.
- Hopefully the insights from this work will be useful both on the ground and to the IAM community.

# Acknowledgements

For the opportunity :

John and Snowmass Crew

For Inspiration:

All thought provoking researchers

For funding:

National Science Foundation

ERPI

DOE

CMU

Our presentations & a few papers can be found at:

https://www.dropbox.com/sh/9skgog59wdd3m4x/AAAQzsPhamXaRmGOIOhyz7Dpa?dl=0

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