

# Possible global warming futures

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# SRES: Forecasts or scenarios?

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

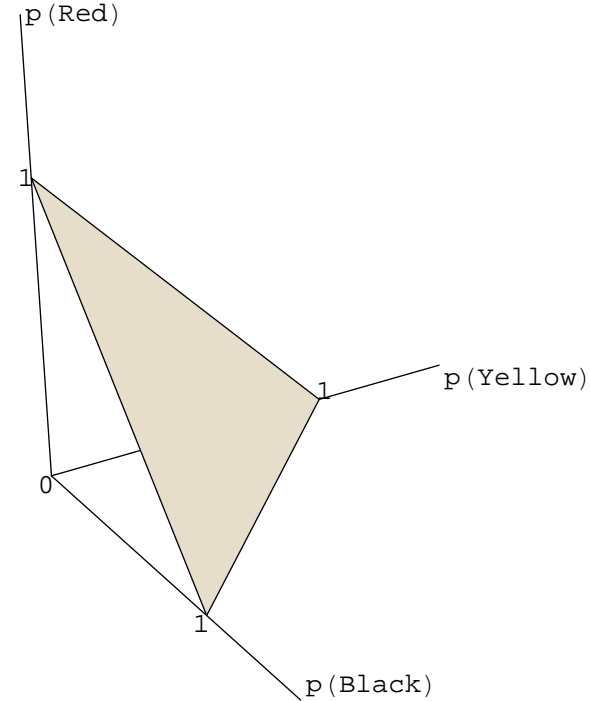
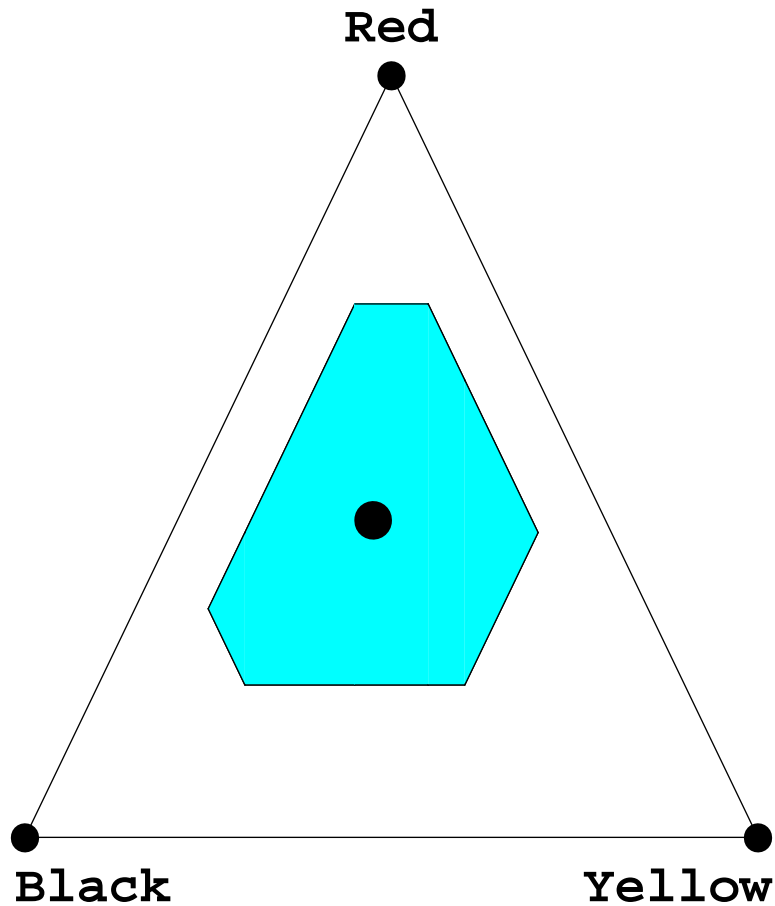
- No, we can't have probabilities
- Yes, they are not all equally likely

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

# 1. Imprecise probabilities

# Using a set of probabilities $\mathcal{C}$

Ellsberg's urn contains 3 kind of colored marbles...



# Application to possible futures

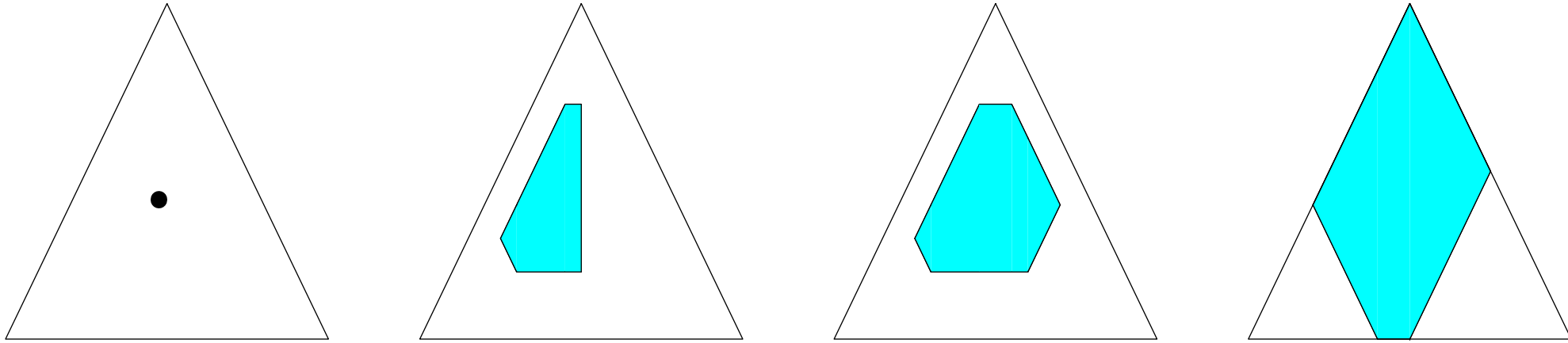
$\mathcal{C}$  is called the **credal** set, it represent beliefs.

$\mathcal{C}$  defines a partial order:

$A$  is more probable than  $B$  if and only if

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

# More information, smaller credal set



We don't have much information about 2100  
 $\Rightarrow$  Large  $\mathcal{C}$

# Define $\mathcal{C}$ by upper bounds

Define  $\mathcal{C}$  by ruling out some probability distributions:

$$\mathcal{C} = \{ p \text{ such that } p(E) \leq \Pi(E) \text{ for all } E \in \Omega \}$$

A simple way to define the upper bound  $\Pi$  is by using a *possibility* distribution  $\pi(\omega)$ :

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

# Interpretations and arithmetic

- $1 - \pi(\omega)$  is the degree of surprise of scenario  $\omega$  (Shackle 1954)
- $\pi(\omega)$  is the possibility level of  $\omega$  (Zadeh 1978)
- $\pi(\omega)$  is the maximum probability of  $\omega$  (Smets et al. 2000)

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

Fuzzy arithmetic:

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

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

## **2. The possibility of global warming**

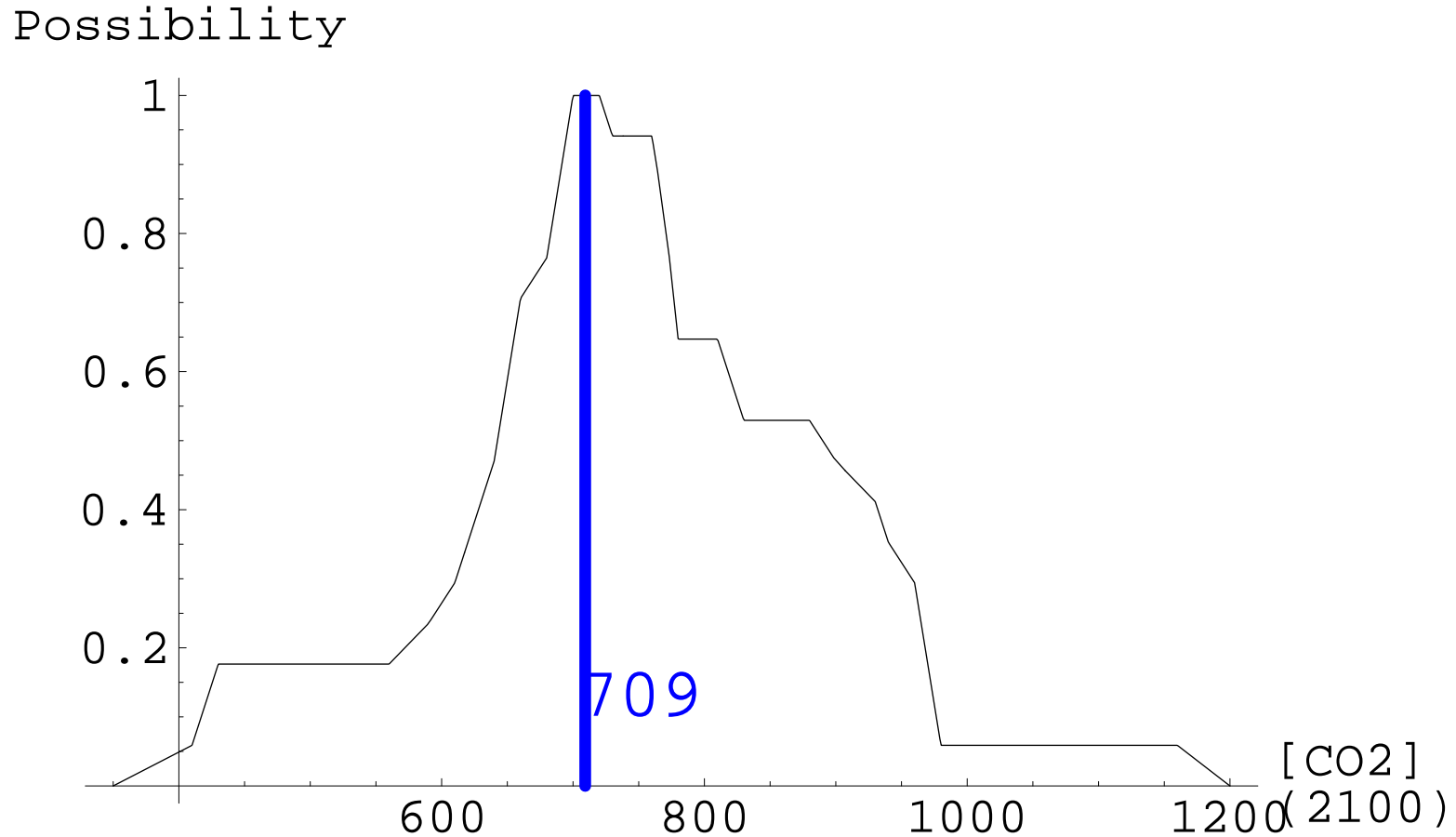
# Assessing global warming futures

Pilot study based on published literature.

Warming in 2100 depends multiplicatively on:

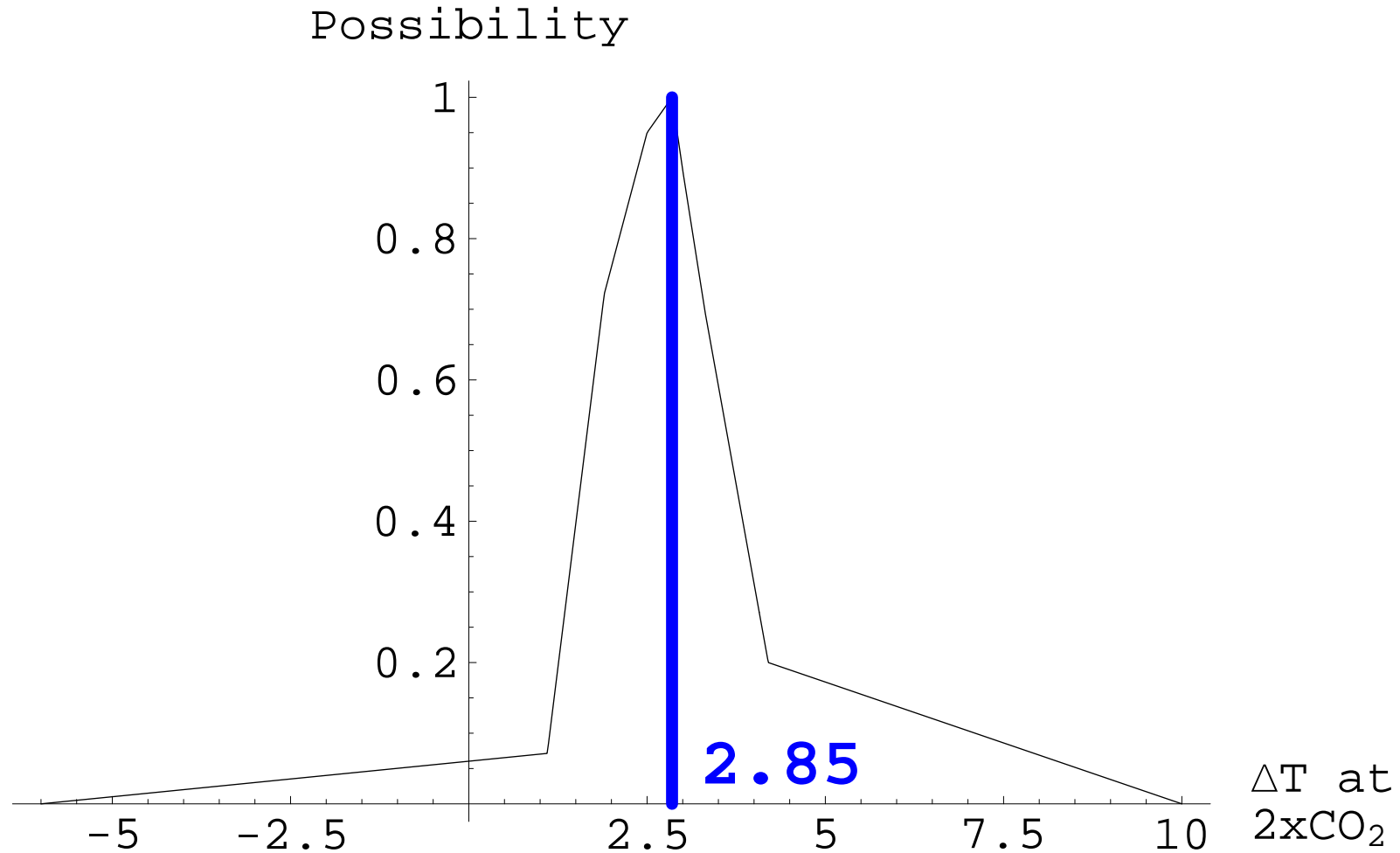
- CO<sub>2</sub> concentration [CO<sub>2</sub>] increase
- Climate sensitivity  $\Delta T(2 \times \text{CO}_2)$

# Summarizing model results on [CO<sub>2</sub>]



Based on 56 'no-intervention' records in Morita's SRES database

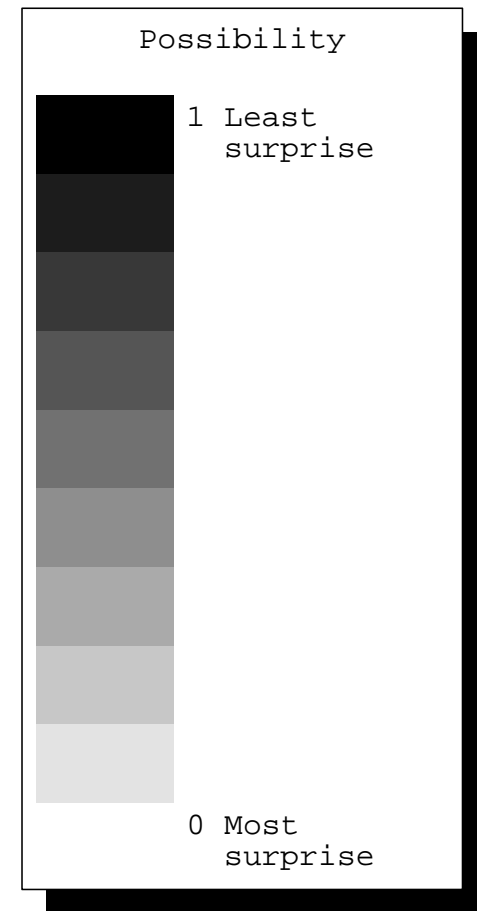
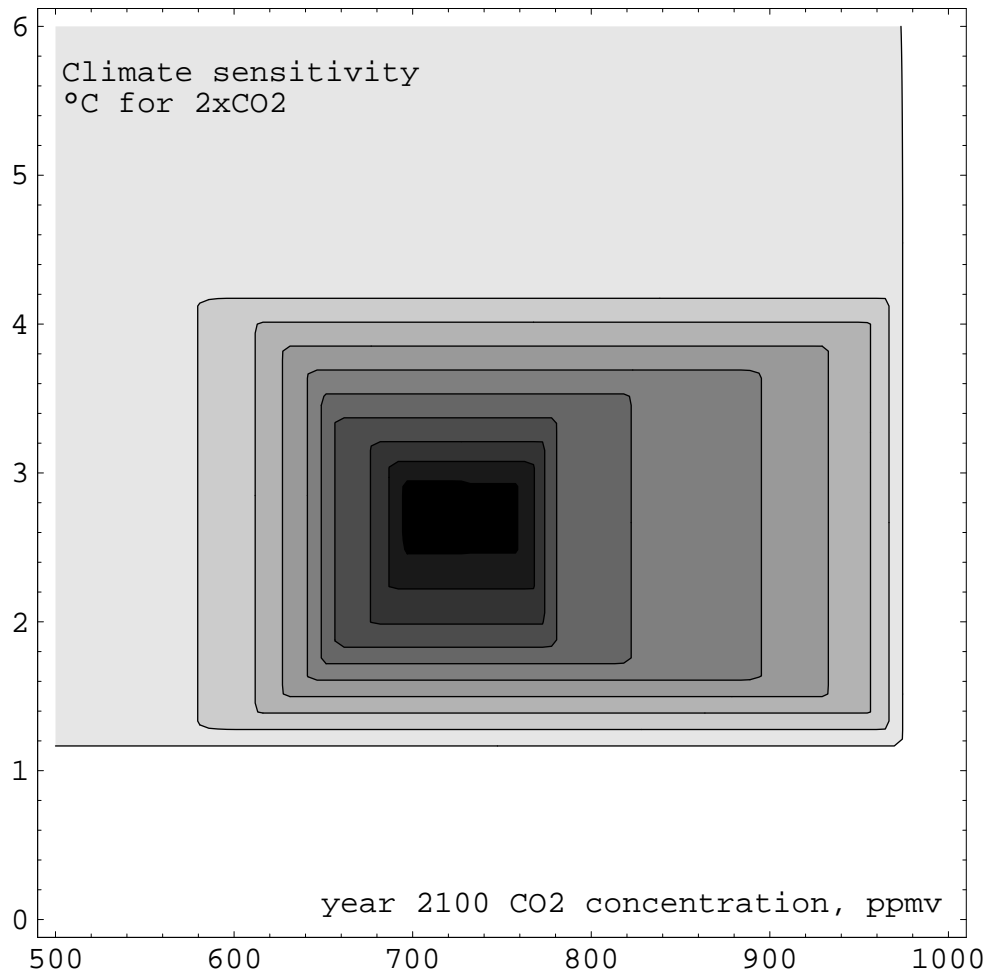
# Climate sensitivity $\Delta T(2 \times \text{CO}_2)$



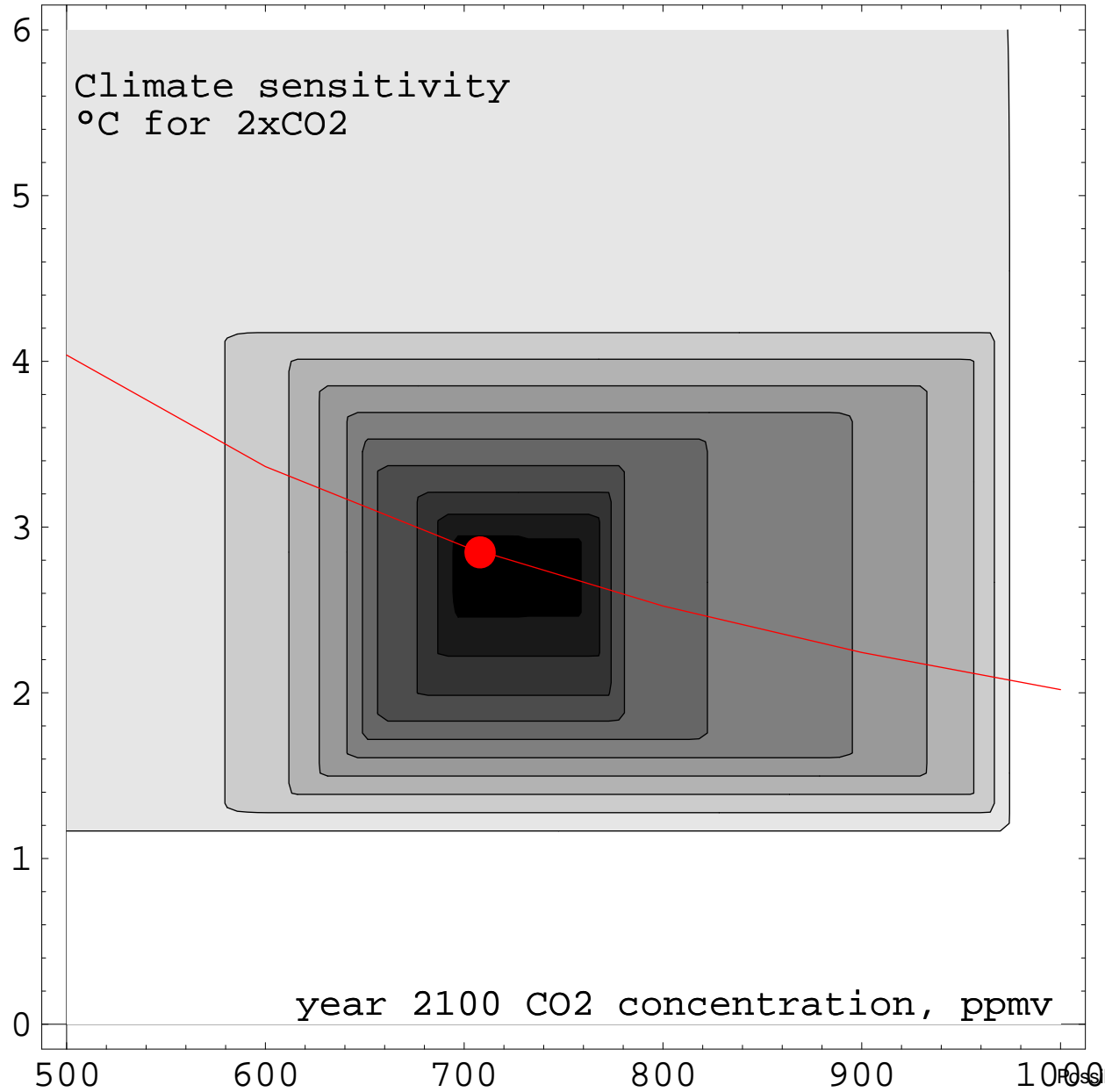
Based on 16 experts surveyed by D. Keith and G. Morgan.

# Joint possibility distribution.

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

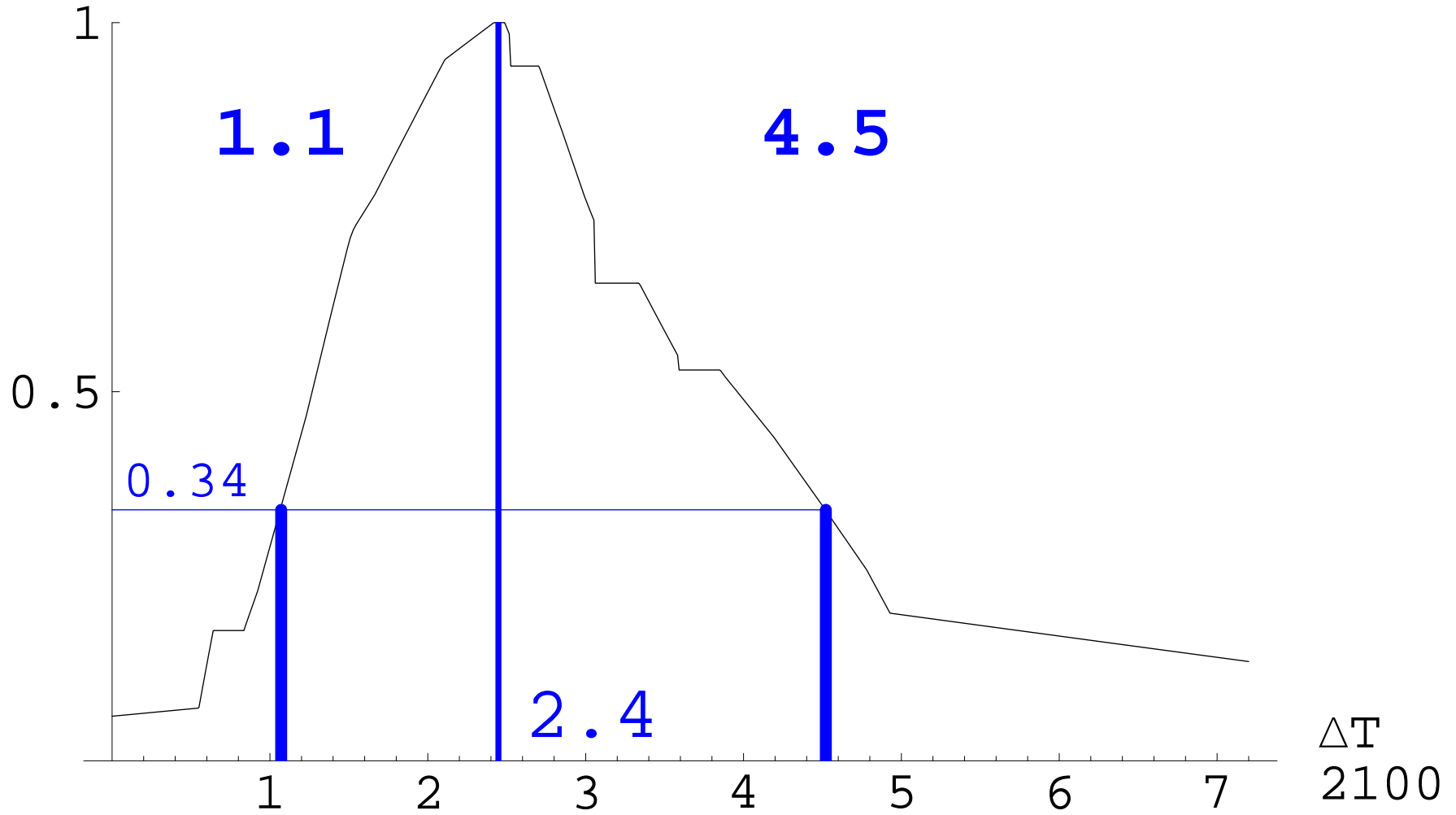


# The possibility of 2.4° C warming



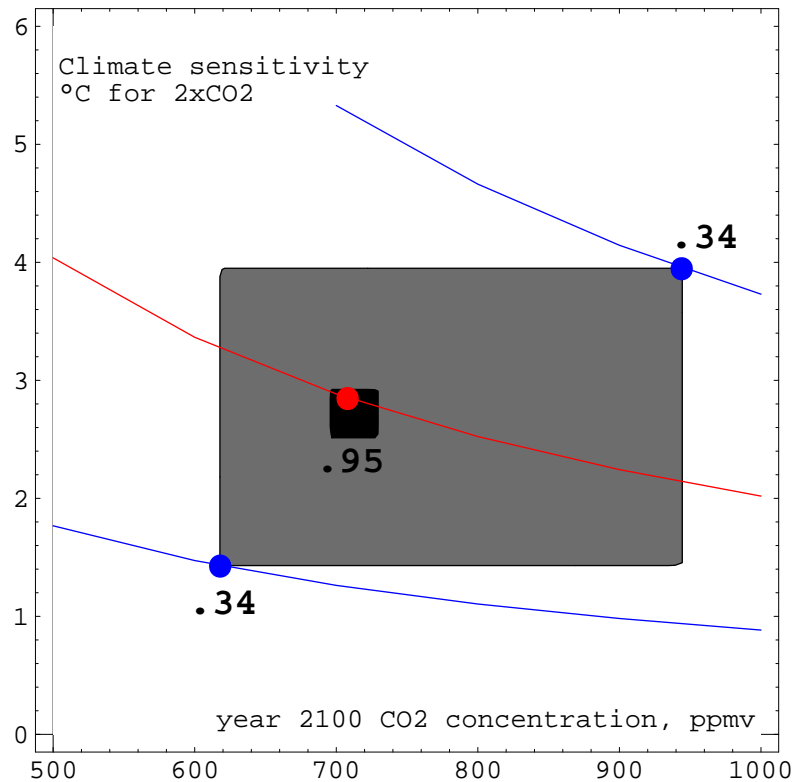
# Global warming 2100 possibility

Possibility

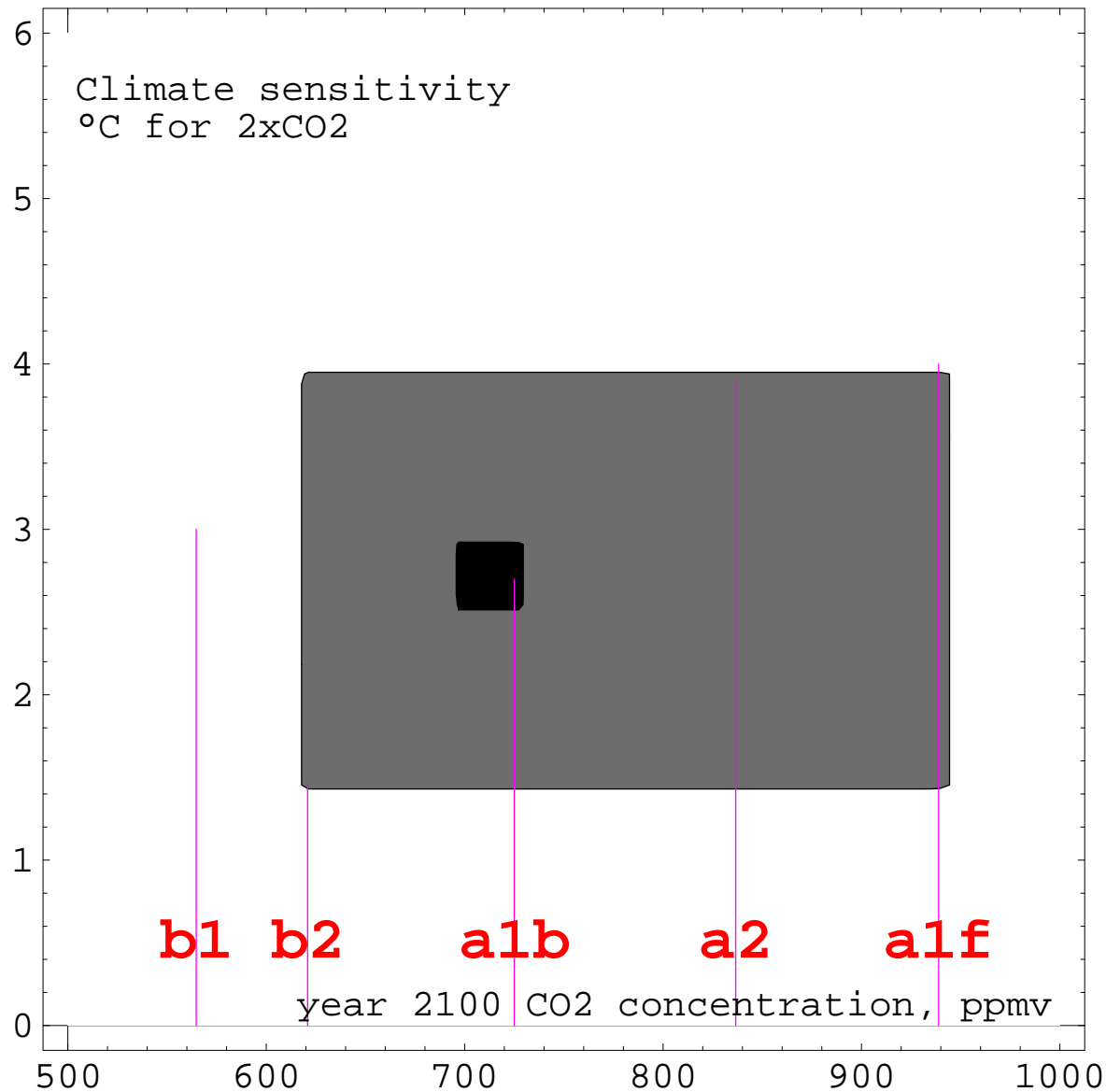


# Possible global warming futures

	$\pi$	[CO <sub>2</sub> ] ppmv	Sensitivity °C/ <sub>2</sub> ×CO <sub>2</sub>	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

- A method to quantify possible global warming futures
- PRELIMINARY: +2.4°C least surprising. Range +1.1°C to +4.5°C.
- Next step: Precautionary policy analysis in Integrated Assessment Models with uncertainty. And time.

Thanks.

IEW meeting in Laxenburg, Austria, June 24–26th 2003

# Rationality with imprecise probabilities

Walley's precautionary rationality:

Policy  $A$  is preferred to  $B$  iff

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

This avoids sure loss (no arbitrage)