

# Path-Dependencies, Emerging Properties and Uncertainties in Emissions Scenarios

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# 4 Types of Uncertainties in CC

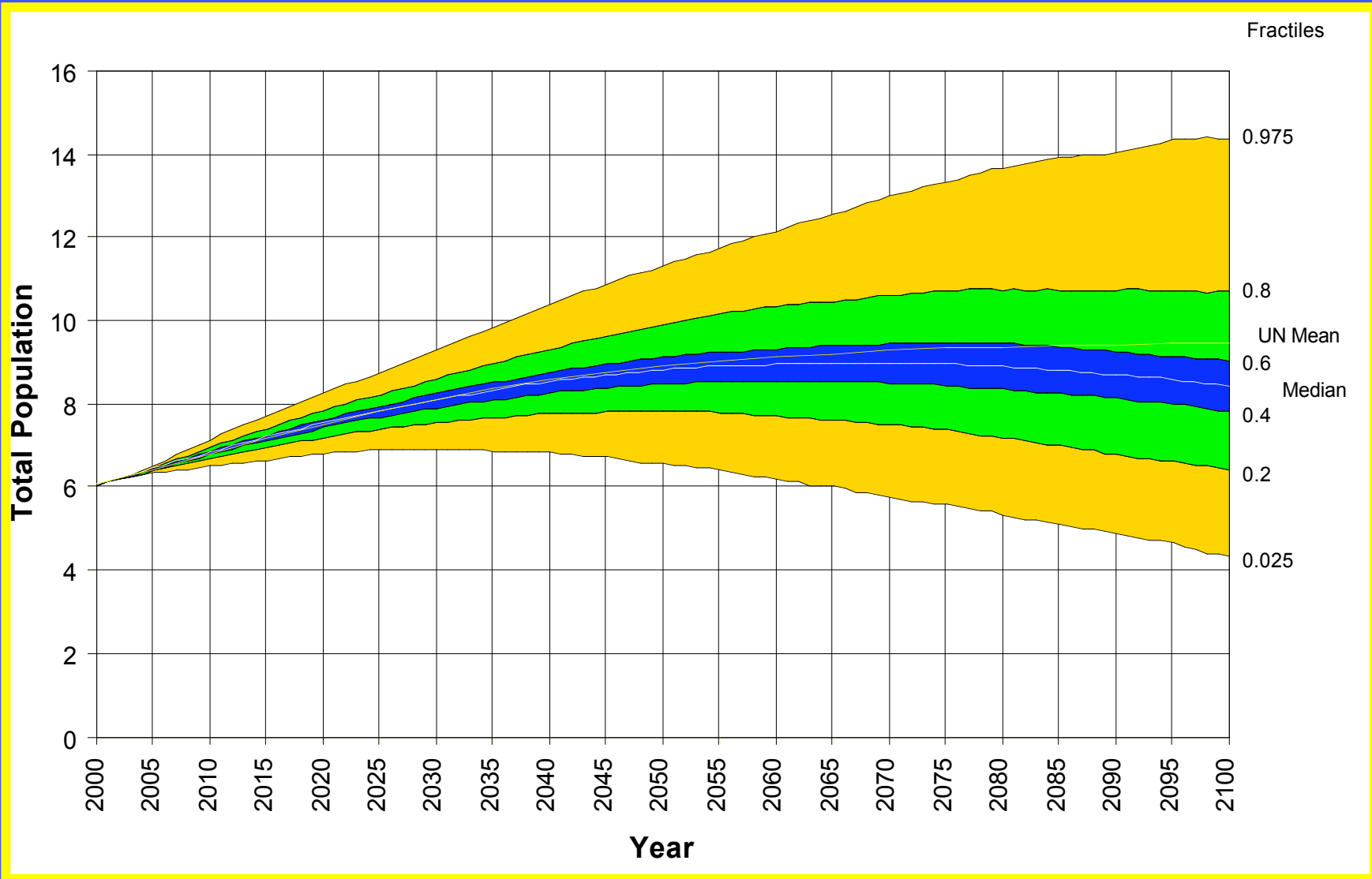
- Natural: C-cycle, feedbacks, climate sensitivity
- Socio-economic 1: future GHG emissions
- Socio-economic 2: vulnerability
  - ◆ Vulnerability 1: level of affluence
  - ◆ Vulnerability 2: env. change beyond CC
- Technological: diffusion+mitigation costs
- Political/policy: type of decisions, policy scope, policy instruments

# Major Uncertainties in Scenarios

- Demographic (growth & composition)
- Economic (growth, structure, disparities)
- Social (values, lifestyles, policies)
- Technological (rates & direction)
- Environmental (limits, adaptability)
- Valuation (metrics, discounting, non-market damages and benefits)

- Drivers
- Relationships
- Interdependencies
- Emissions (outcomes)

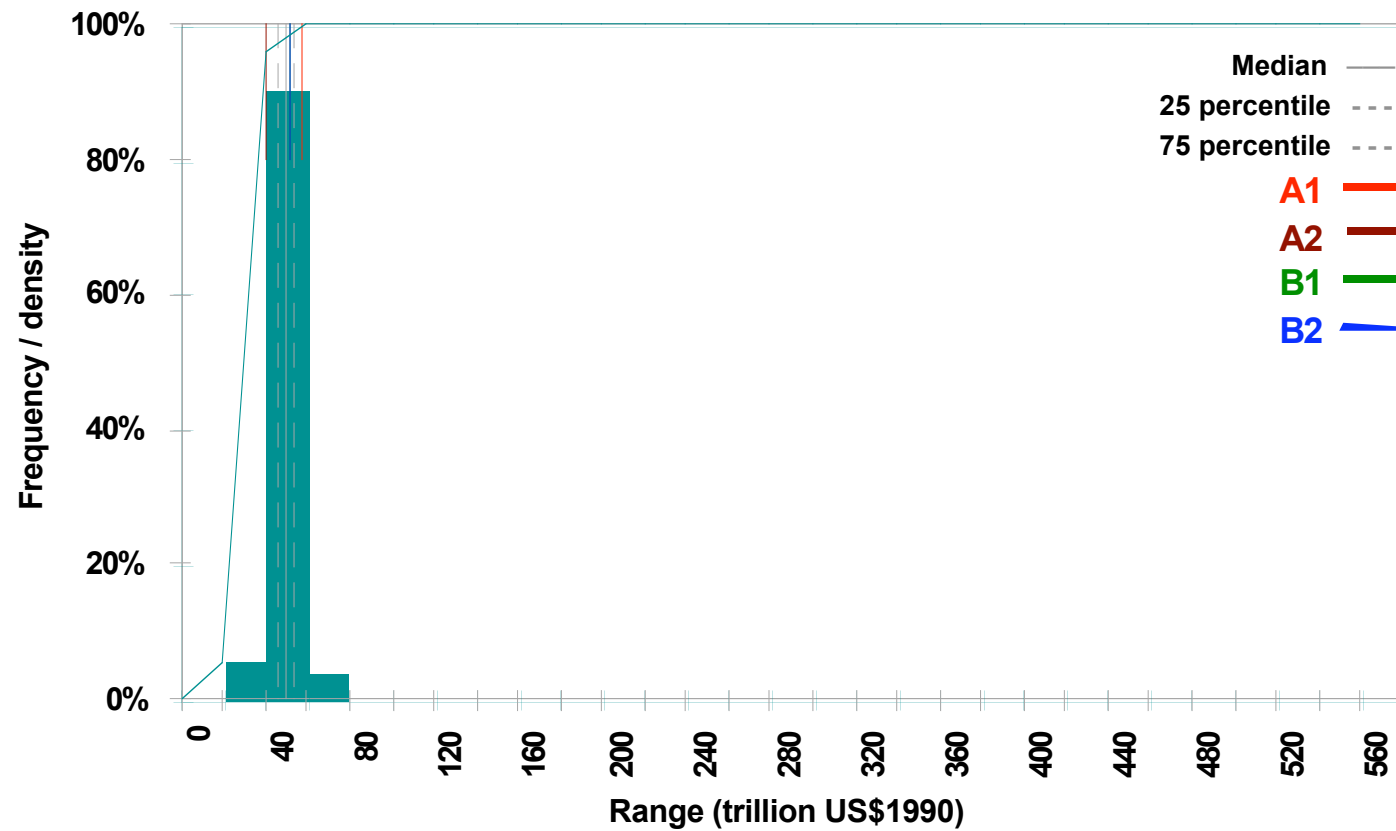
# Global Population Scenarios

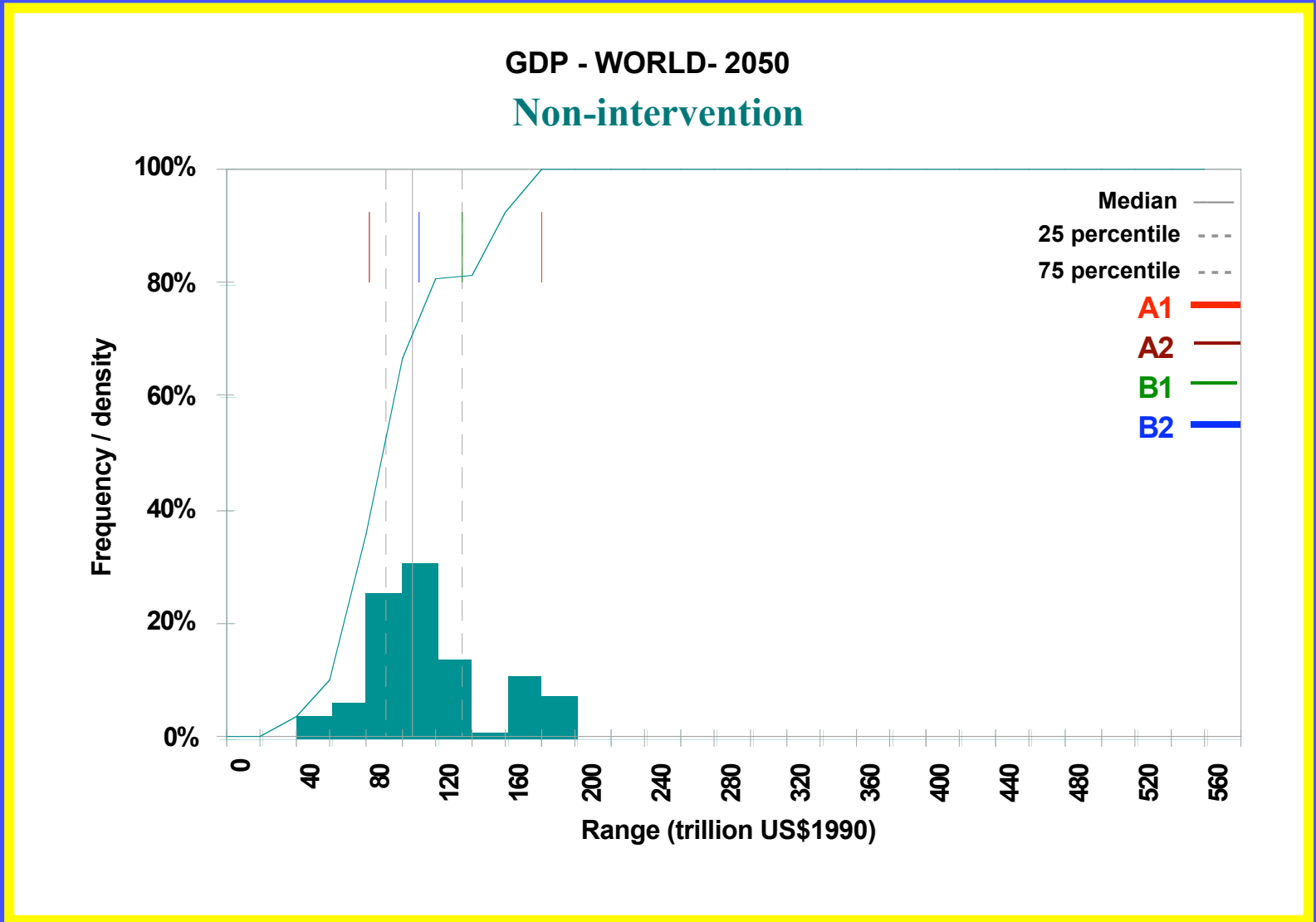


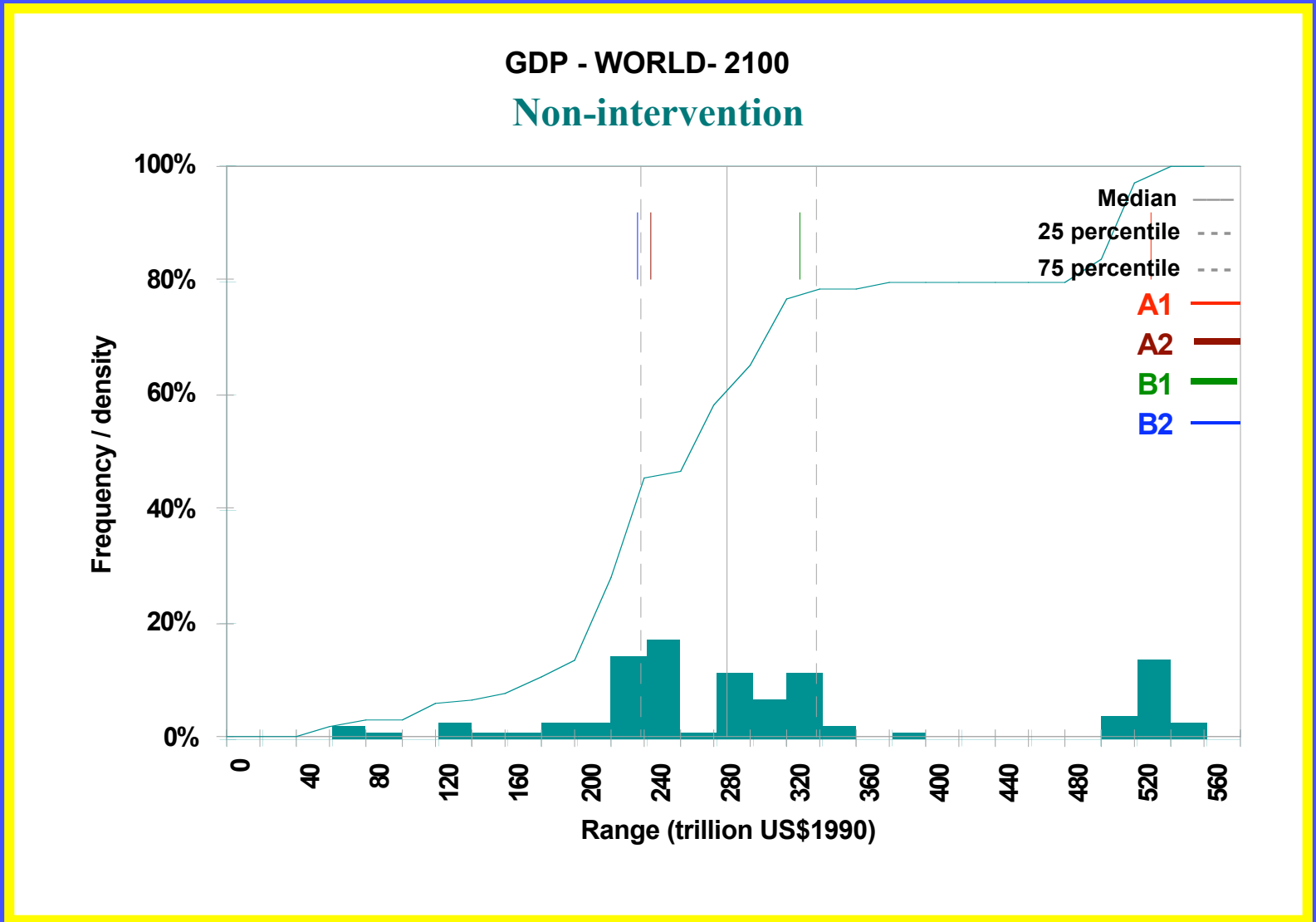
Source: Lutz *et al.* 2001.

## GDP - WORLD- 2020

### Non-intervention



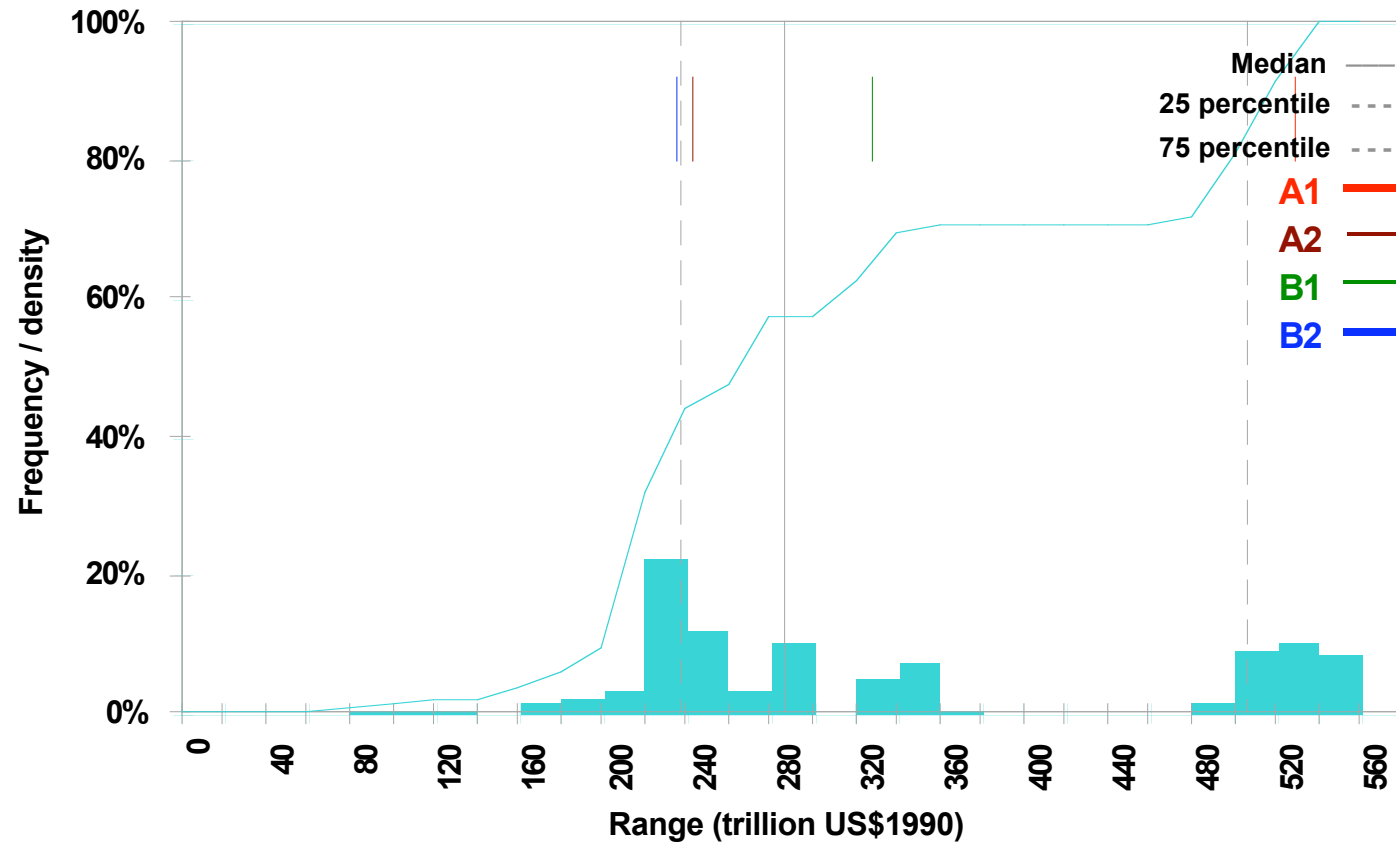






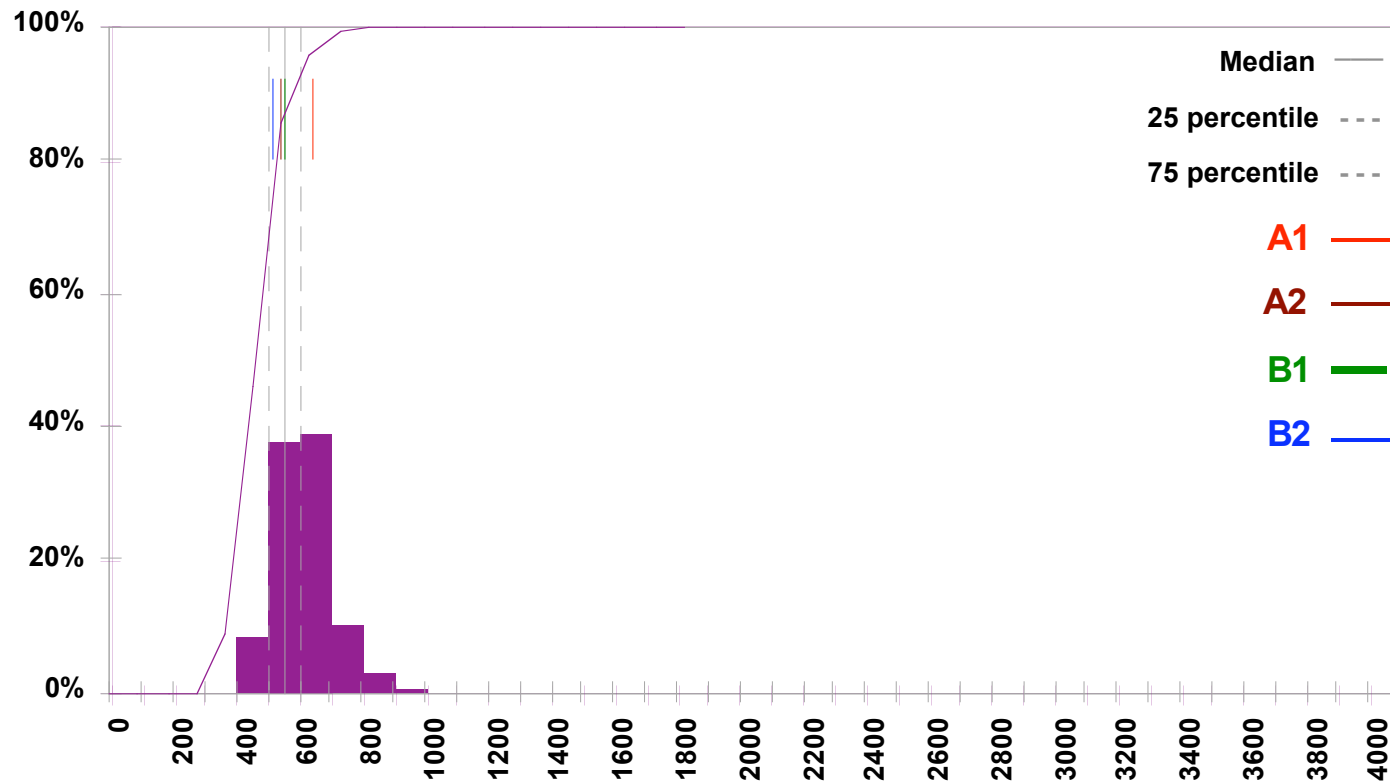
## GDP - WORLD- 2100

### Intervention



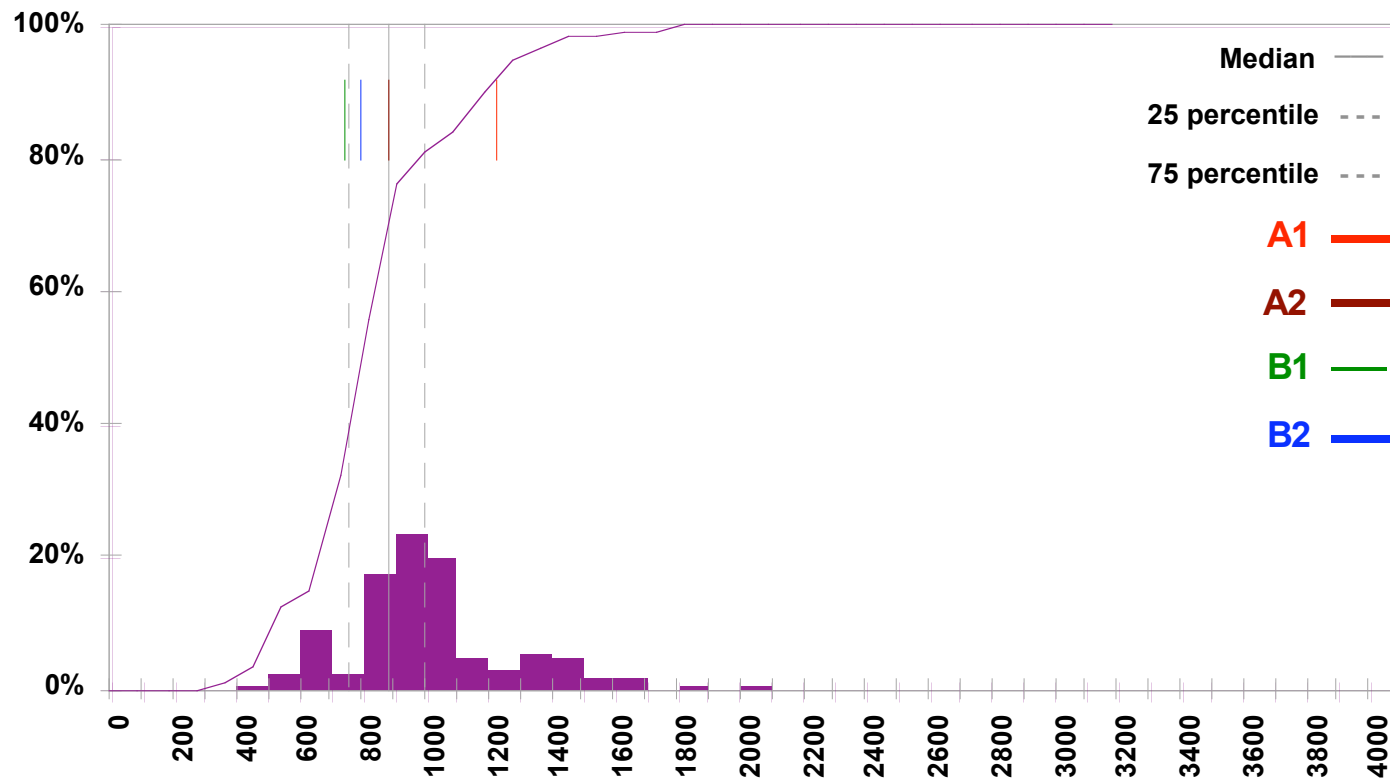
## Primary Energy - WORLD - 2020

Non-intervention



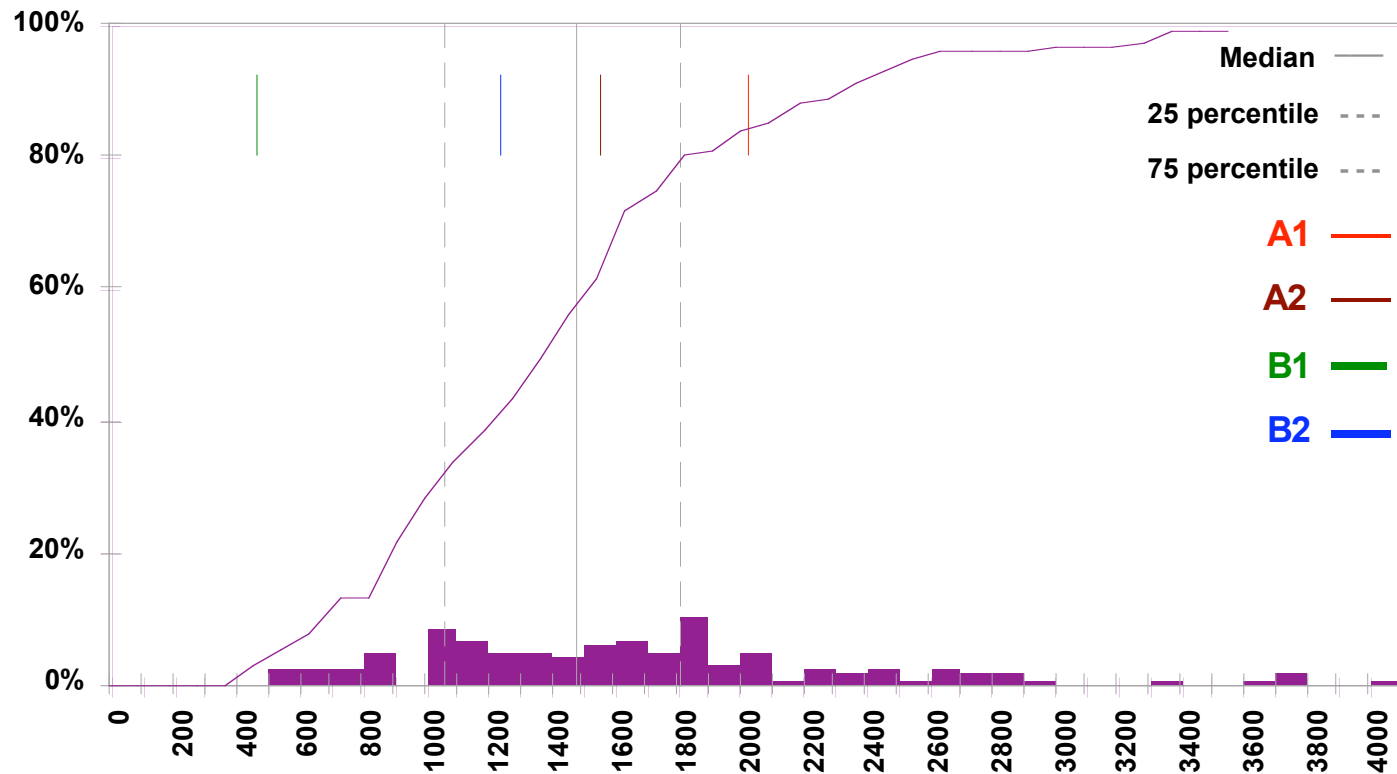
## Primary Energy - WORLD - 2050

Non-intervention



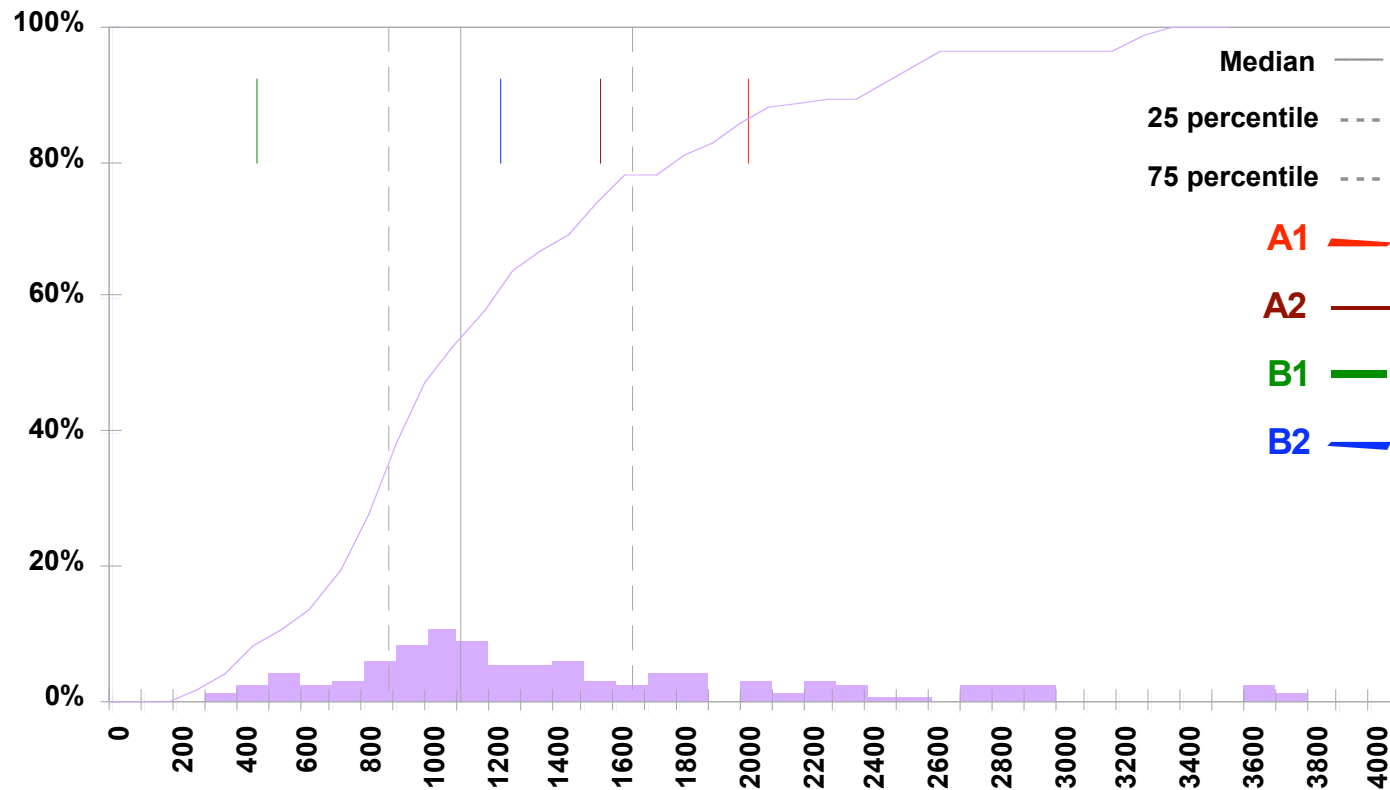
## Primary Energy - WORLD - 2100

### Non-intervention



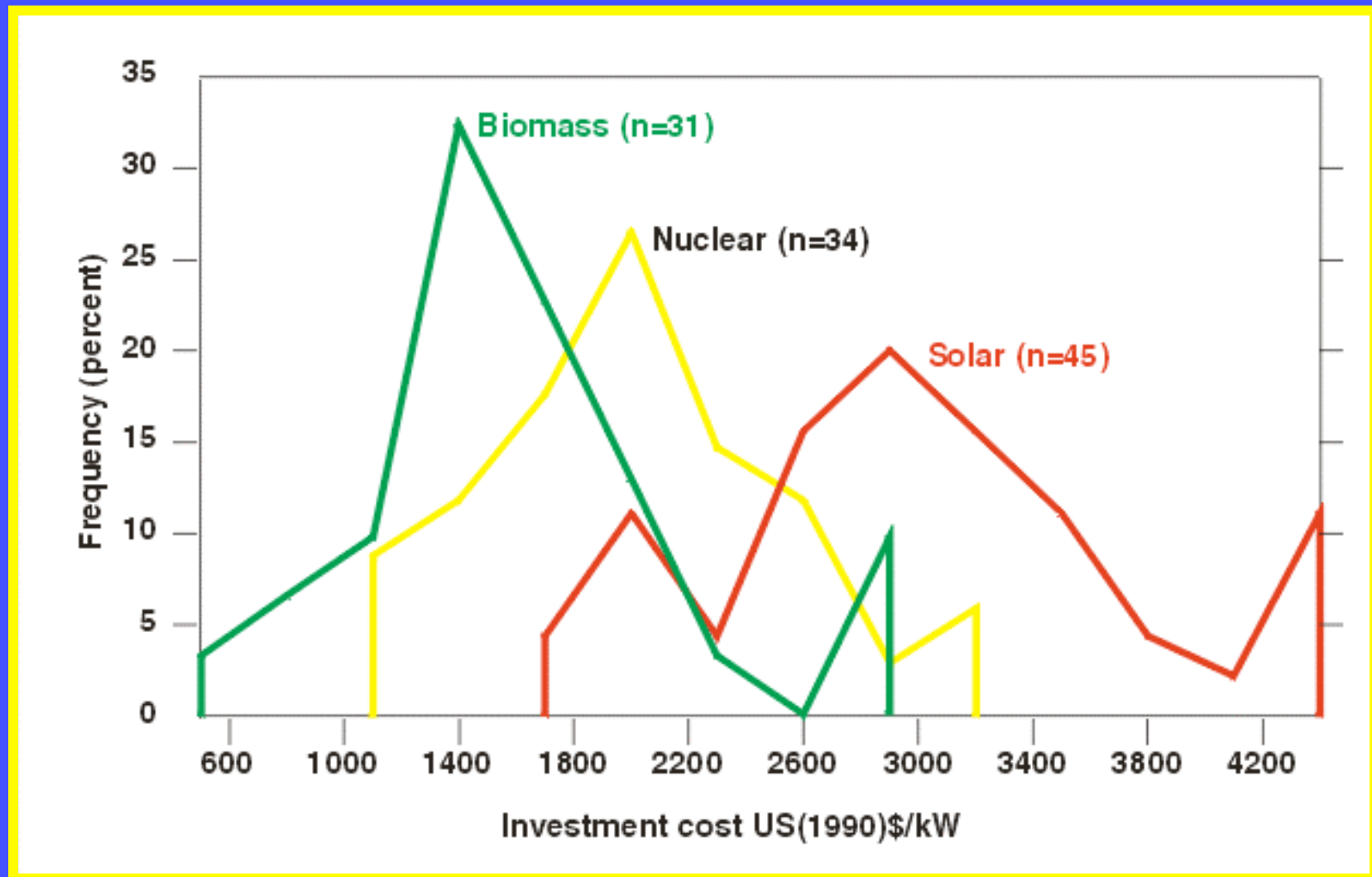
## Primary Energy - WORLD - 2100

### Intervention



- Drivers
- Relationships
- Interdependencies
- Emissions (outcomes)

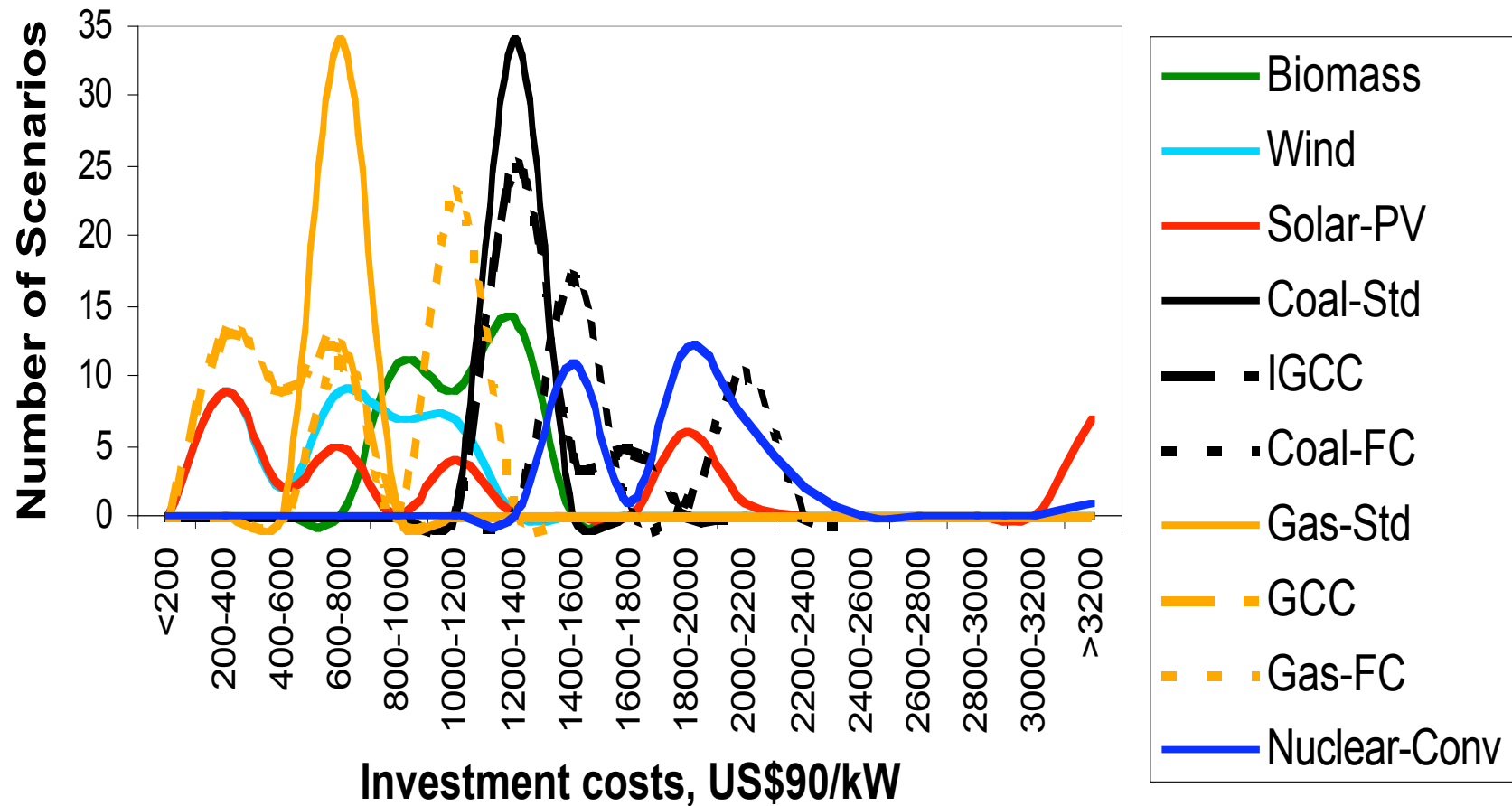
# Energy Investment Costs from Literature



IIASA

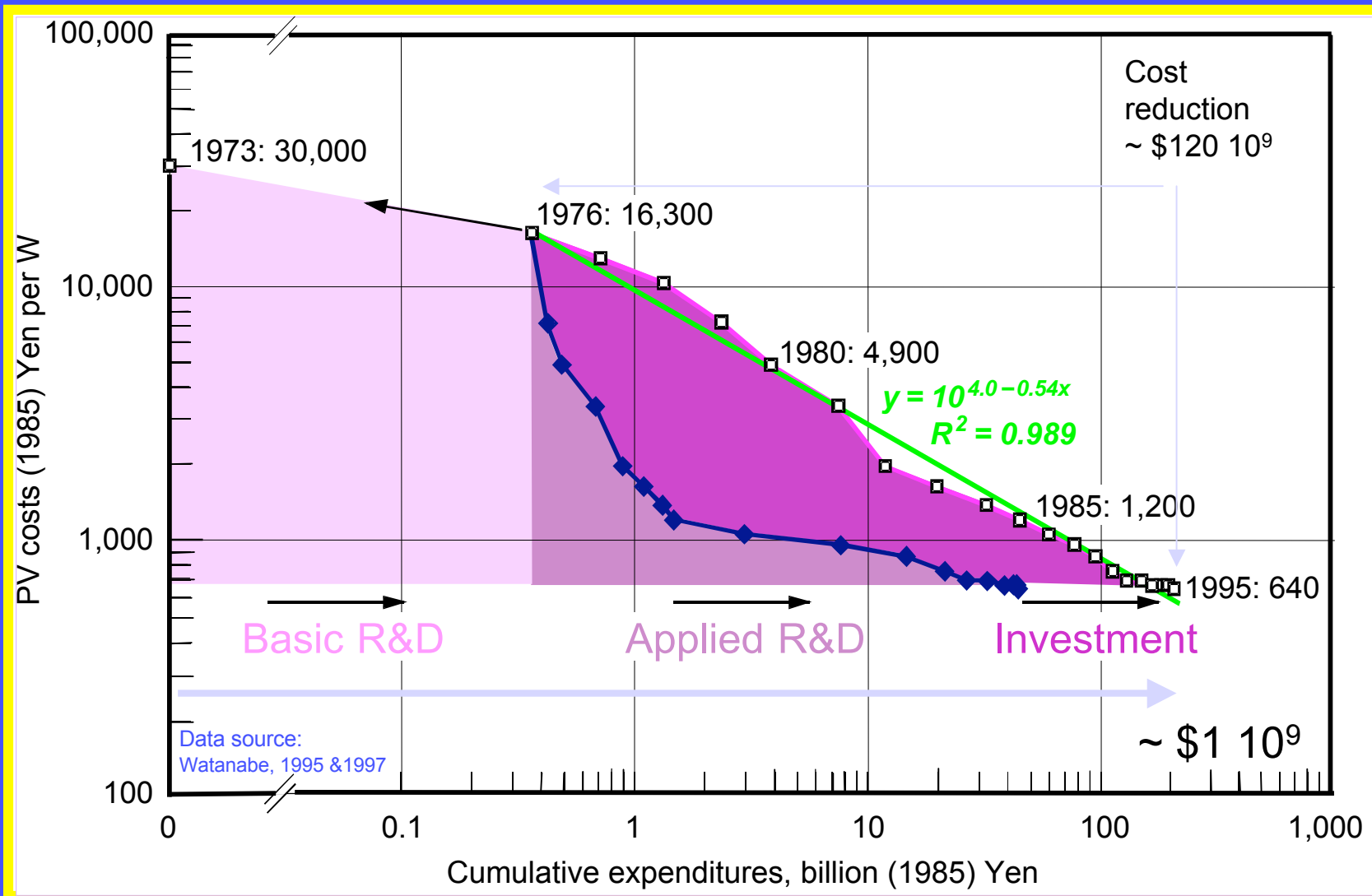
TNT 2000

# Distribution of Investment Costs in 2100



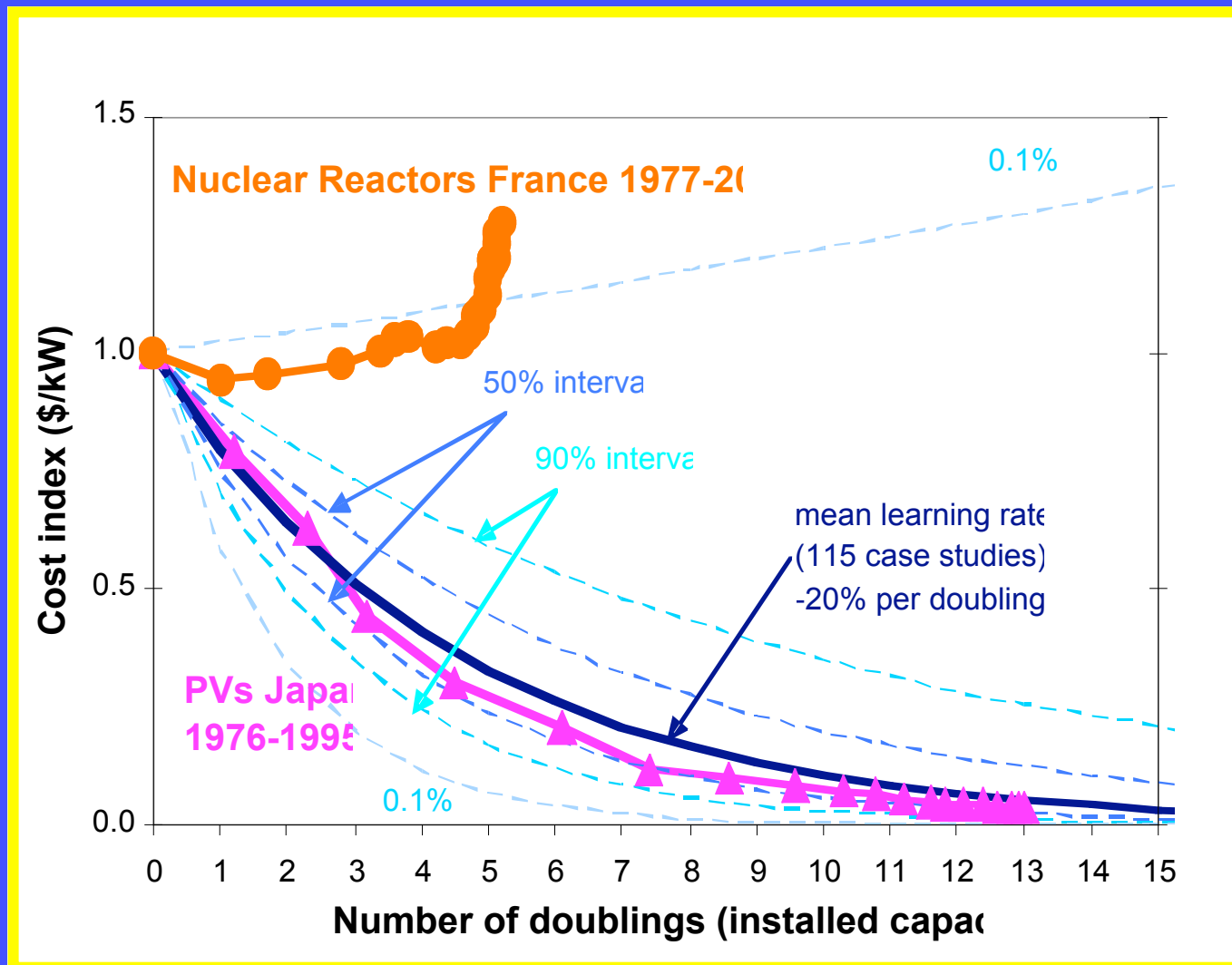


# Japan - PV Costs vs. Expenditures



# Technological Uncertainties

## Learning rates (push) and market growth (pull)



# DYNAMICS OF TECHNOLOGY

- **Deep Uncertainty:**

Limited knowledge on feasibility and costs of future technologies

- **Technological Learning:**

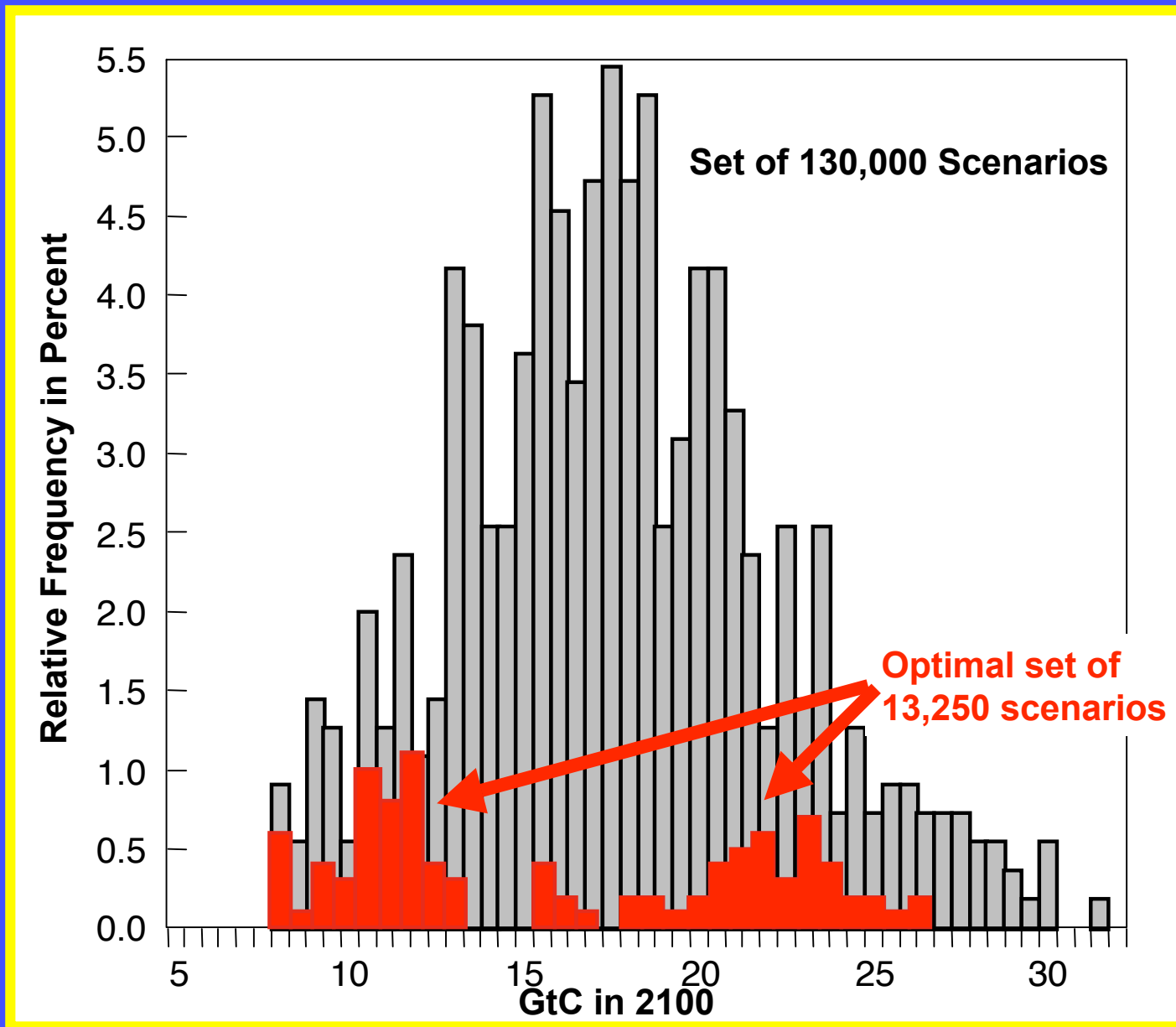
Improvements are a function of accumulated experience (learning curve)

# Technological Learning and Uncertainty



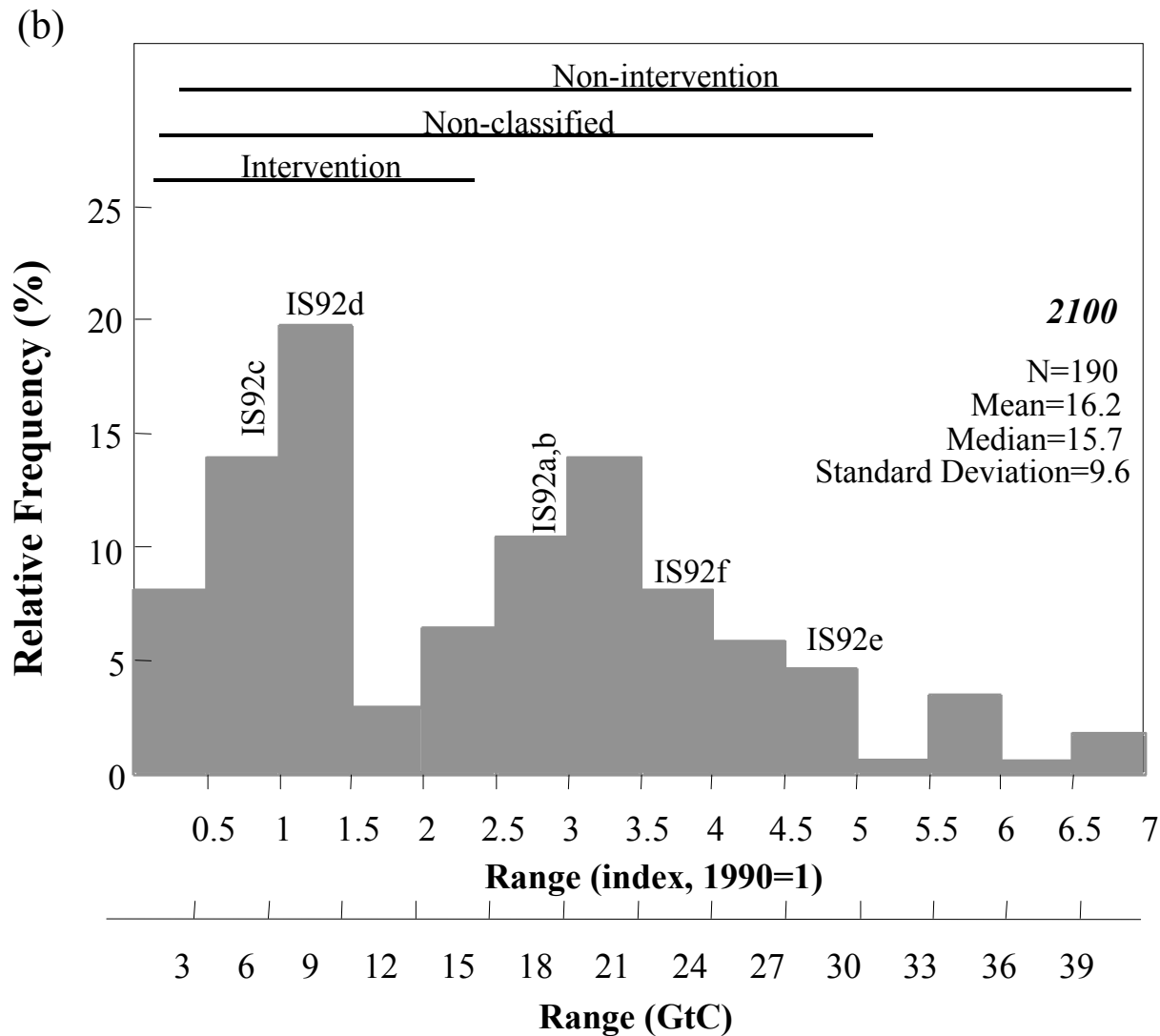
- Integration of stochastic draws
- Objective function incl. “risk term”
- Non-convex, stochastic optimization
- Common population, GDP and final energy demand
- Result: optimal diversification portfolios

# CO<sub>2</sub> Emissions from Scenarios with Technological Uncertainty



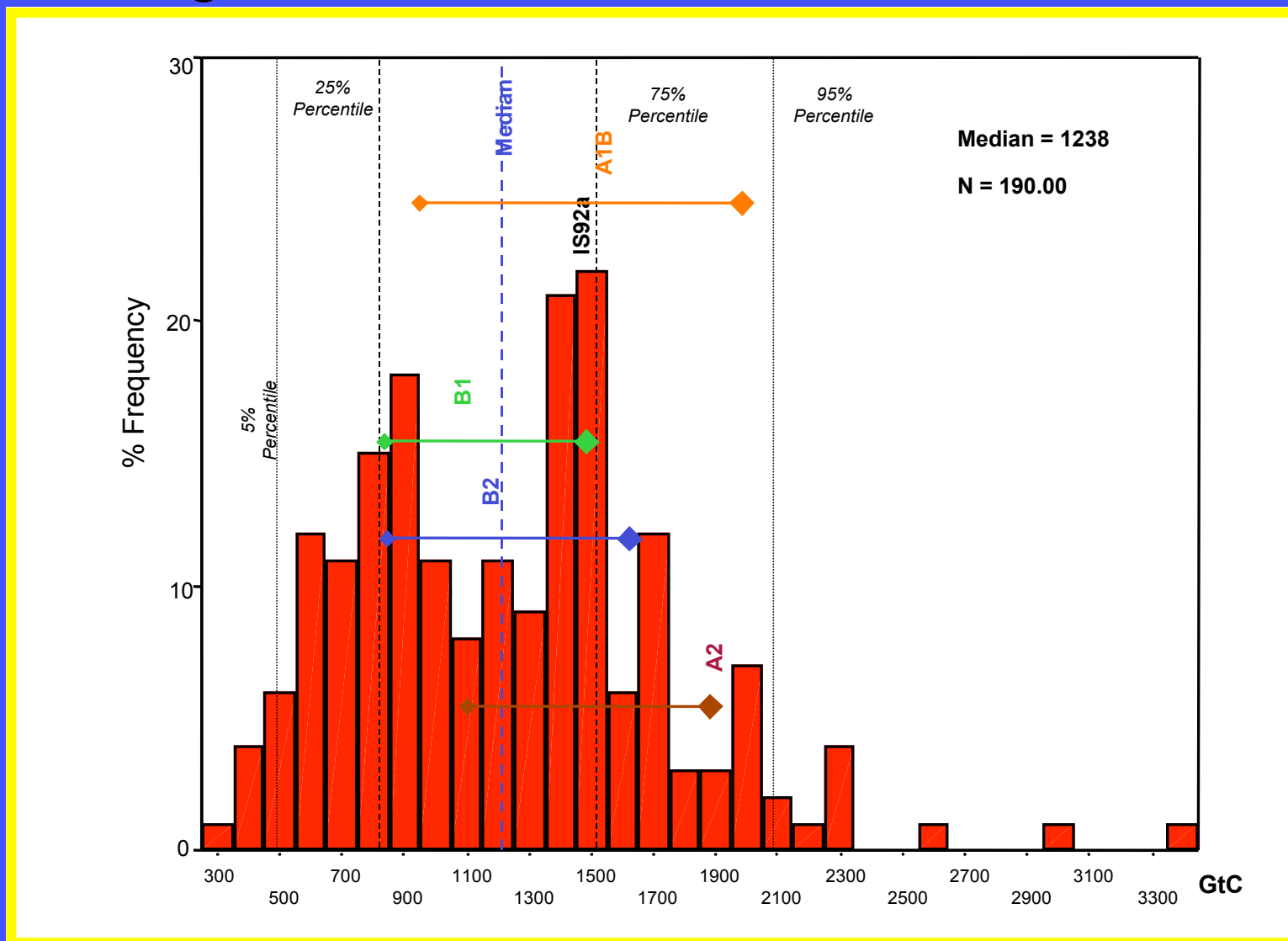
- Drivers
- Relationships
- Interdependencies
- Emissions (outcomes)

# Carbon Dioxide Emissions



# Cumulative CO<sub>2</sub> Emissions

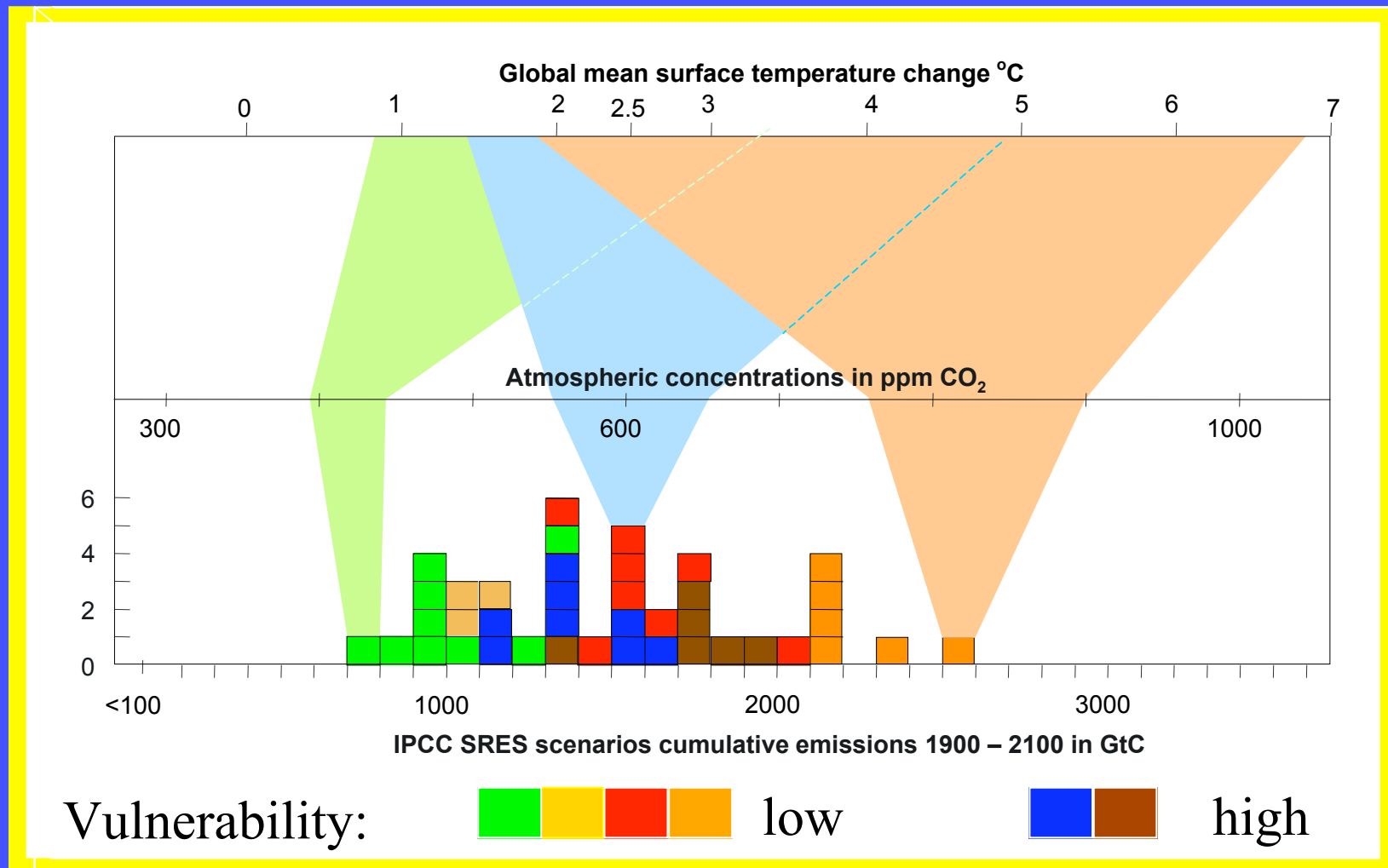
## Histogram for 190 Scenarios in the Literature



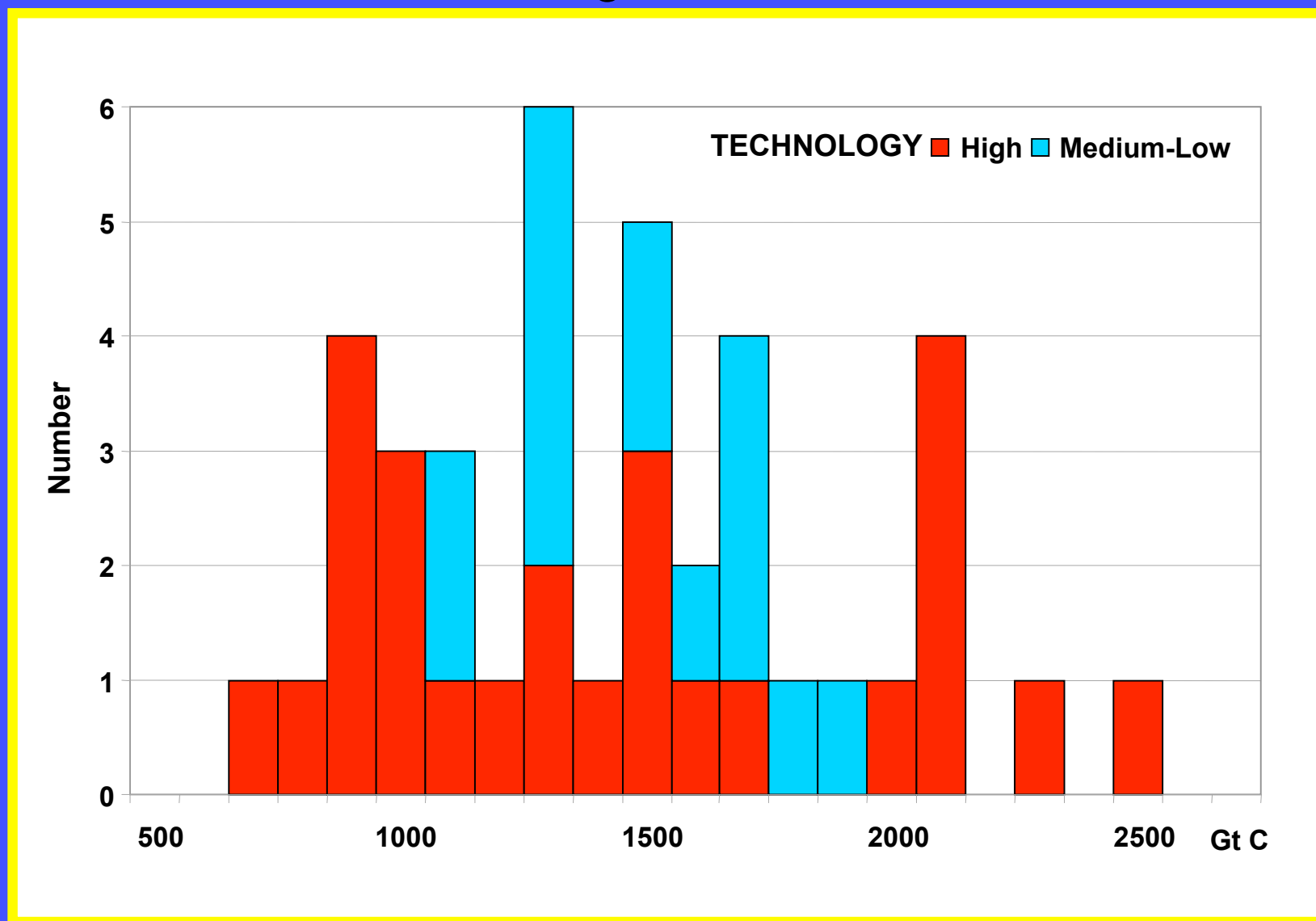


# MAJOR CLIMATE CHANGE UNCERTAINTIES

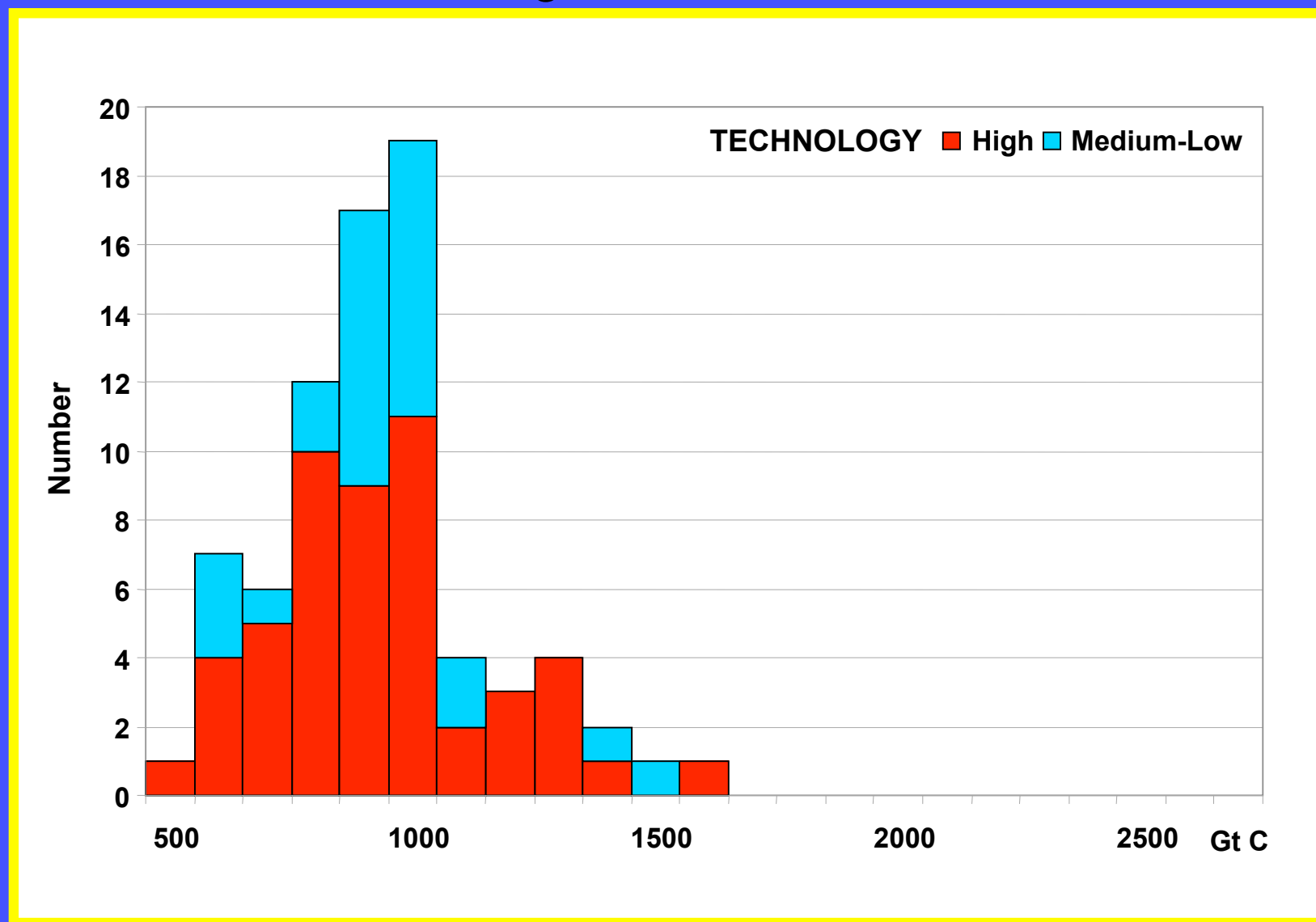
Cumulative CO<sub>2</sub> of IPCC SRES scenarios and resulting CO<sub>2</sub> concentrations and climate sensitivity in °C temperature change based on MAGICC model



# Distribution of Cumulative Carbon Emissions Across the Range of SRES Scenarios



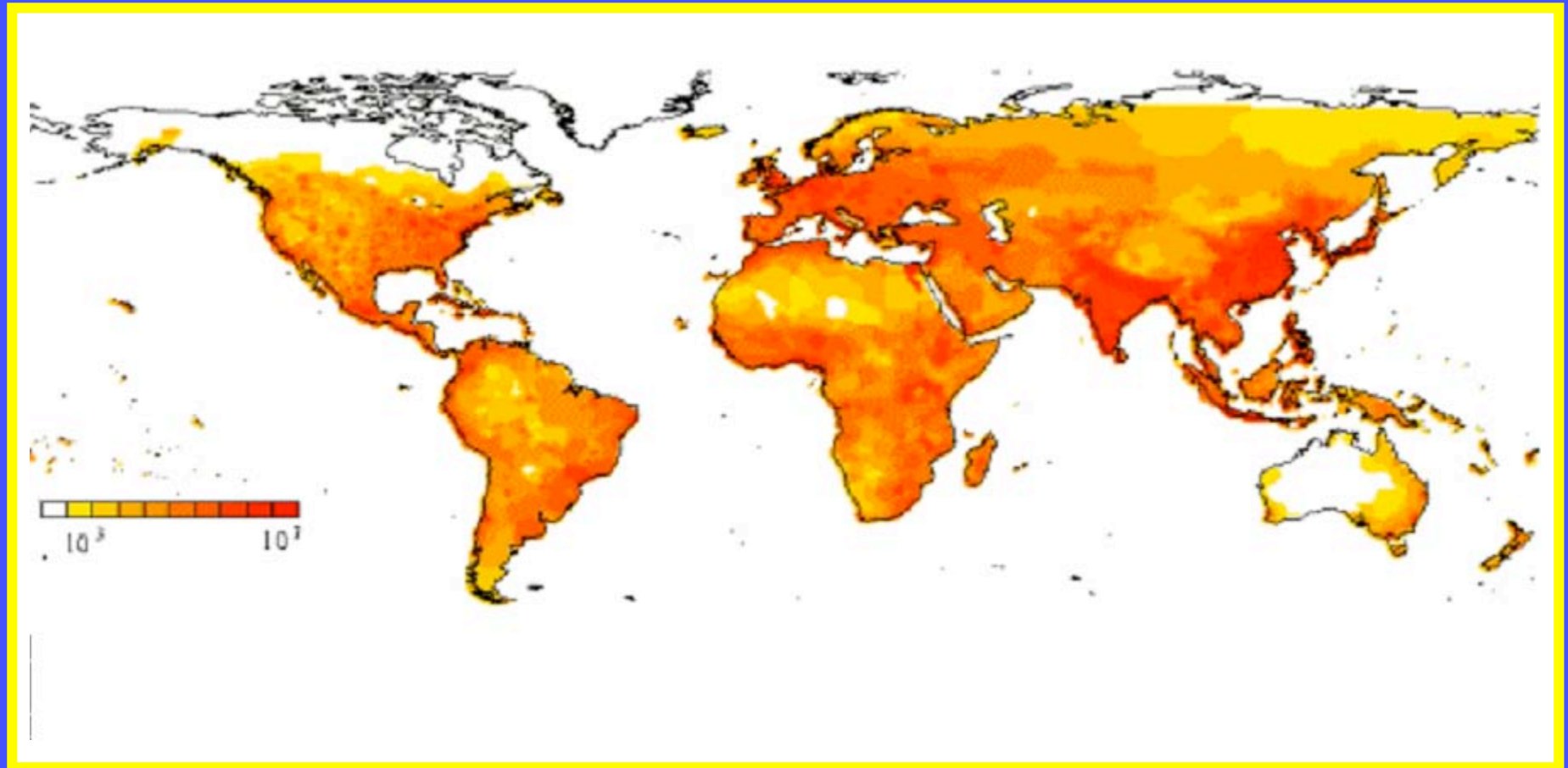
# Distribution of Cumulative Carbon Emissions Across the Range of Post-SRES Scenarios



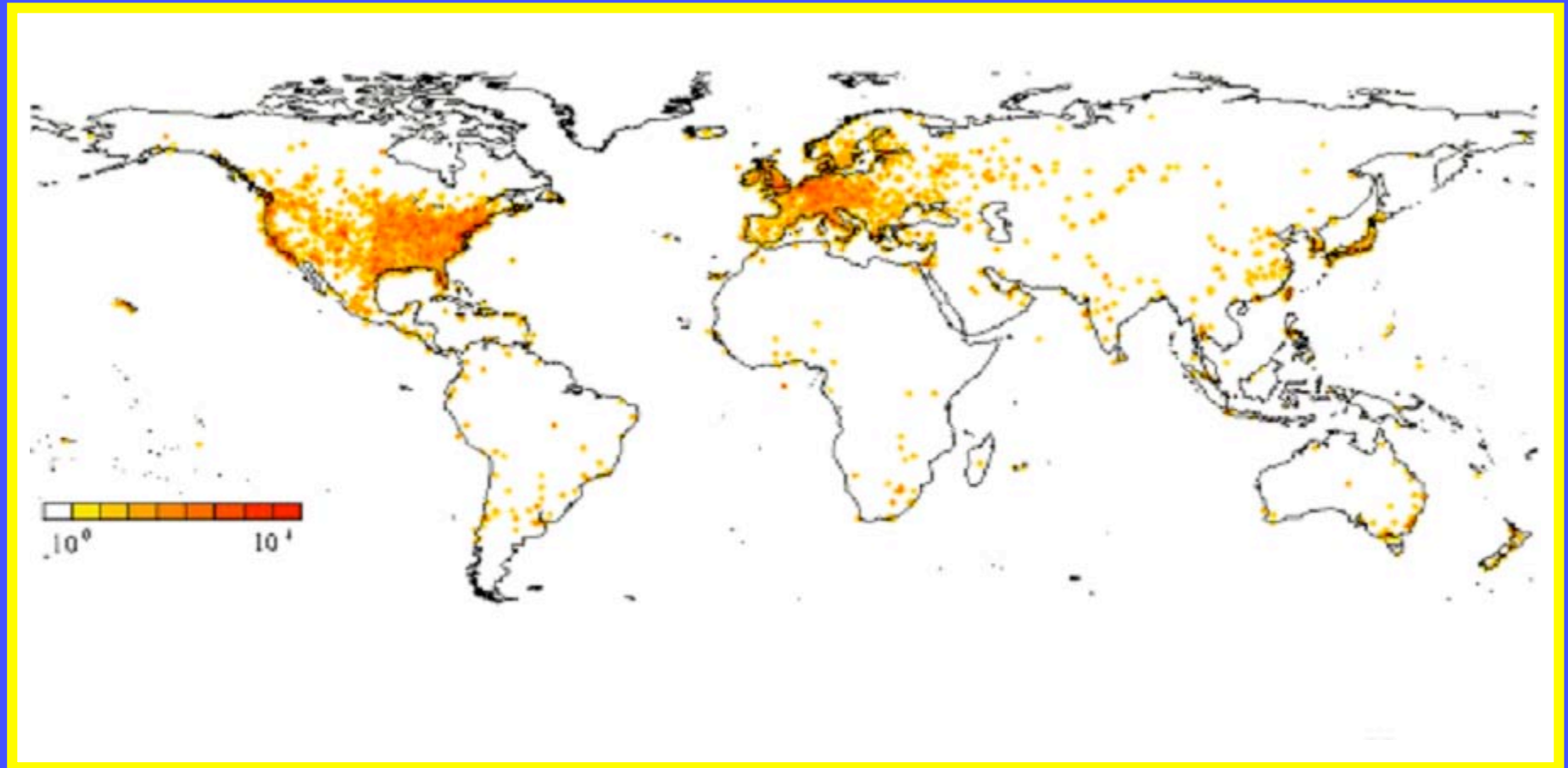
# Representation of Uncertainty

- Tails often more important than the mean
- Distributions for drivers and relationships
- Interdependencies among drivers
- Uncertainty increases with resolution
- Span ranges of models and scenarios

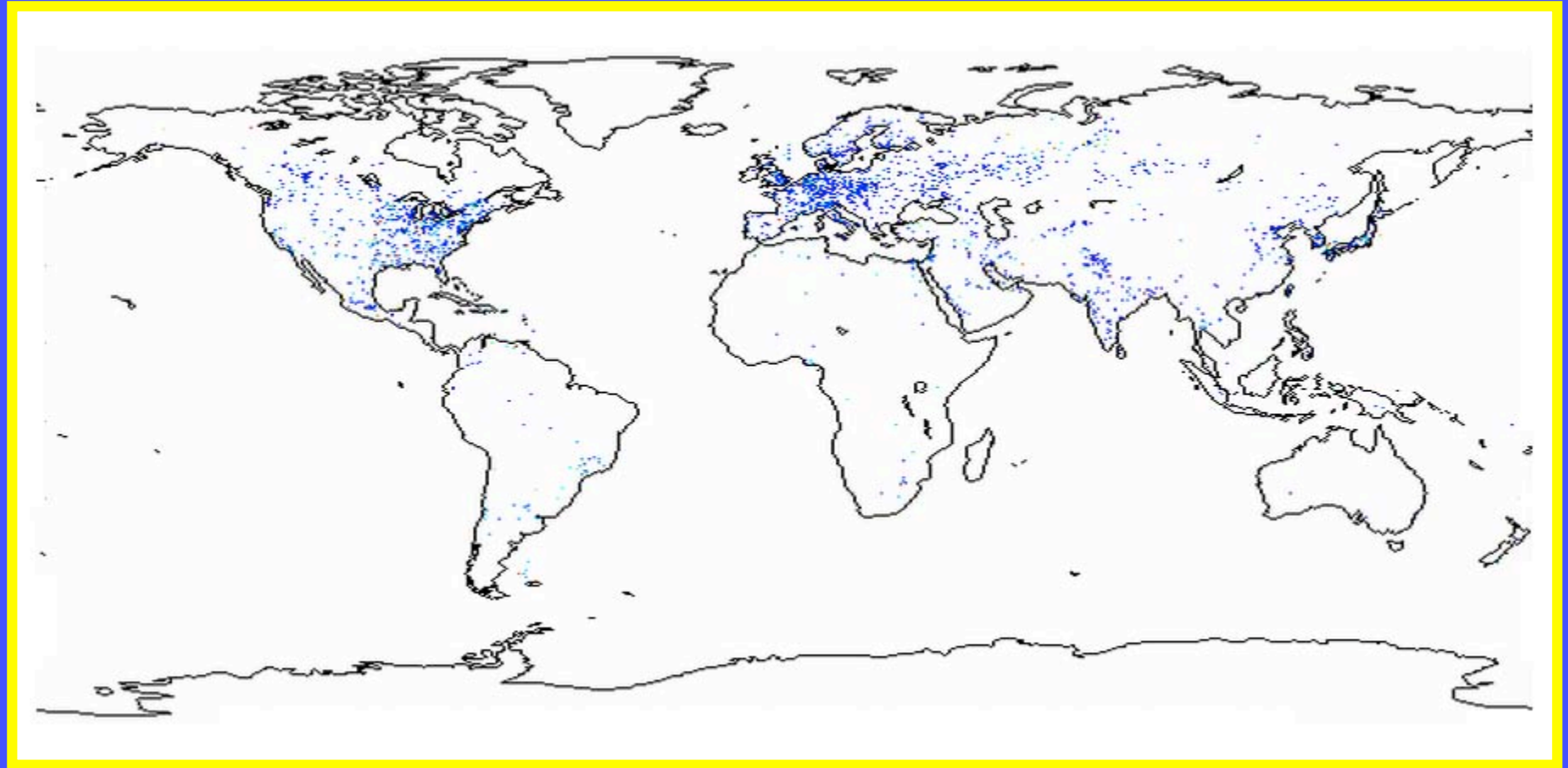
# Population



# Internet

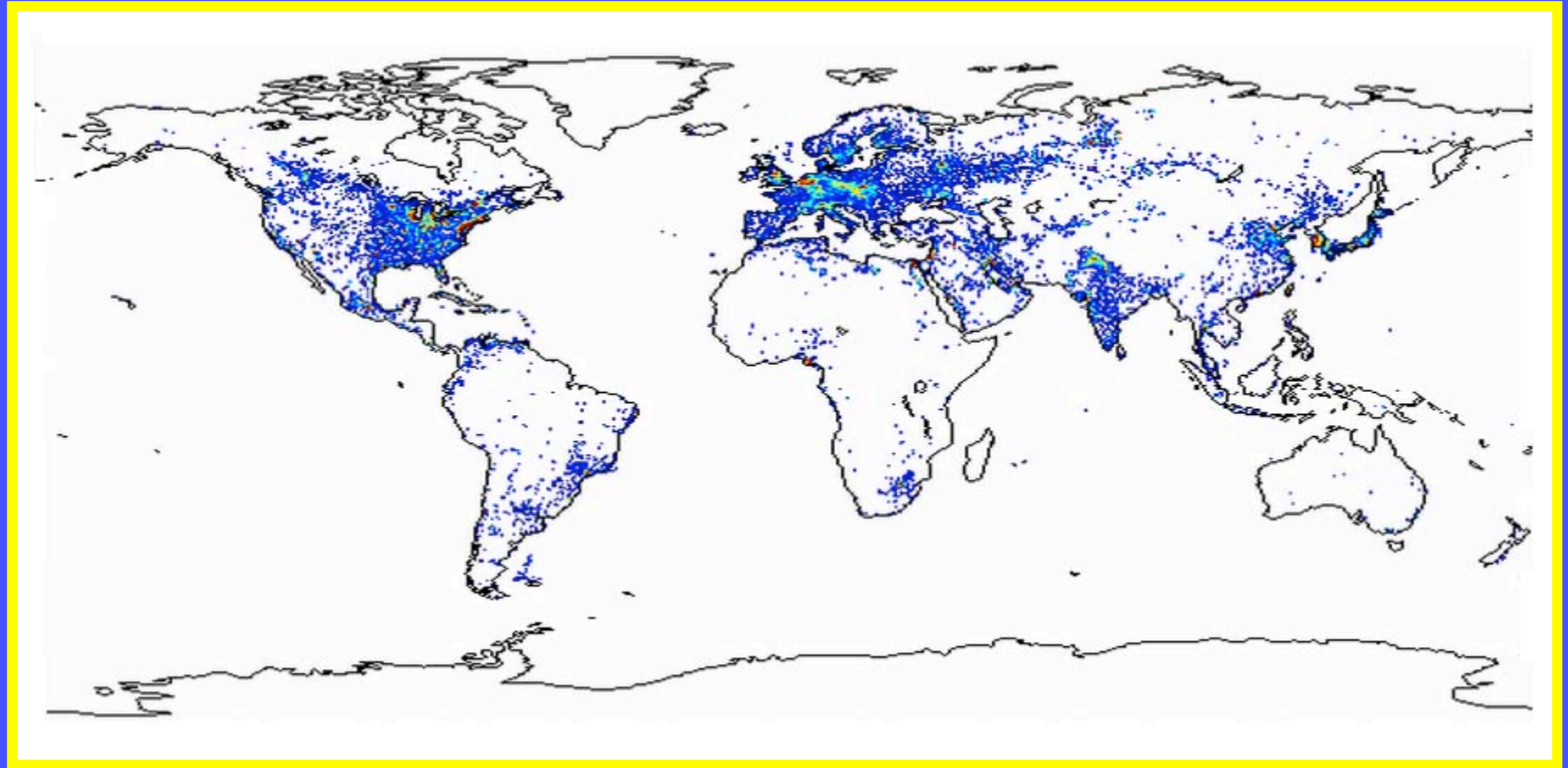


# Night Lights





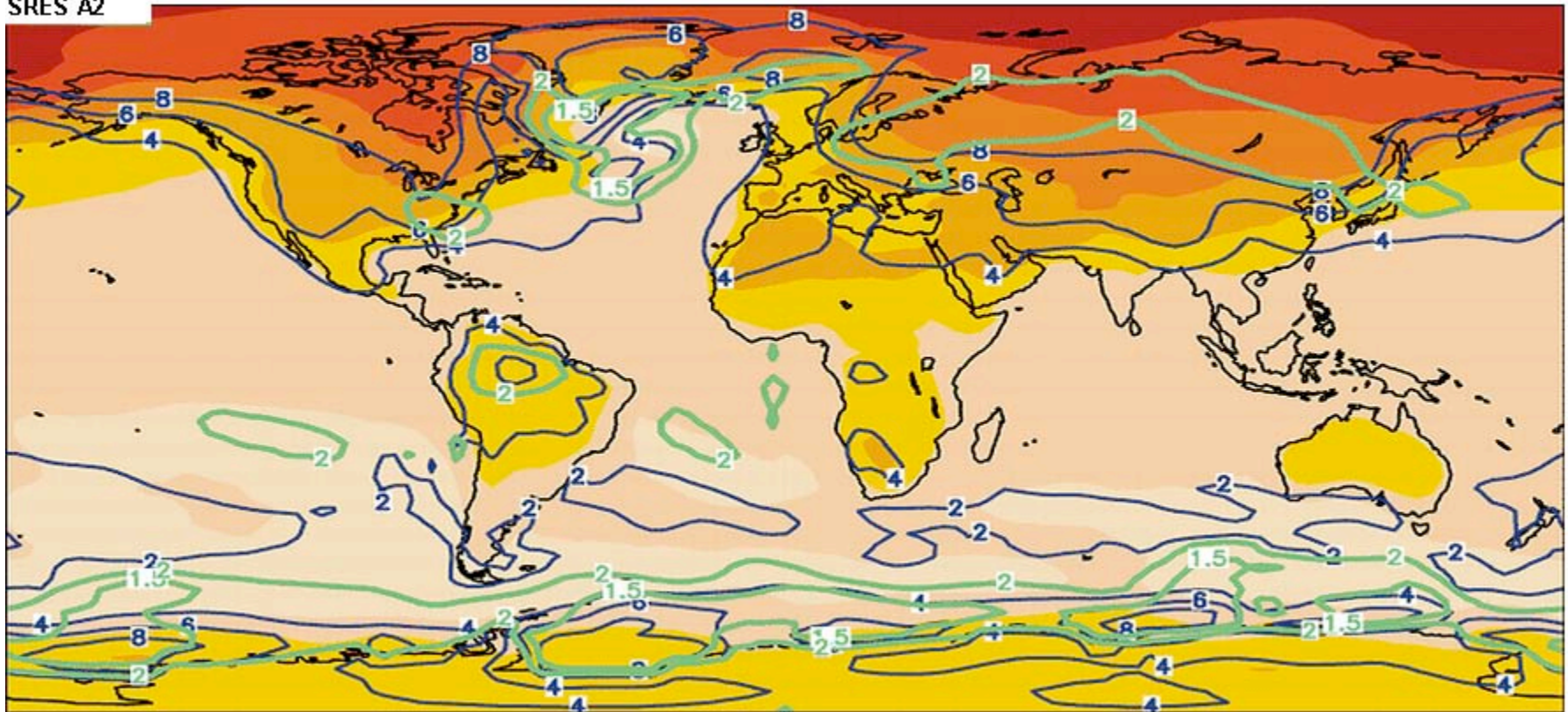
# Night Lights





# \_ Temperature

SRES A2



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