

Possible global warming futures

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SRES: Forecasts or scenarios?

+5.5° C in 2100: are IPCC scenarios forecasts?

- No, we can't have probabilities
- Yes, they are not all equally likely

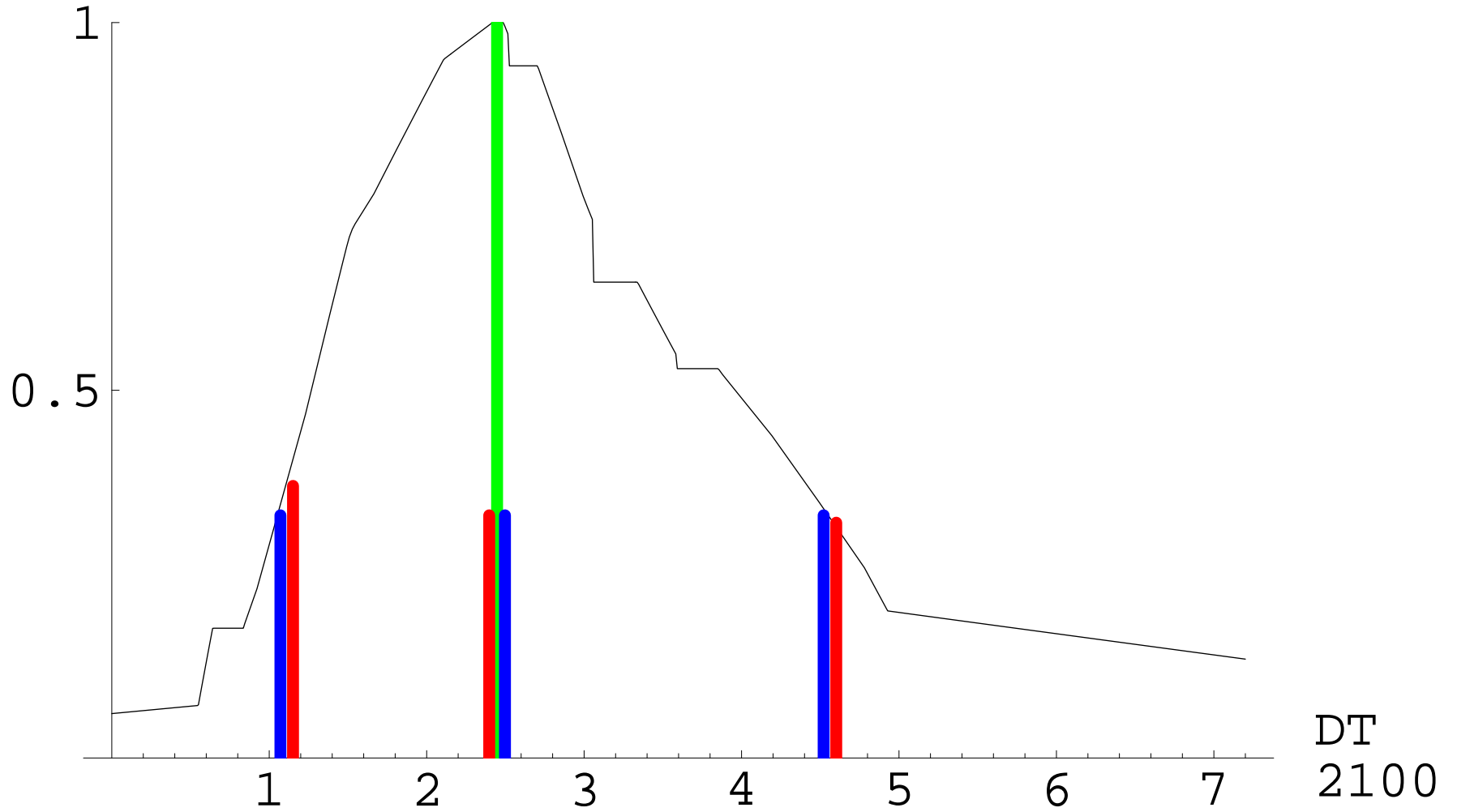
Resolve the controversy using imprecise probabilities,
a more general information theory...

Outline

- Possibility as imprecise probabilities
- Assessing the possibility of global warming
- Communicating information about distant futures

Global warming in 2100

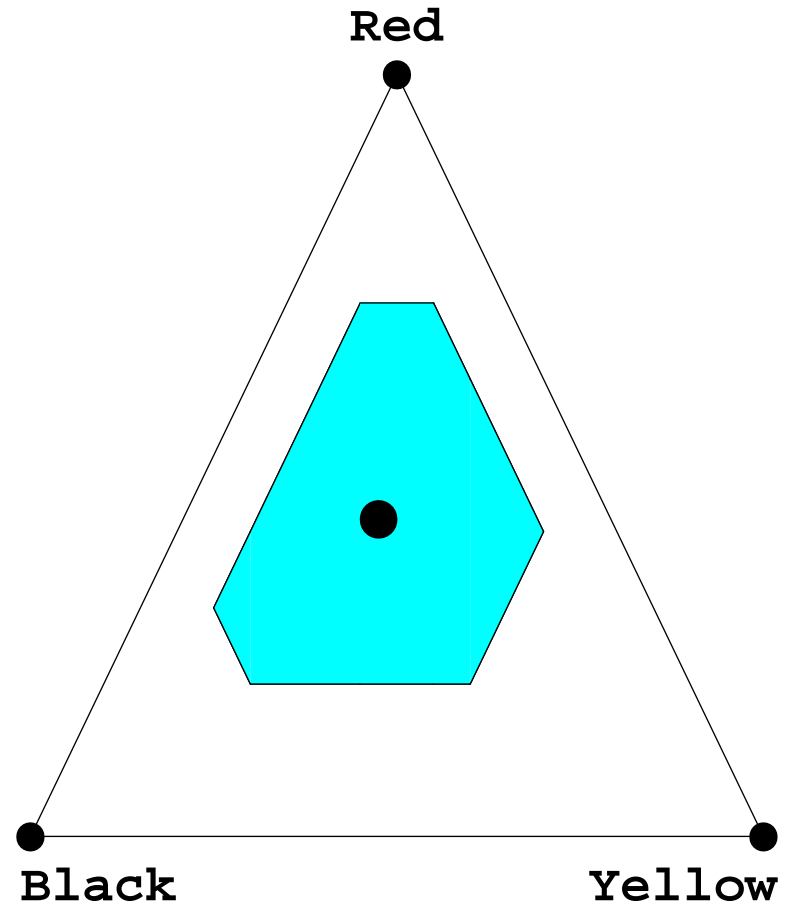
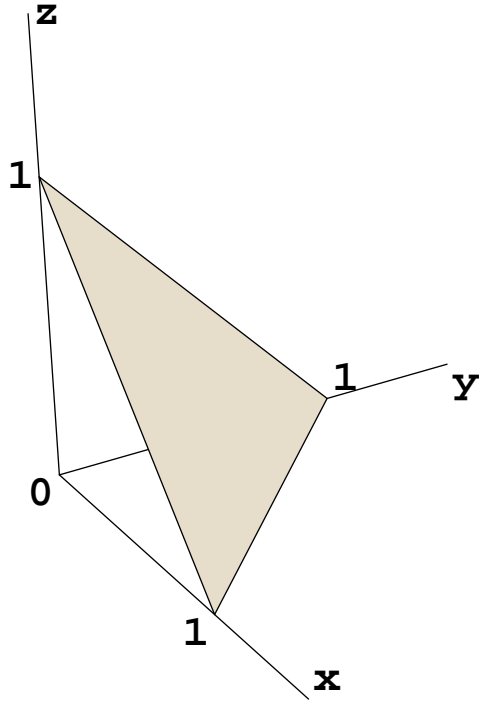
Possibility



1. Imprecise probabilities

Using a set of probabilities \mathcal{C}

Example with 3 alternative states of the world.



Rationality with imprecise probabilities

\mathcal{C} is called the **credal** set, it represent beliefs.

How to act? Rationally and precaution:

Rationality with imprecise probabilities

\mathcal{C} is called the **credal** set, it represent beliefs.

Accept the gamble A if and only if

the expected value of A is positive for all probabilities $p \in \mathcal{C}$

This criteria avoids sure loss (no arbitrage), but...

The precautionary order is incomplete

Policy A is preferred to B iff

A 's expected net benefit is greater than B 's
for all $p \in \mathcal{C}$

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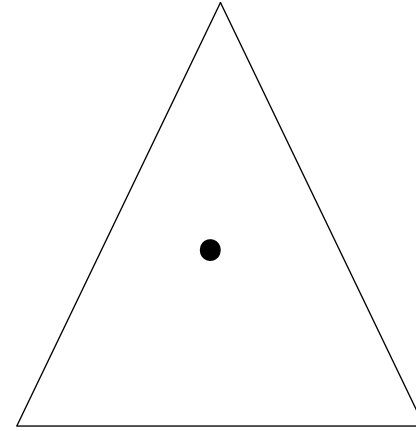
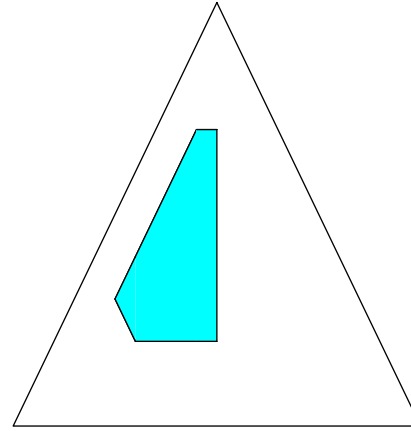
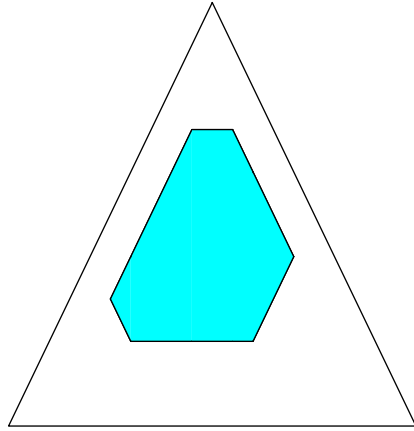
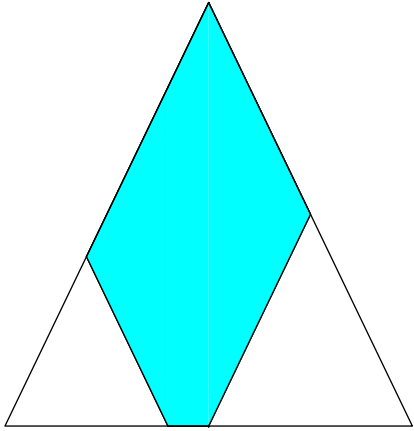
A 's expected net benefit is greater than B 's
for all $p \in \mathcal{C}$

Application to possible futures:

A is more probable than B if and only if

for all $p \in \mathcal{C}$, $p(A) > p(B)$

More information, smaller credal set



Possibility as imprecise probabilities

A nonnegative function $\pi(x)$ defined for $x \in \Omega$ is called a possibility distribution if its maximum is 1.

$$\Pi(E) = \max_{x \in E} \pi(x) \quad \text{for any } E \subset \Omega$$

The credal set consists of all probabilities p such that:

$$p(E) \leq \Pi(E)$$

Interpretation

cf. Zadeh (1978) and Shackle (1954) degree of surprise

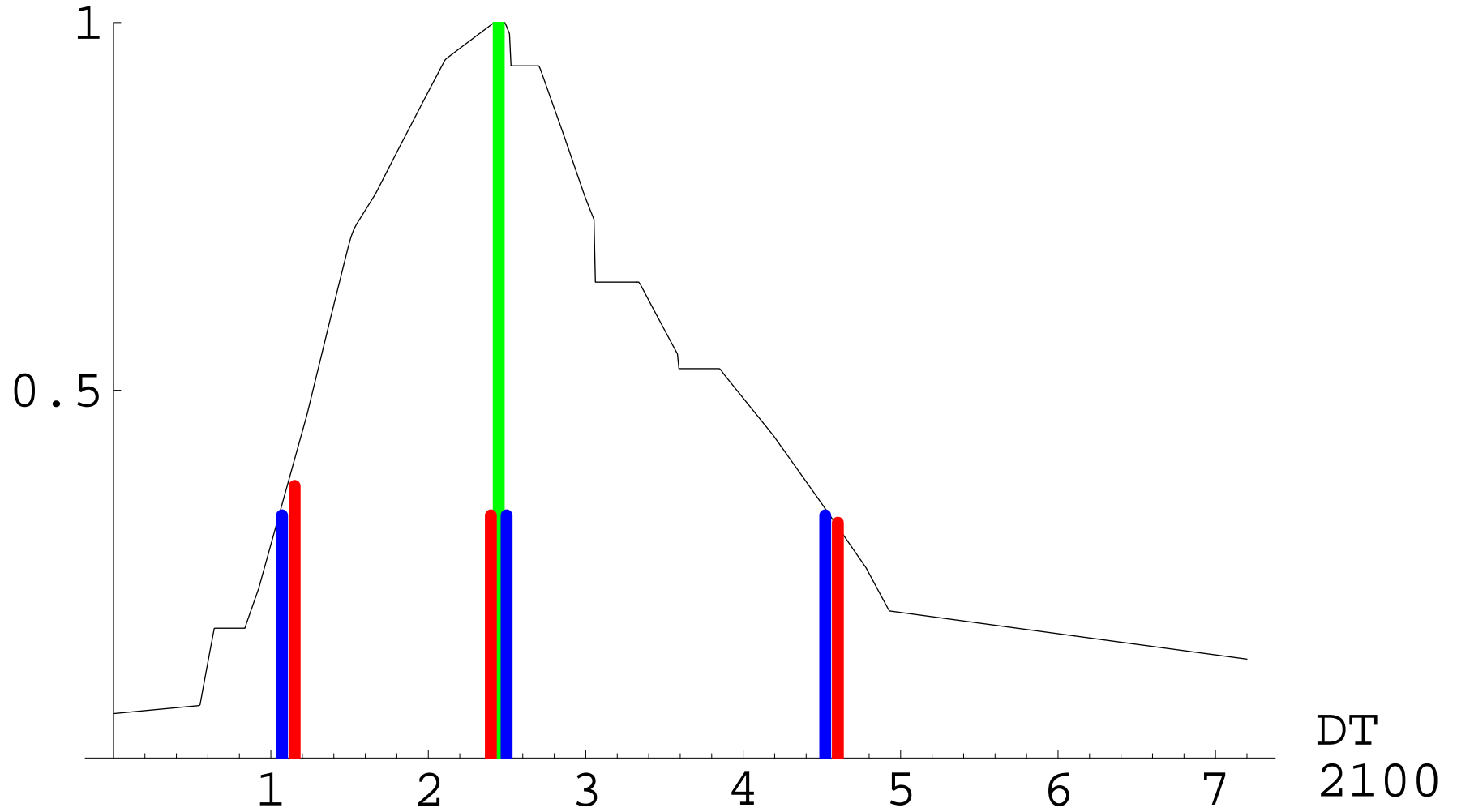
Possibility 1 corresponds to the **least surprising** outcome.

$$\pi(A \text{ or } B) = \max(\pi(A), \pi(B))$$

$$\pi(A \text{ and } B) = \min(\pi(A), \pi(B))$$

3 probabilities in a credal set

Possibility



DT
2100

2. The possibility of global warming

Assessing global warming futures

Rationally subjective, based on published literature.

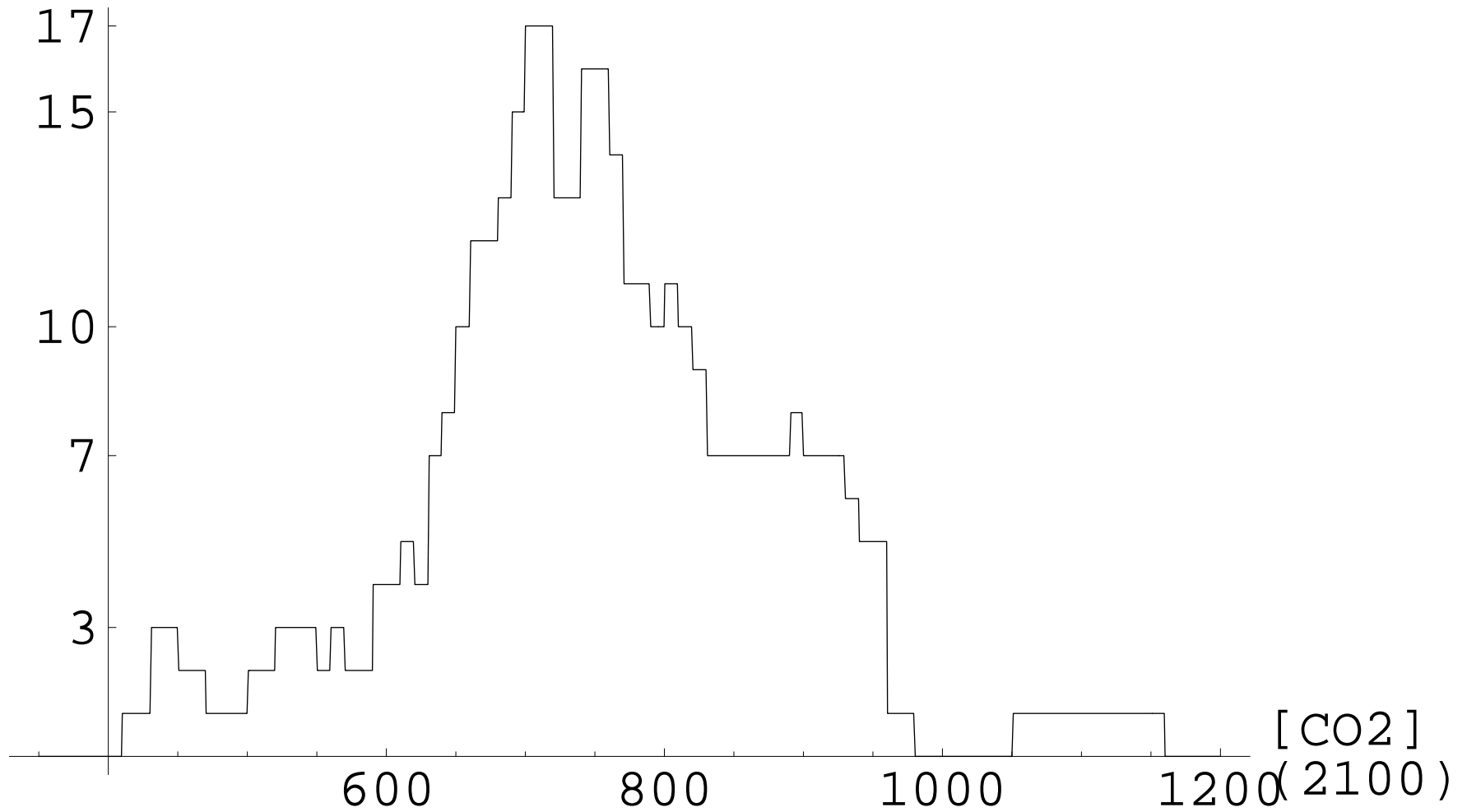
Warming 2100 = CO₂ concentration × $\frac{1}{3}$ climate sensitivity

Summarizing model results on [CO₂]

- M : Atmospheric carbon dioxide concentration in 2100
- Source: All 56 'no-intervention' records in Morita's SRES database
- The possibility of M is proportional to the number of models predicting concentration 5% close to M

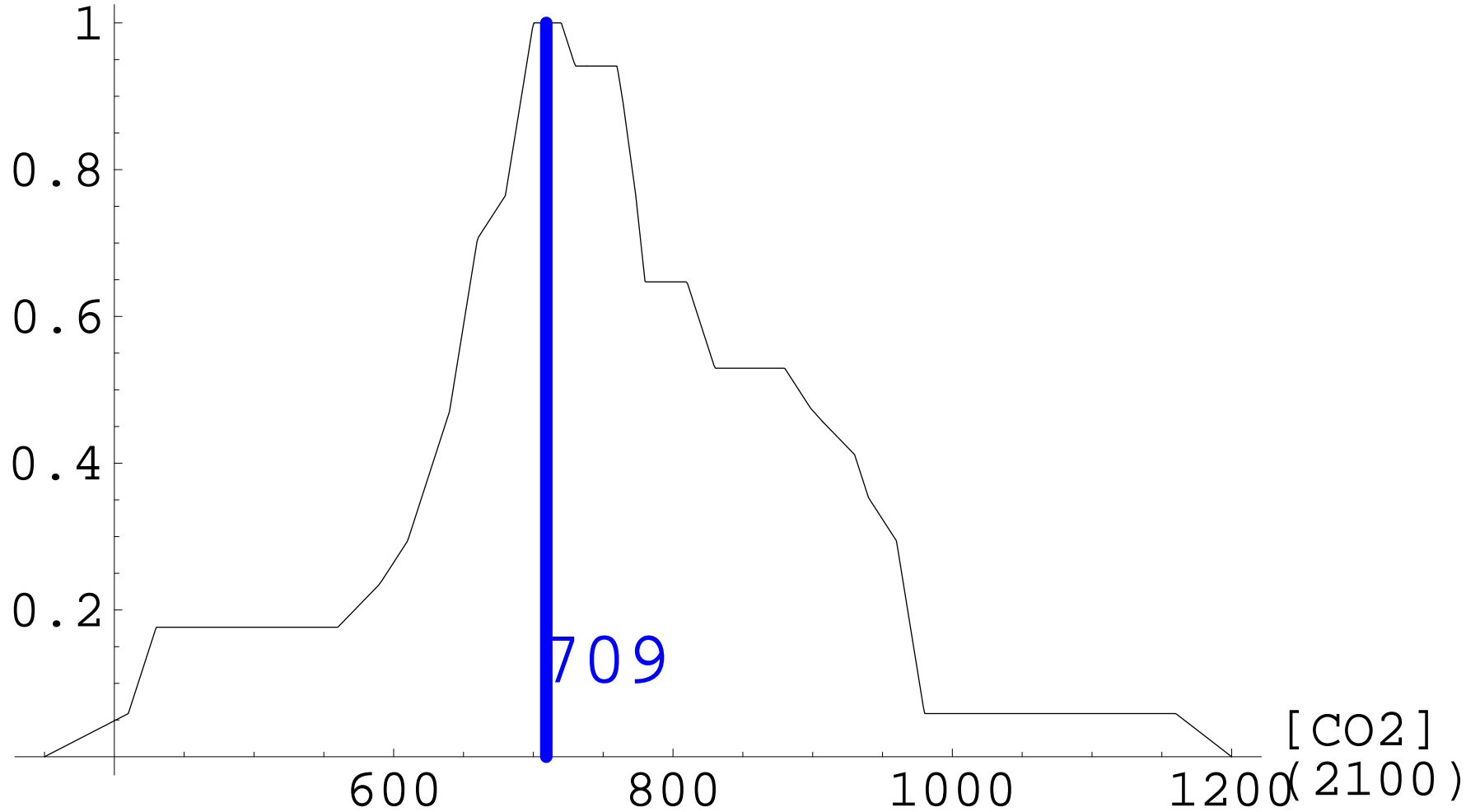
Histogram of available results

Number of
model runs



Possibility of CO₂ concentration in 2100

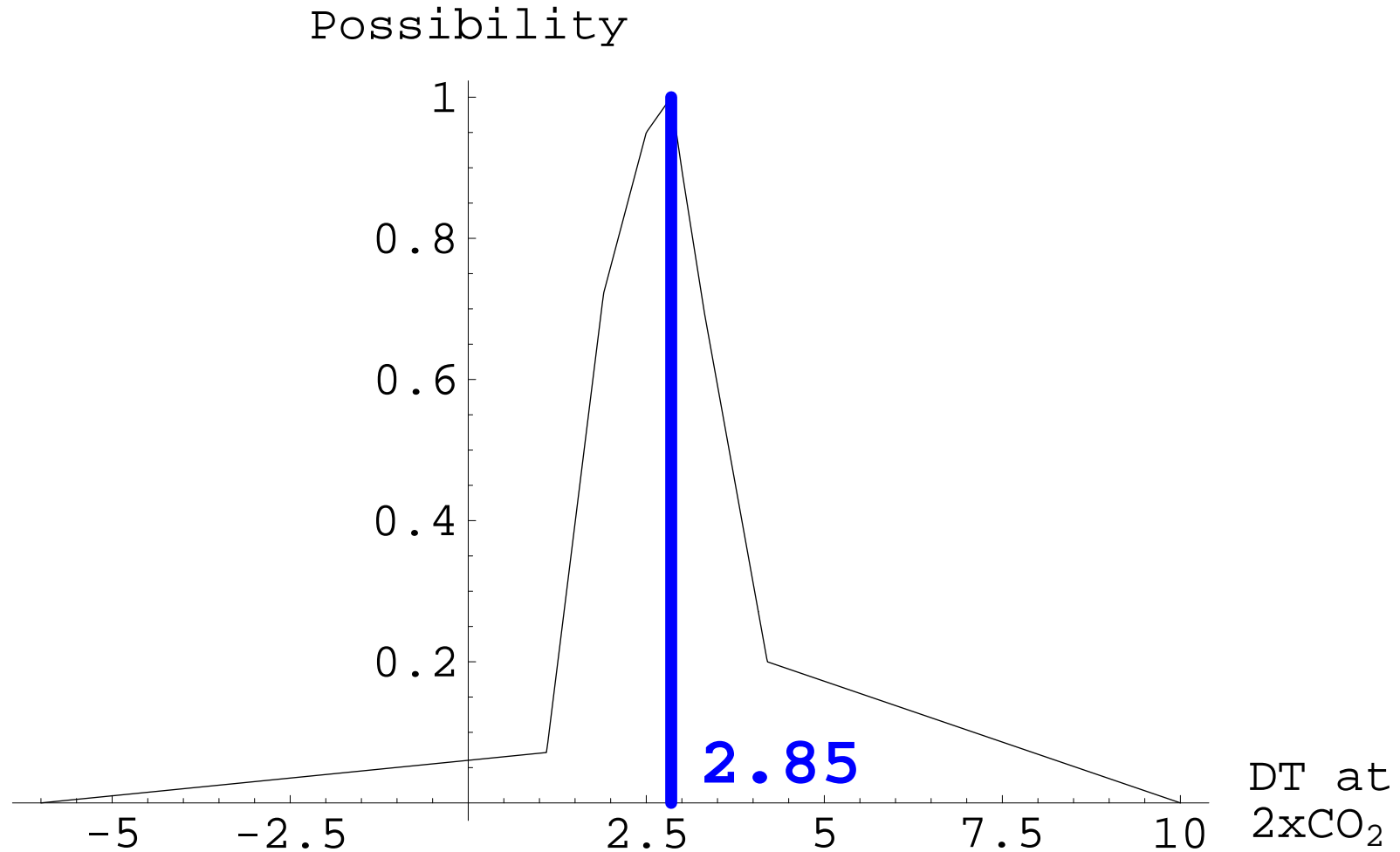
Possibility



Experts judgment on climate sensitivity

- $\Delta T(2 \times \text{CO}_2)$: Equilibrium global warming for a doubling of pre-industrial CO_2 concentration
 - 16 experts elicitation survey by Keith-Morgan
1. Transform elicited probabilities into possibility
 2. Discount experts pretending to know better (standard deviation lower than peer average/2).
 3. Fusion without the independence assumption (hyper-cautious conjunction)

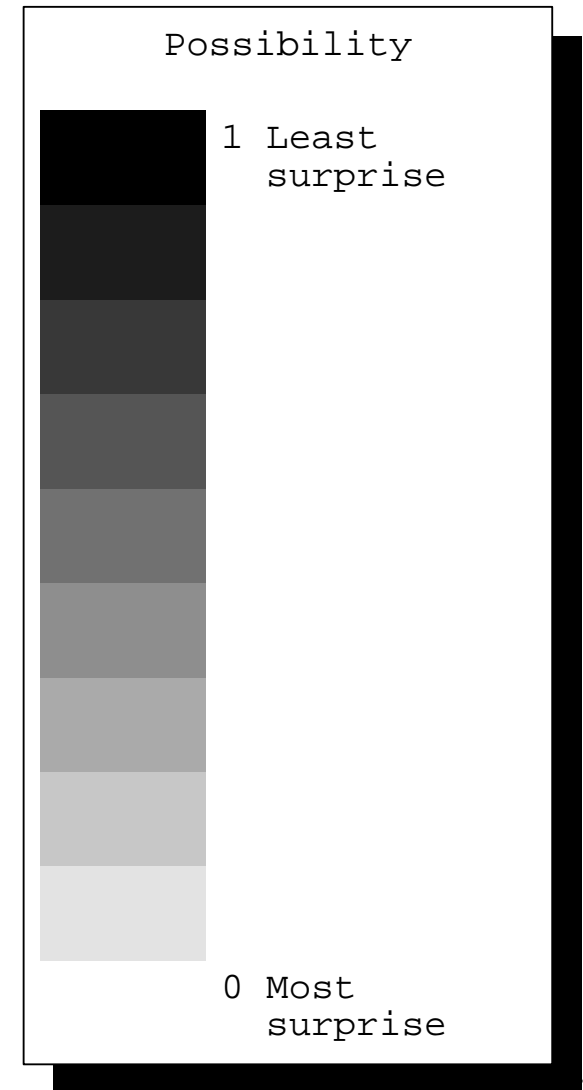
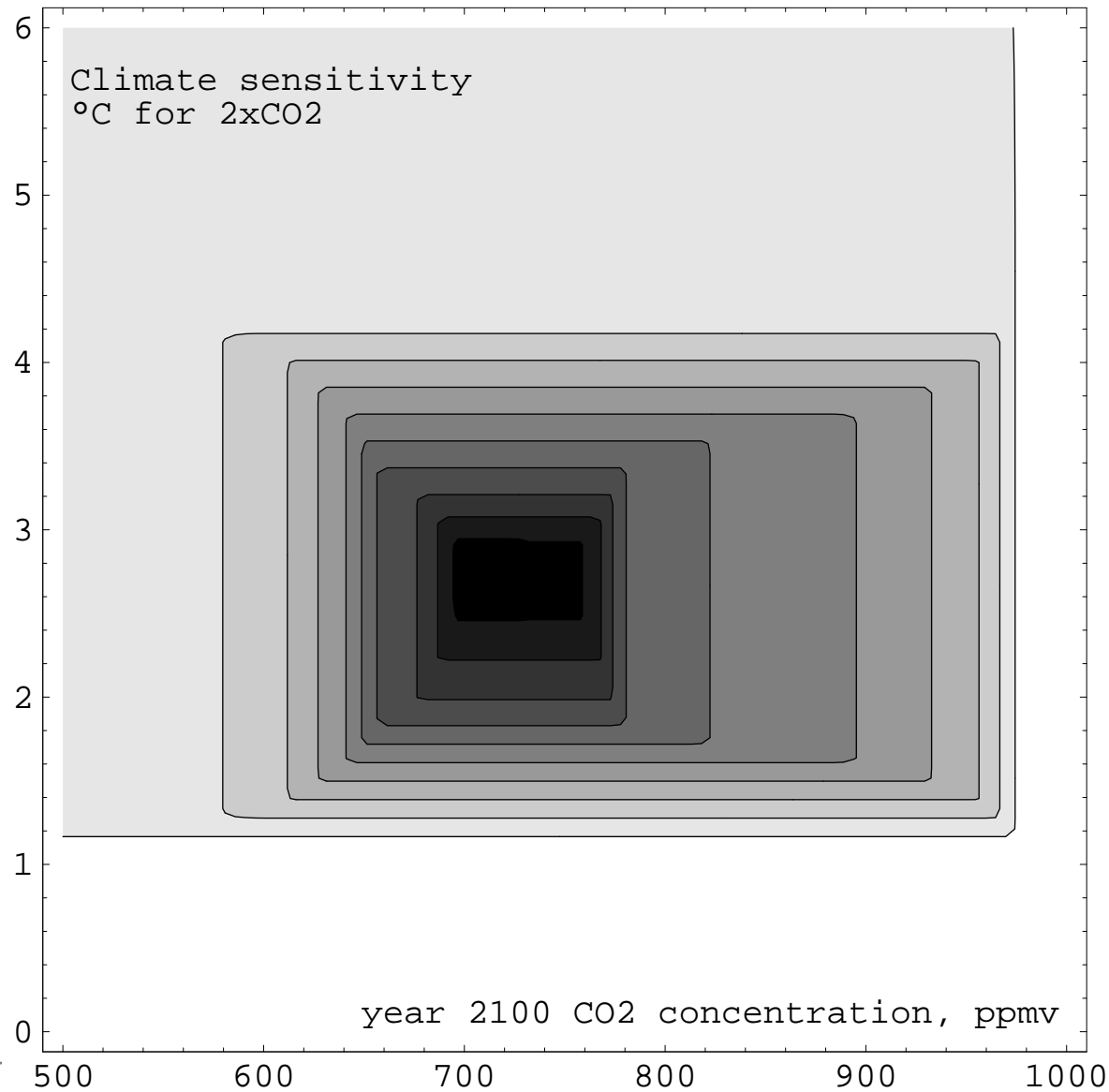
Subjective assessment of $\Delta T(2\times\text{CO}_2)$



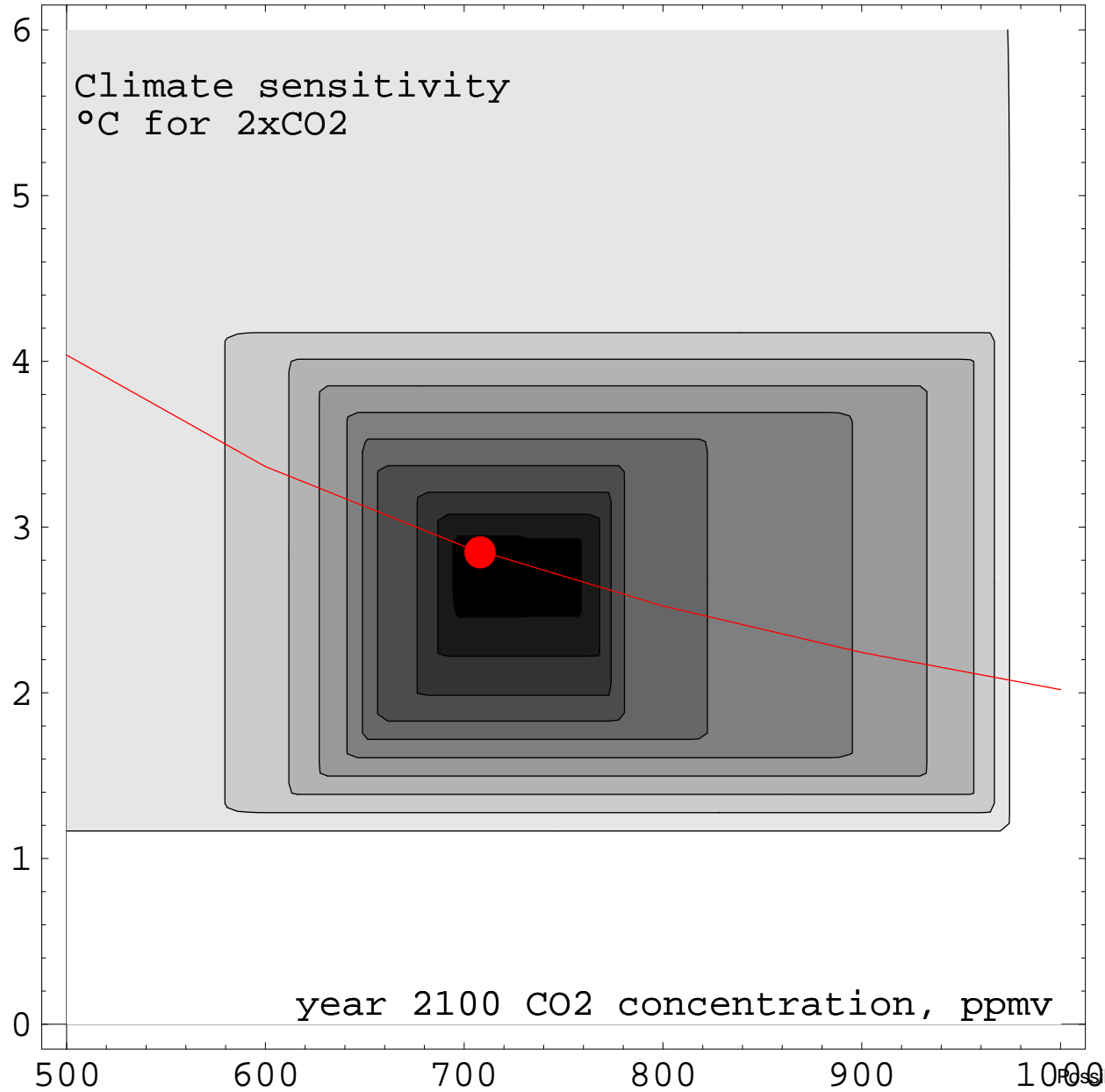
\mathcal{C} is the joint possibility distribution.

Assuming no interaction, the possibility of a future is the minimum of the possibility of each of its components.

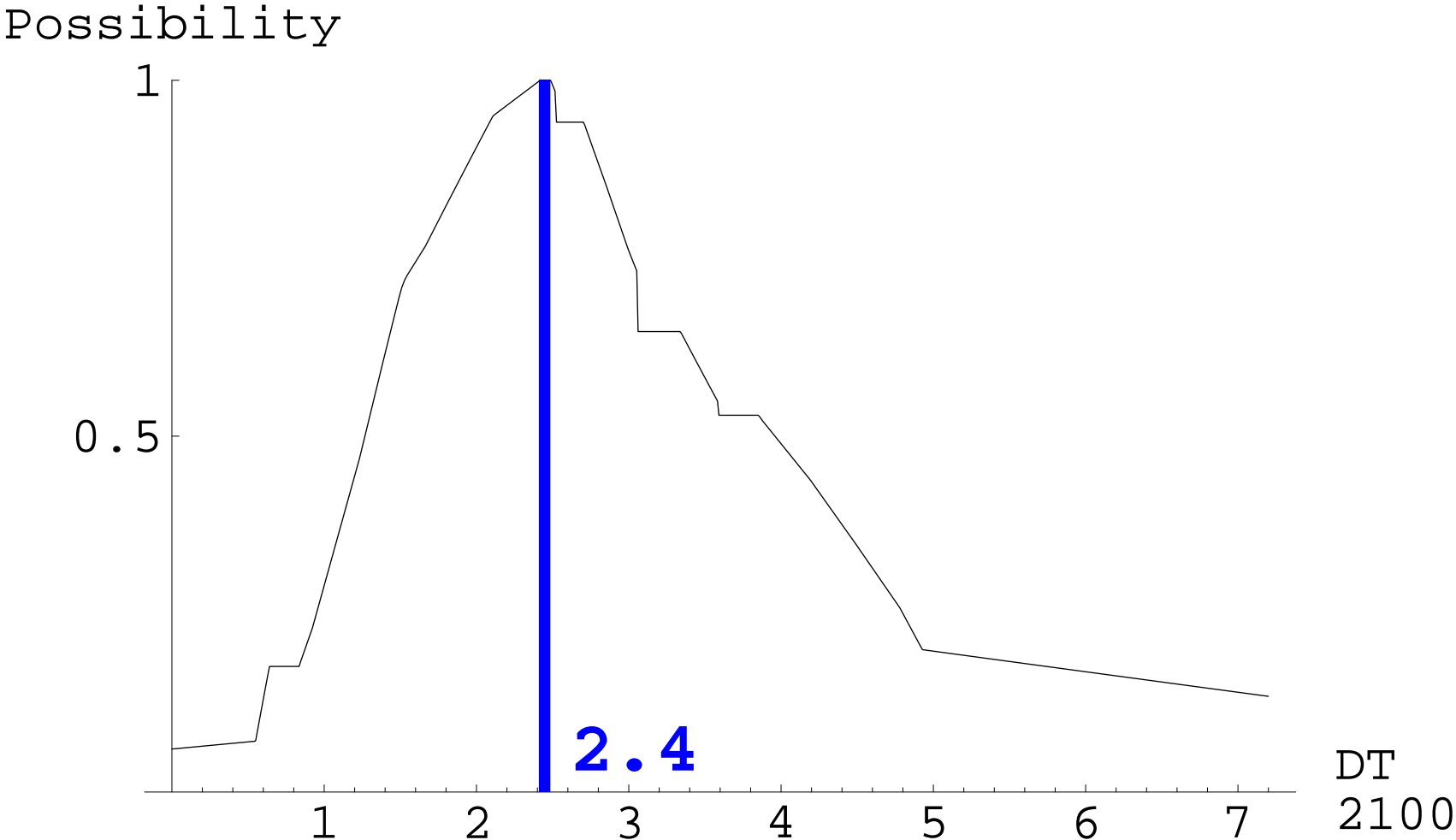
The joint possibility distribution



The possibility of 2.4° C warming



Global warming 2100 possibility



3. Communicating information about distant futures

The problematic gap

A recurring dilemma of **Futures** research:

- **Forecasts** with probabilities
- **Scenarios** without any quantitative likelihood

Proposition: **Possible futures** with possibilities.

Example: Intergovernmental Panel on Climate Change emissions scenarios.

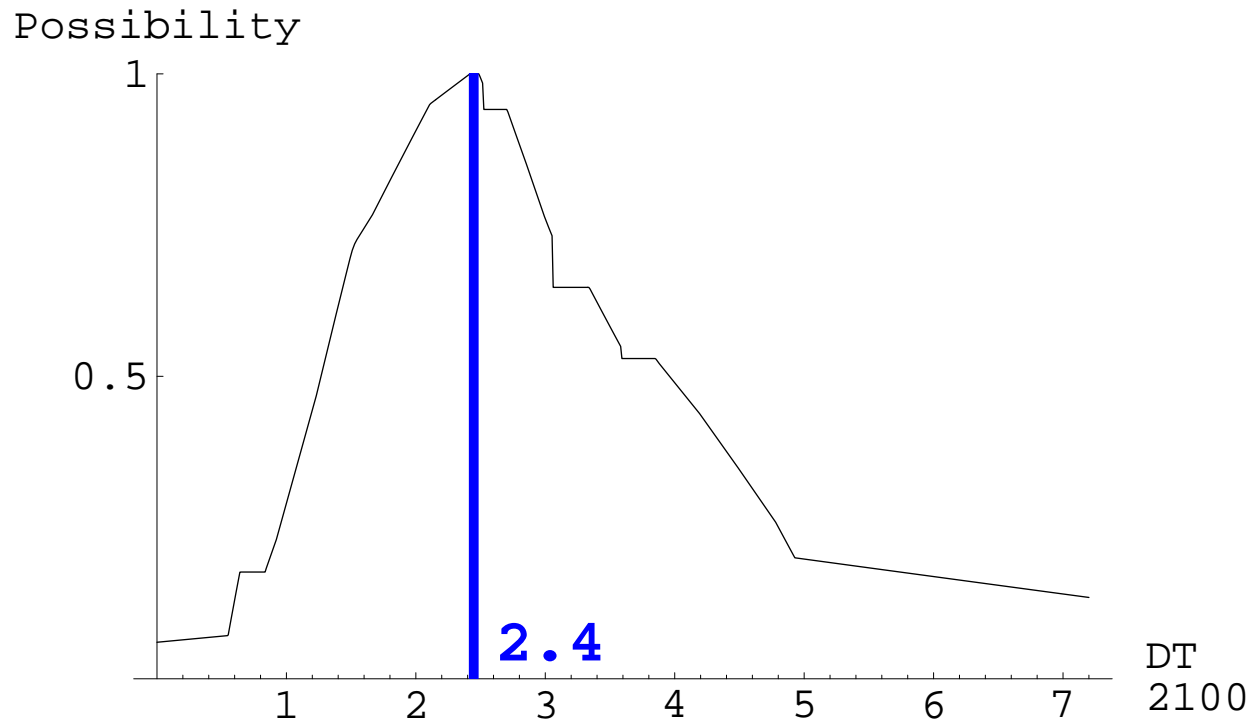
Sampling futures not arbitrarily

We know a joint possibility distribution
on CO₂ concentration and climate sensitivity.

We want to describe 3 possible futures (with their π)
that represent **well** our information

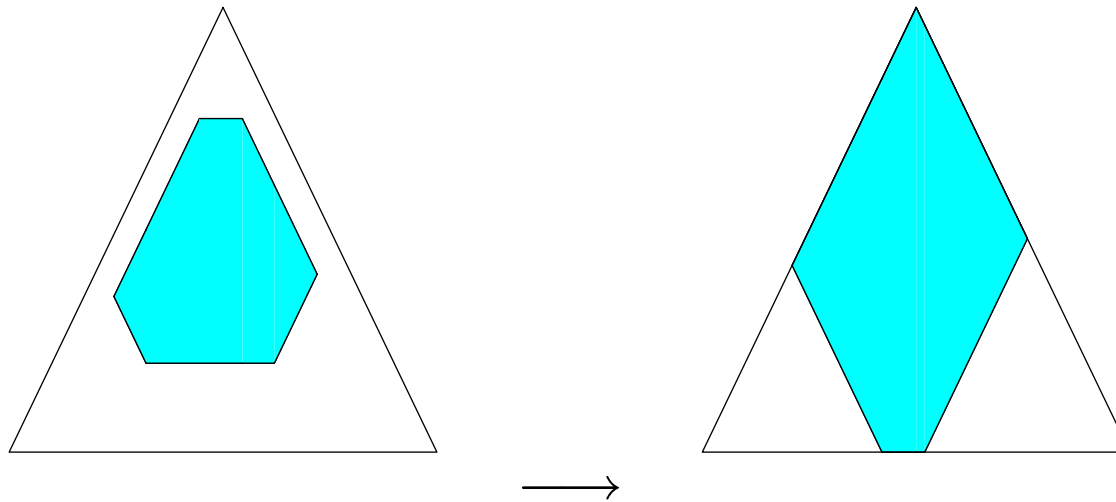
P1. Maximize possibility of the futures-set

Select the business-as-usual, least surprising future.



P2: Reveal only desirable gambles

The announced possibility π
should be no less than the known possibility.



P3: No future more probable

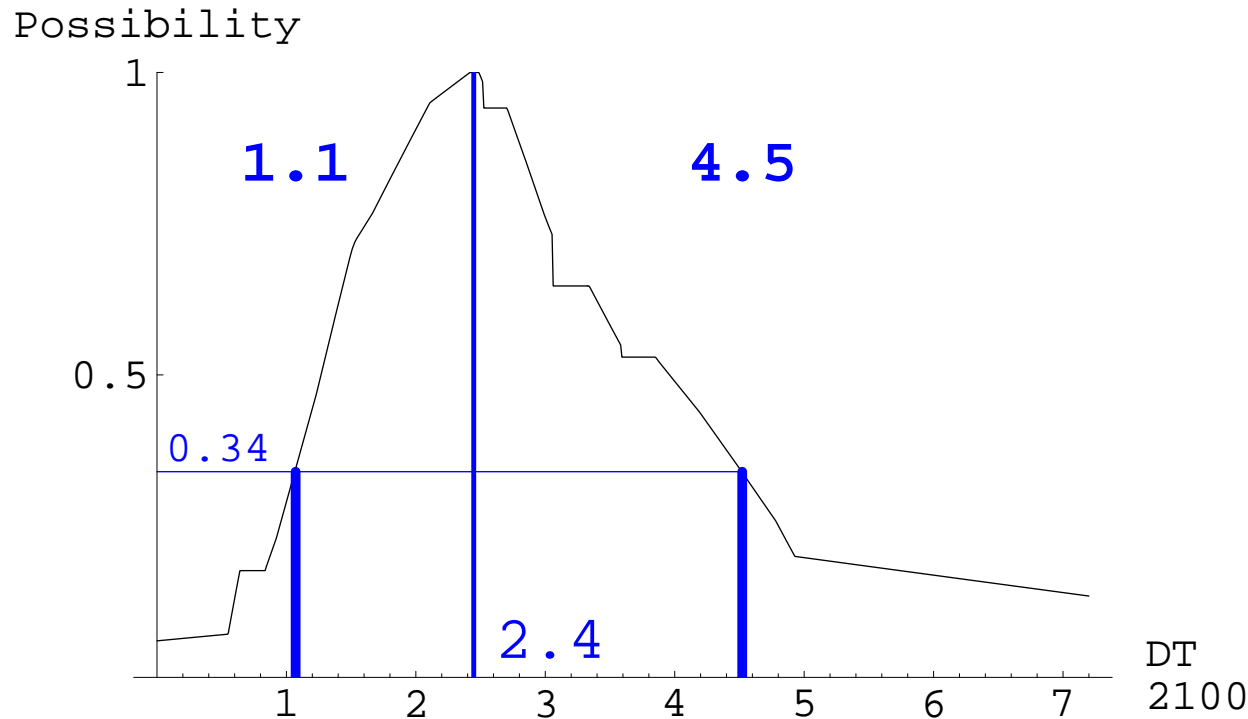
For any two possible futures A and B ,
there is at least one probability p in \mathcal{C} such that

$$p(A) > p(B)$$

P4: Minimize the possibility of missing

Give bounds as wide as possible, but

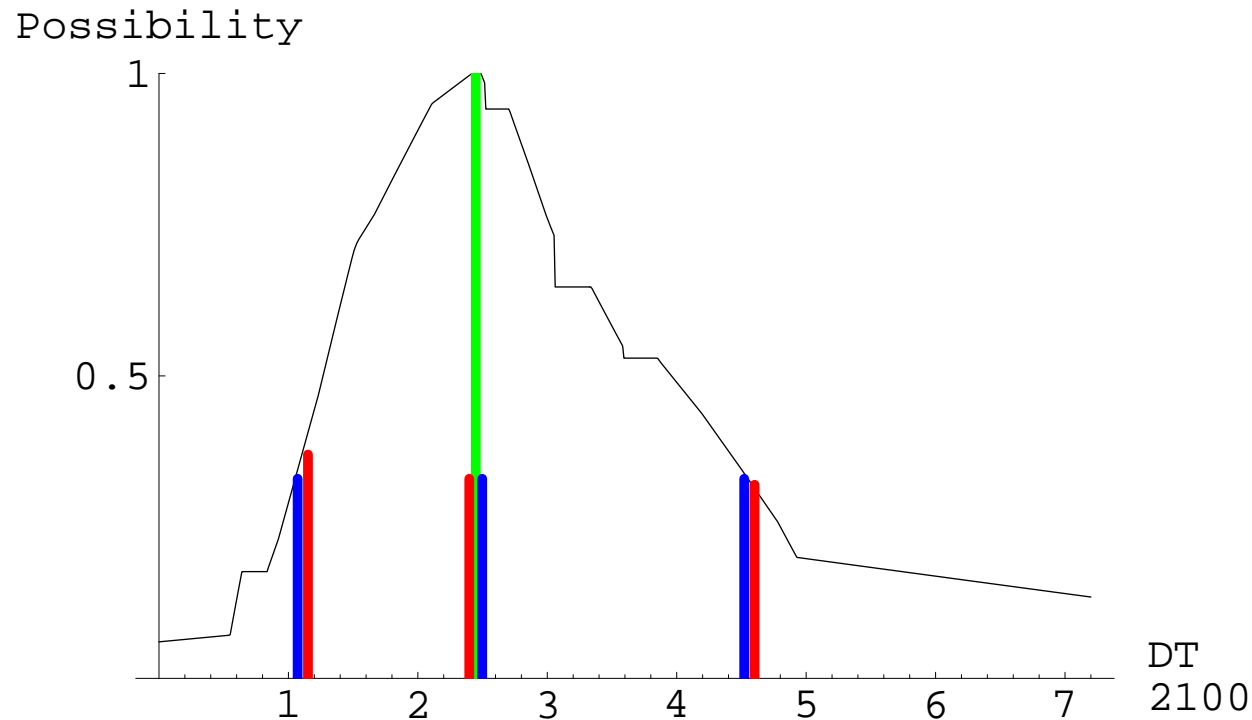
P3 implies: the possibility of these should be $> 1/3$.



P4: Minimize the possibility of missing

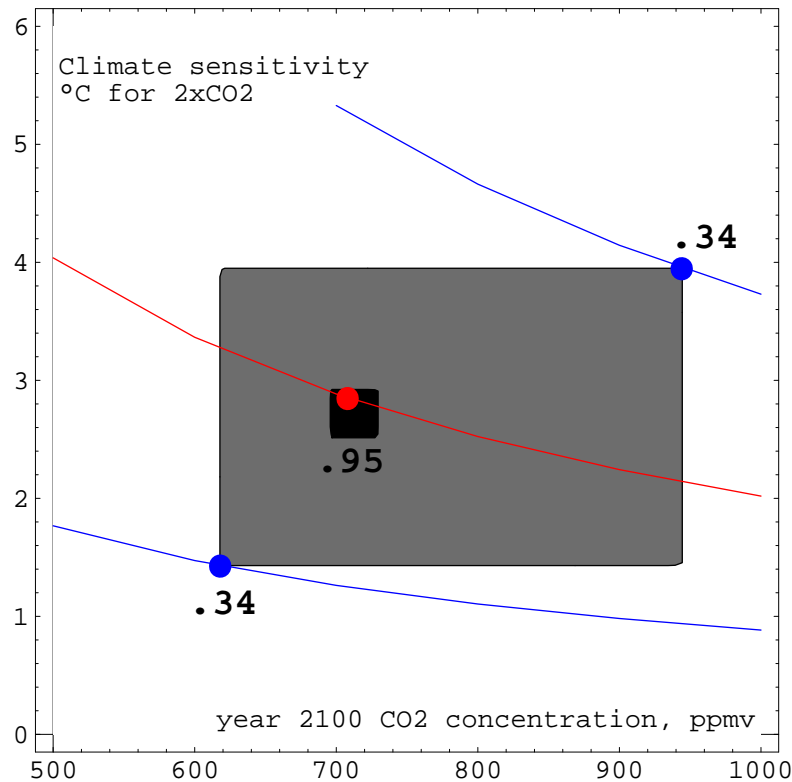
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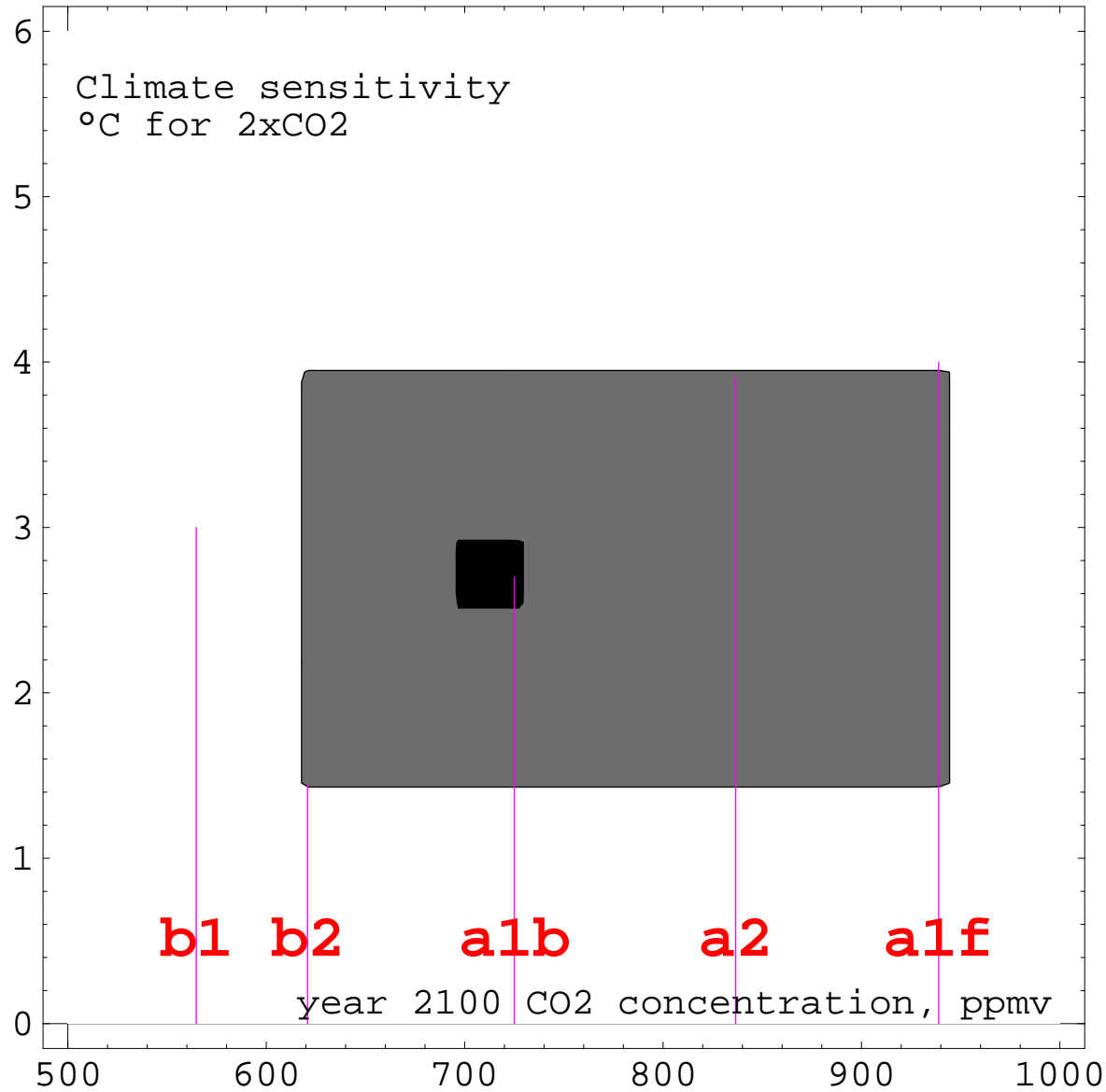


Possible global warming futures

	π	[CO ₂] ppmv	Sensitivity °C/ ₂ ×CO ₂	Warming °C
Baseline	1	709	2.85	2.4
Low	0.34	618	1.43	1.1
High	0.34	944	3.95	4.5



Relation with IPCC scenarios



Summary and conclusion

Hierarchy of knowledge

Information about futures can be given as:

- Credal set
- Possibility distribution
- Set of possible futures
- Least surprising future

Concluding remarks

- +2.85°C the least surprising global warming in 2100
- In the range +1.43°C to +3.95°C, the bounds are no less probable than the central value.
- Next step: Precautionary policy analysis in Integrated Assessment Models with uncertainty. And time.

Thanks.

HDGC lunch seminar at Carnegie Mellon University, April 30th 2003