Coping with Uncertainty

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with Yuri Ermoliev and Arkady Kryazhimskiy

special thanks to:

Tanja Ermolieva, Volker Krey,
Keywan Riahi, Alexey Smirnov

Uncertainty and Systems Science

- Overview of uncertainty types
- Description of uncertainties (climate change & technology)
- Improved decision making (technology and insurance portfolios)
- Some IIASA highlights

A Taxonomy of Uncertainties

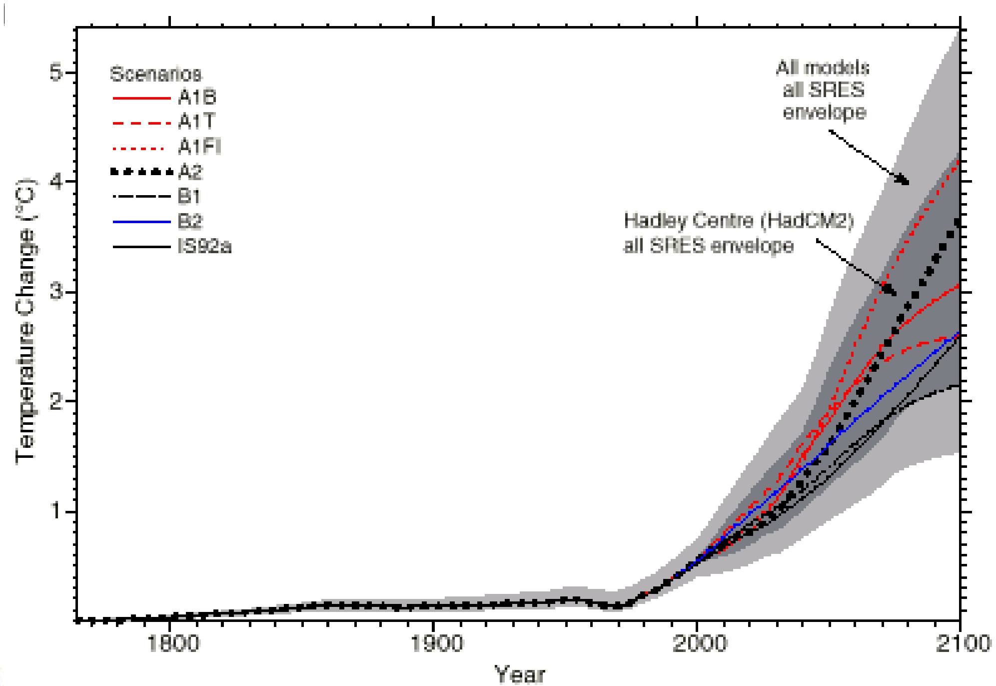
- **What's the problem?**
  Context and problem framing (linguistic) uncertainty

- **How big is it?**
  Data and modeling (epistemic) uncertainty

- **What should be done about it?**
  Policy response and effectiveness (contingency/agency) uncertainty

Example Climate Change:

Projected Global Mean Temperature Change and Sources of Uncertainty



INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

WMO UNEP

IPCC WG1 TAR: “By 2100, the range in the surface temperature response across the group of climate models run with a given scenario is comparable to the range obtained from a single model run with the different SRES scenarios”

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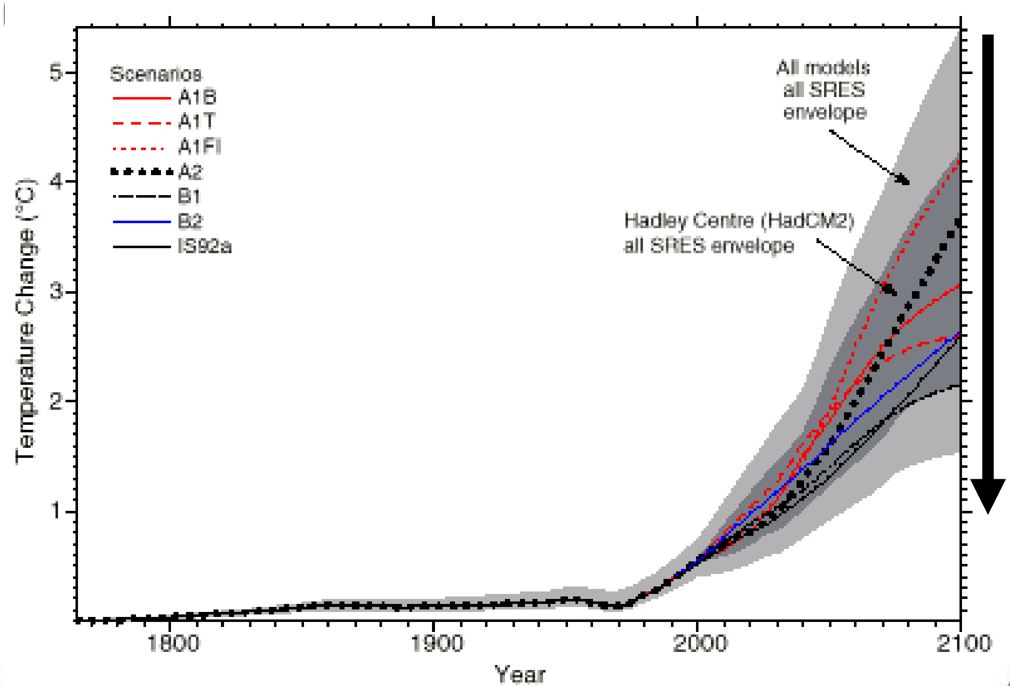


Baseline Uncertainty:
50 % climate (sensitivity) modeling
25% emissions (POP+GDP influence)
25% emissions (TECH influence)

Uncertainty on extent and success of climate policies

Ask the Experts?

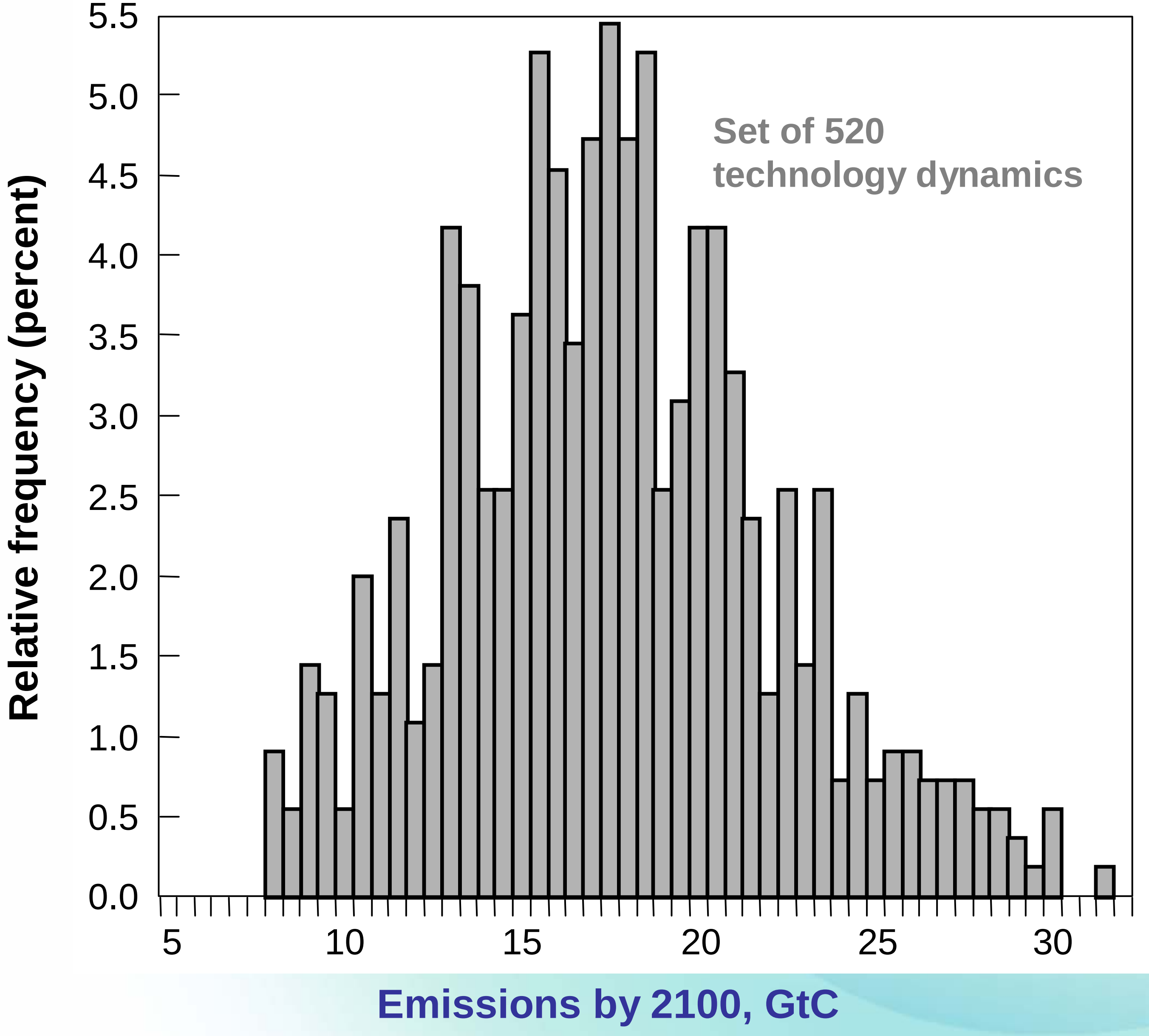
- *"Heavier-than-air flying machines are impossible."* Lord Kelvin, 1895.
- *"I think there is a world market for maybe five computers."* Tom Watson, IBM chair, 1943.
- *"But what ... is it good for?"* IBM engineer commenting on the microchip in 1968.
- *"There is no need for any individual to have a computer in their home."* Ken Olson, President, Digital Equipment, 1977.

More fun: http://my.athenet.net/~jlindsay/SkepticQuotes.html

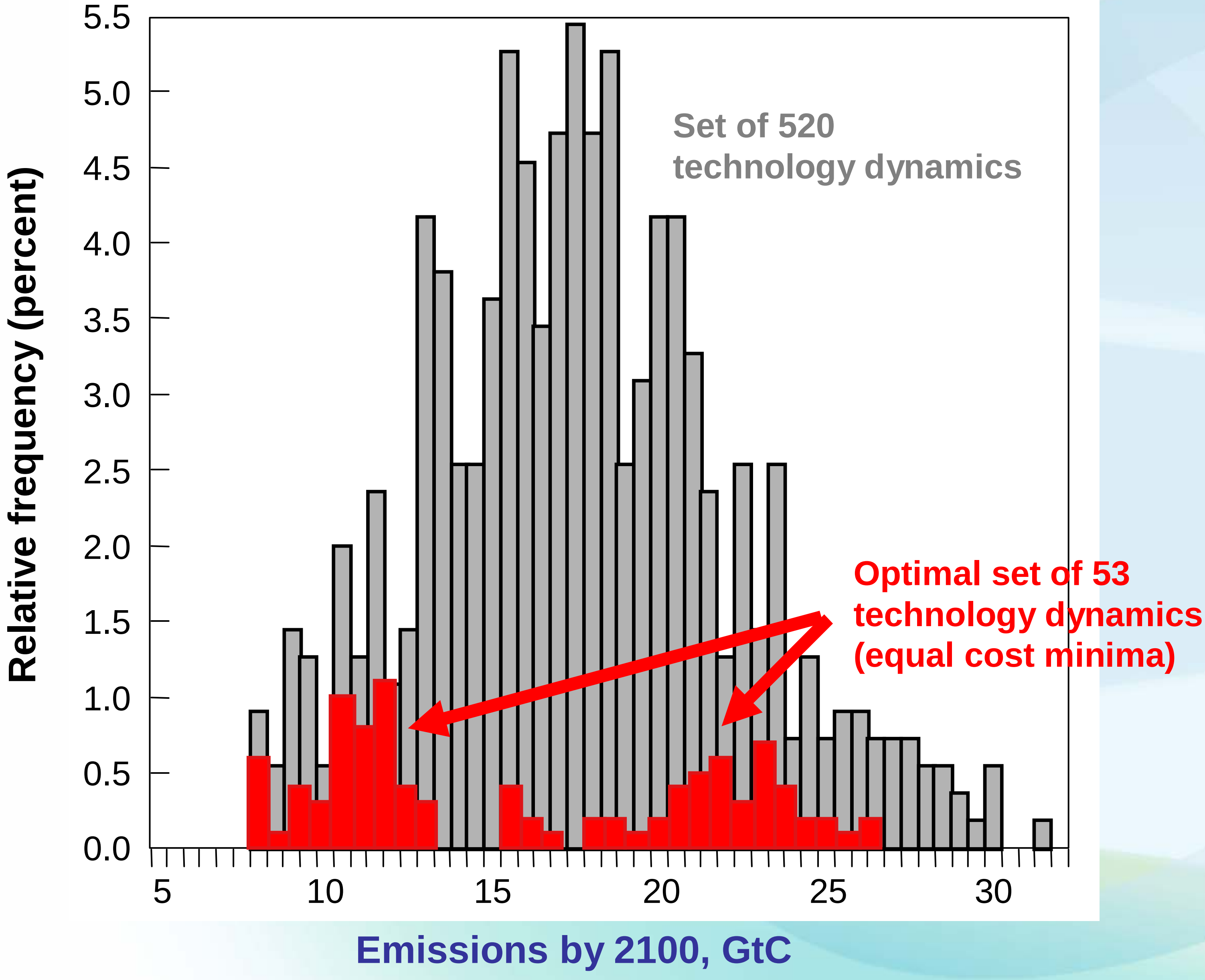
Describing Technological Uncertainty

- Andrii Gritsevskyi and Nebojsa Nakicenovic
- Full technology uncertainty and impacts on emissions (climate change)
- All major TC mechanisms: innovation uncertainty, increasing returns, spillovers
- Builds on of increasing returns work of Brian Arthur
- Use of massive parallel computing
- Uncertainty distribution bi-modal, illustrating lock-in into alternate states
- Environmental characteristics and costs not correlated (clean can be as cheap as dirty)

Emissions from 130,000 Scenarios of Technological Uncertainty



Emissions from 130,000 Scenarios of Technological Uncertainty



Linguistic/Context Uncertainty:

What does this plant do?

Linguistic/Context Uncertainty:

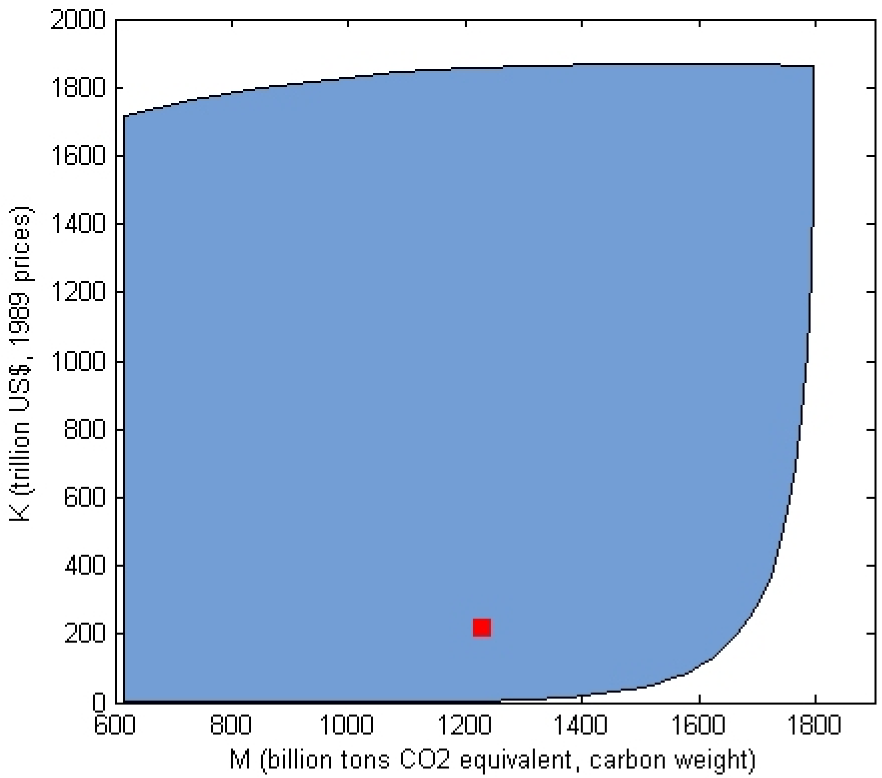
What does this plant do?

Vienna waste incinerator bowing to "green" public perception

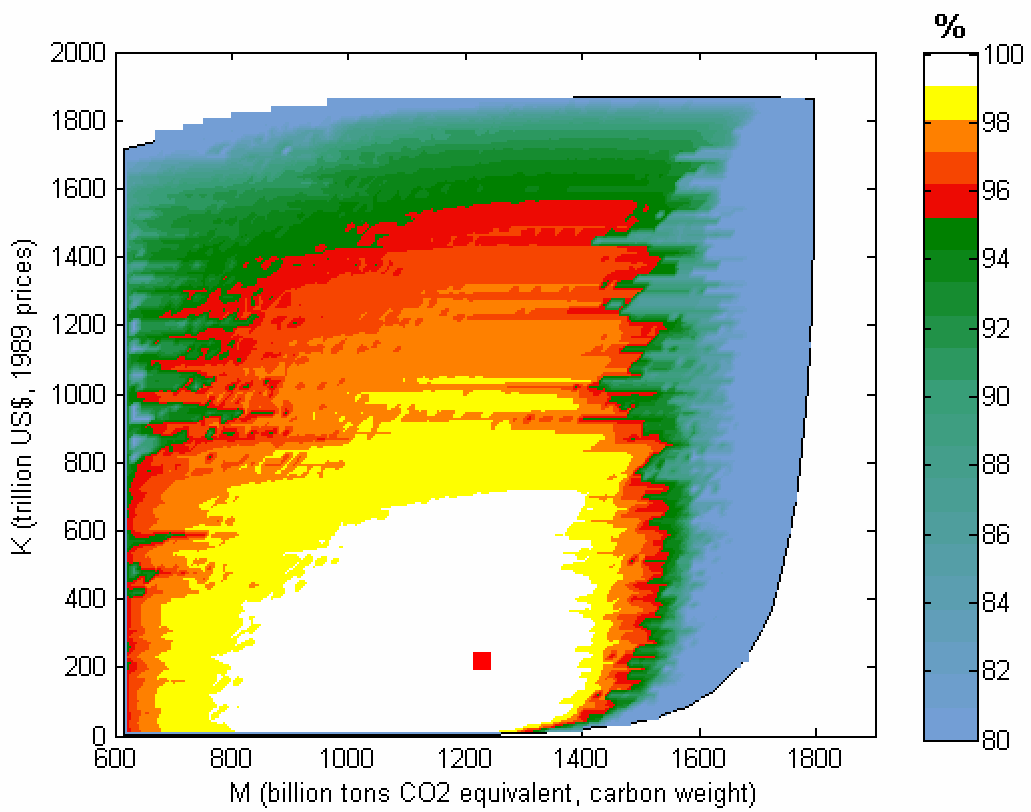
Attainability Domain Analysis of Climate Change Policy

- Analytical analysis of all possible states of Nordhaus' DICE model
- Two policy variables:
  investment & emissions (abatement)
- First performed by YSSP Alexey Smirnov
- Successive overlays of
  -- objective function, revealing "indifference" space (linguistic ambiguity of "optimality")
  -- risk surfaces of catastrophic event (thermohaline shut-down with different climate sensitivities based on Keller *et al.*)

Attainability Domain of DICE with original Optimality Point 2100

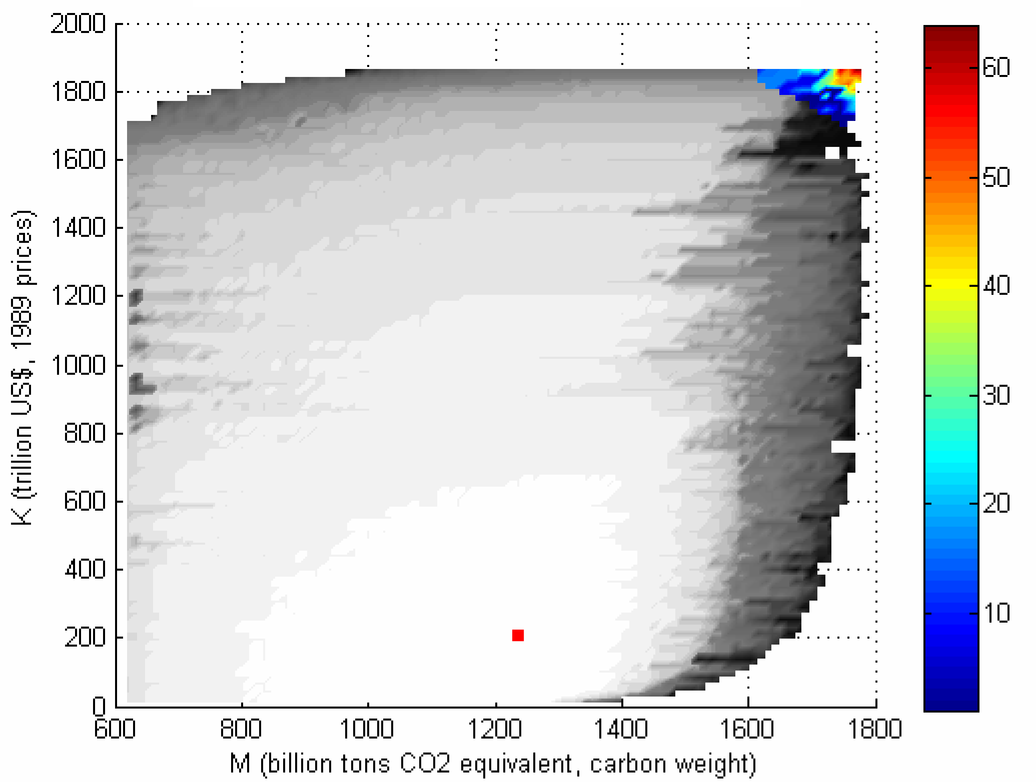


DICE Attainability Domain and Isolines of Objective Function Surface



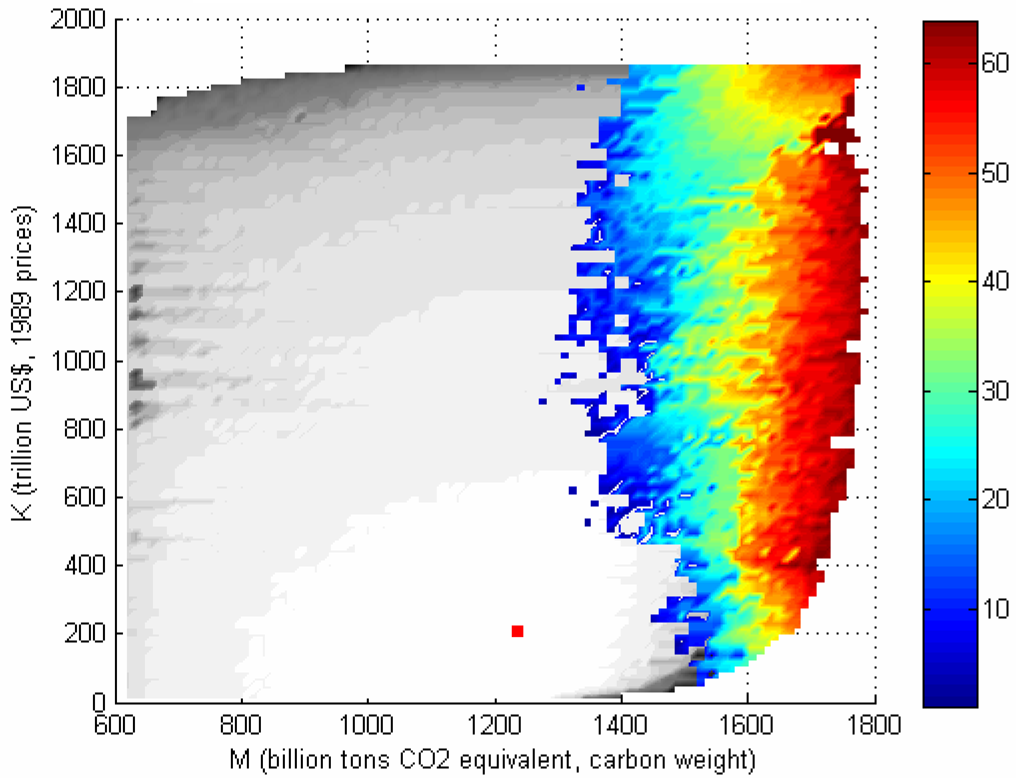
Percent of max. of objective function.
Note the large “indifference” area

Attainability Domain, Objective Function, and Thermohaline Collapse Risk Surfaces



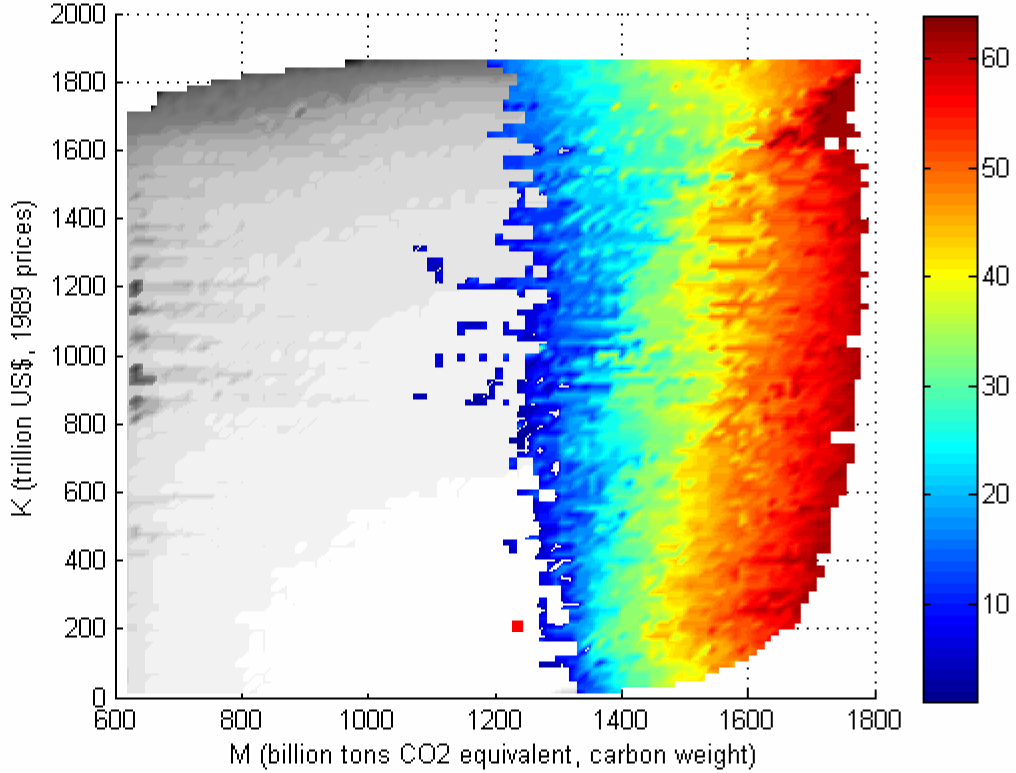
Risk Surface of Thermohaline collapse
(years of exposure 1990-2100)
climate sensitivity = 3 ºC

Attainability Domain, Objective Function, and Thermohaline Collapse Risk Surfaces



Risk Surface of Thermohaline collapse
(years of exposure 1990-2100)
climate sensitivity = 3.5 ºC

Attainability Domain, Objective Function, and Thermohaline Collapse Risk Surfaces



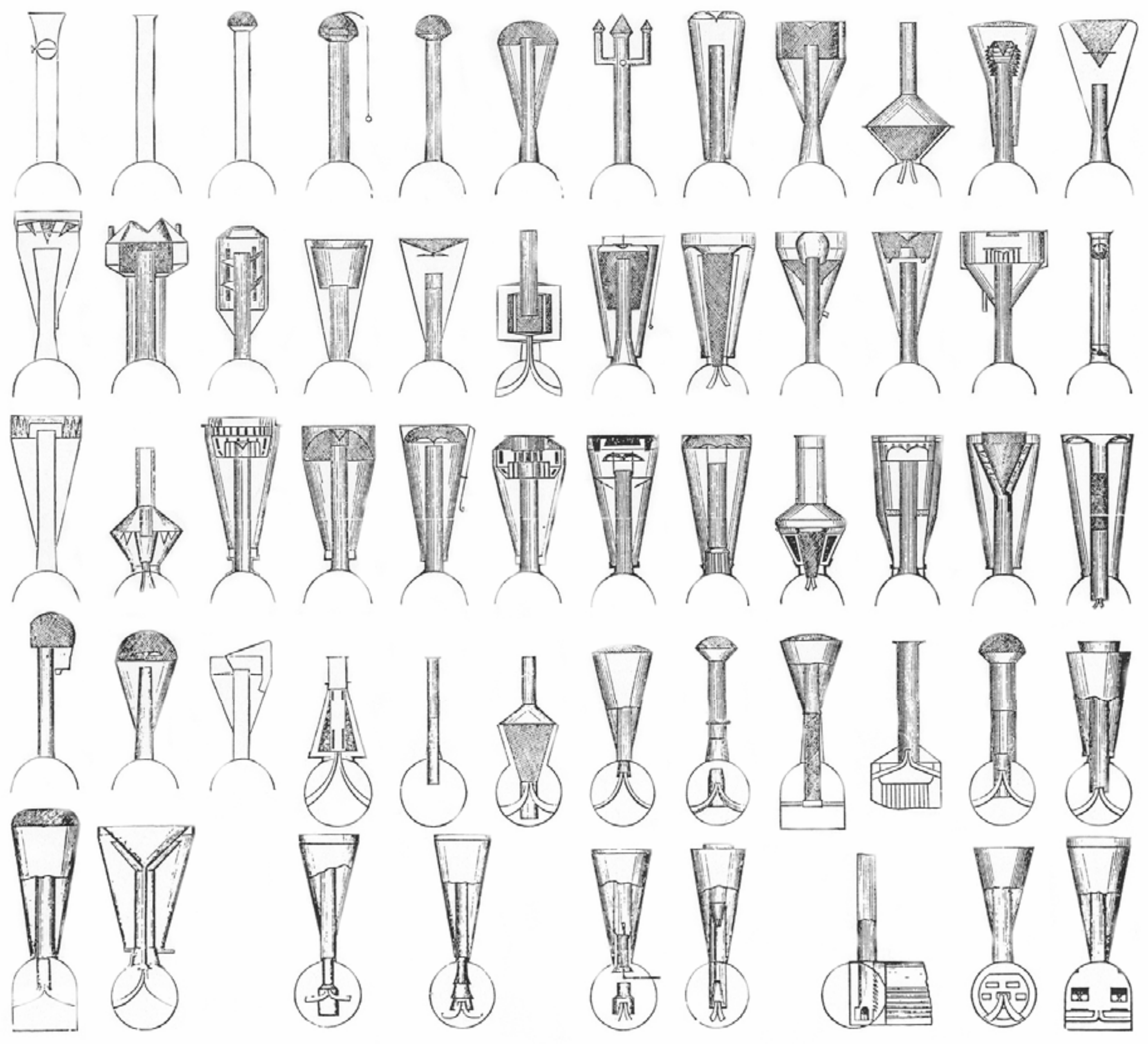
Risk Surface of Thermohaline collapse
(years of exposure 1990-2100)
climate sensitivity = 4 ºC

Improved Decisions under Uncertainty

- Exploration of full uncertainty space
- Explicit treatment of risk
- Risk hedging via portfolio approach
- Today (*pars pro toto*):
  stochastic programming as applied to:
  - technology portfolios (Riahi/Krey)
  - insurance portfolio diversification
    for catastrophic risks (Ermolieva et al.)

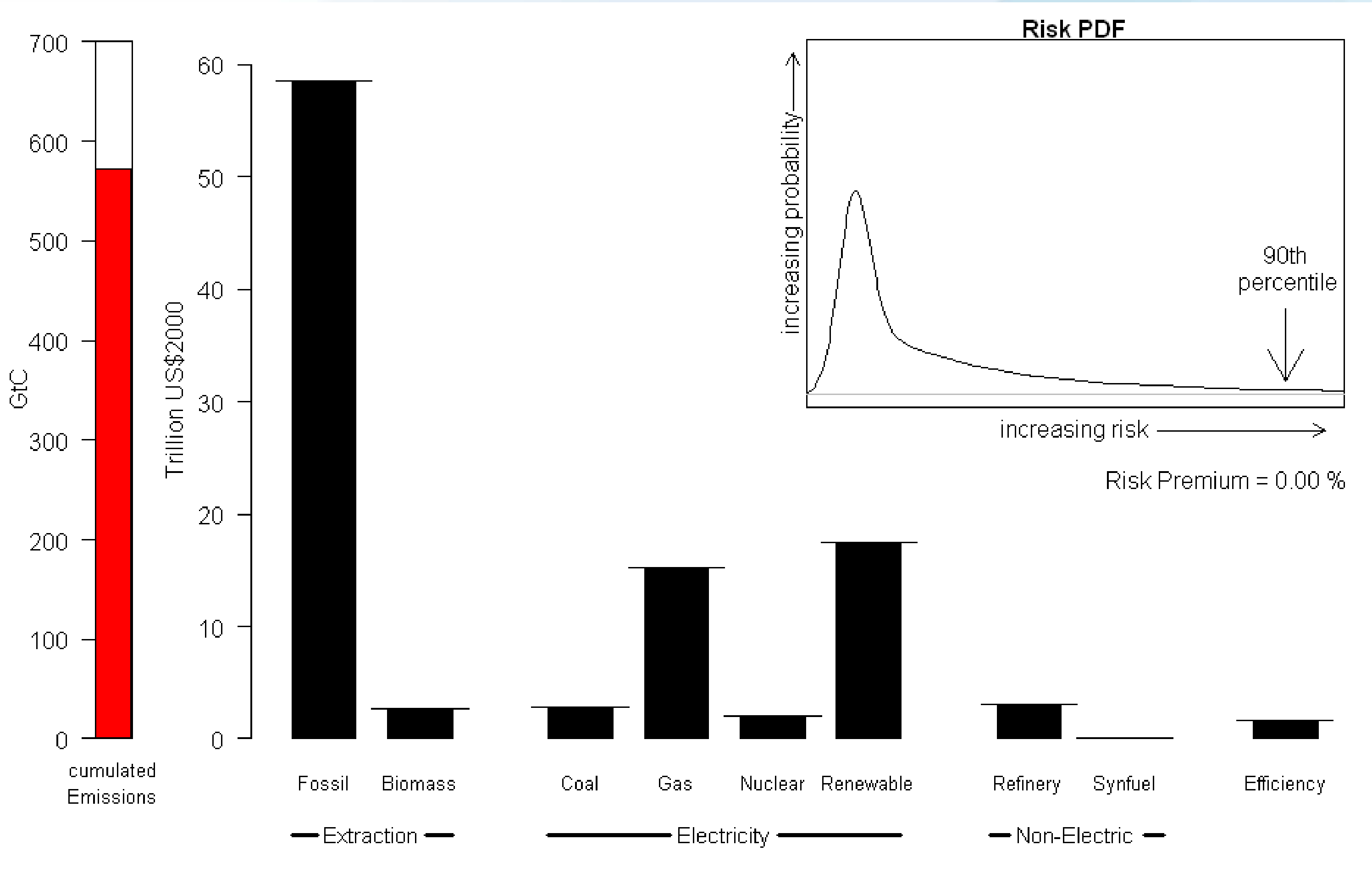
Technological Uncertainty :

Patented but non-functional smoke-spark arrestors



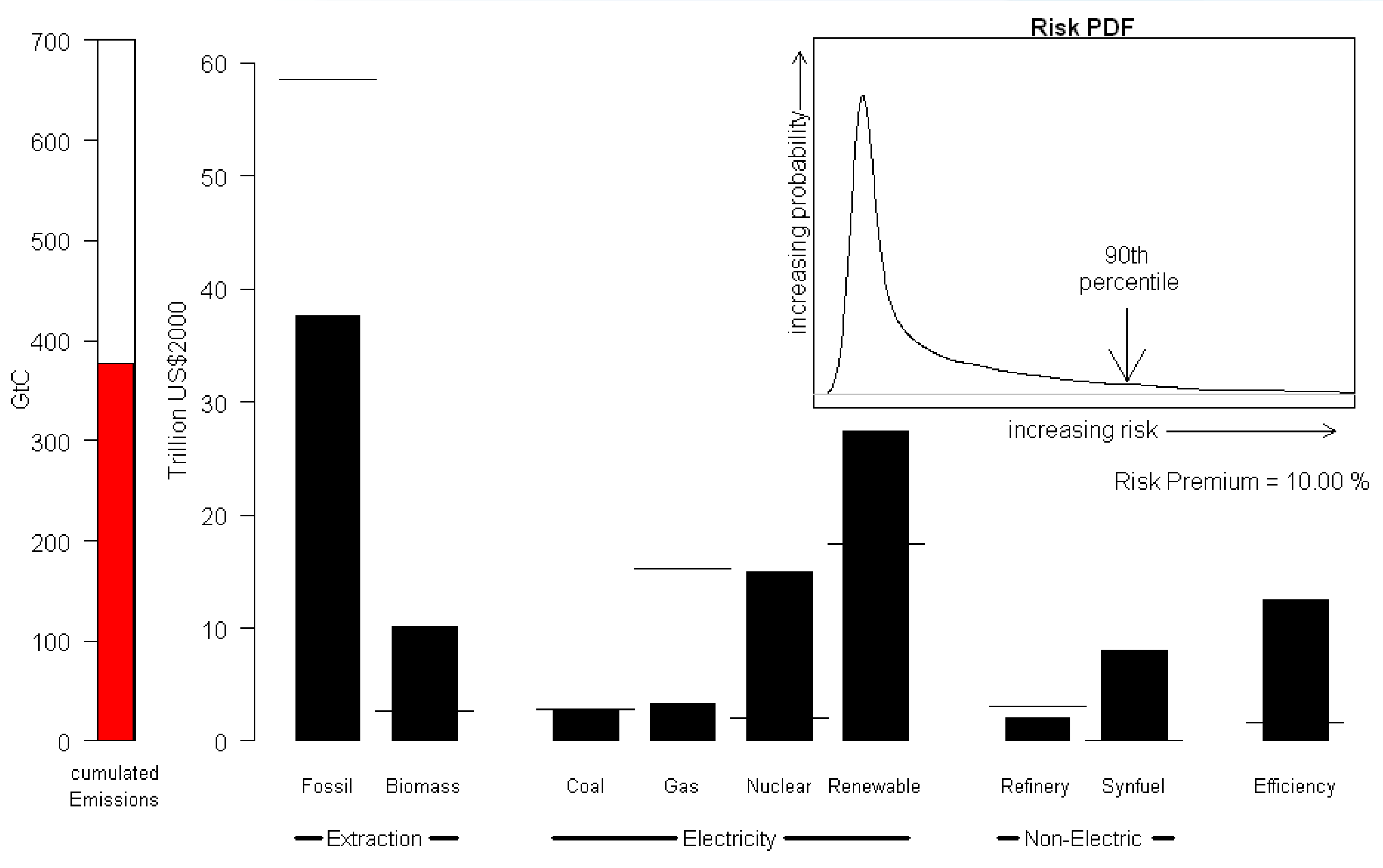
Source: J. White, *American Locomotives*, 1968.

Energy Technology Portfolio Investments and Resulting Cumulative Carbon Emissions without uncertainty



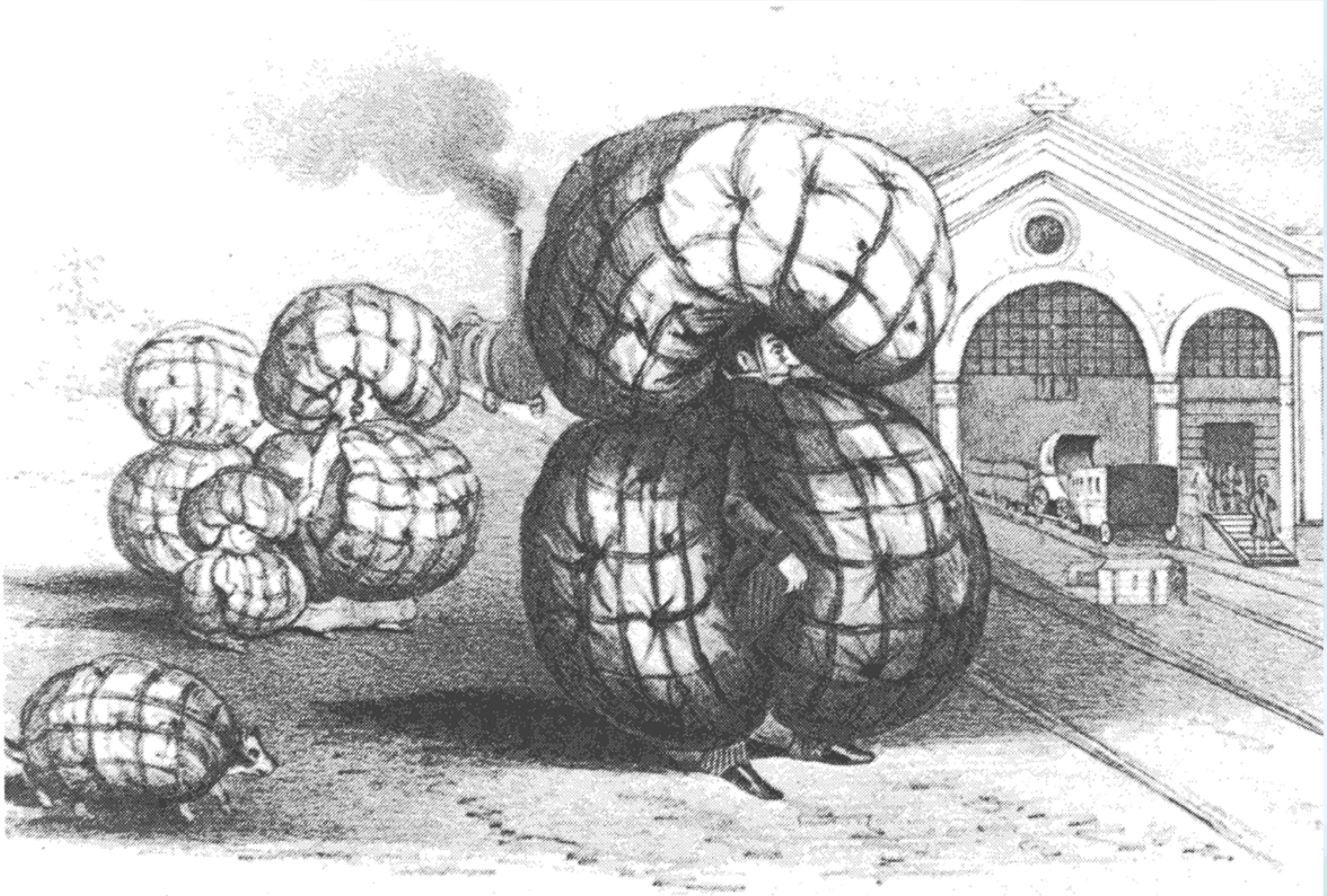
Stochastic MESSAGE model (Keywan Riahi & Volker Krey)

Energy Technology Portfolio Investments and Resulting Cumulative Carbon Emissions under Uncertain Costs and Uncertain Carbon Taxes



Stochastic MESSAGE model (Keywan Riahi & Volker Krey)

Risk Management: The Precautionary Principle?

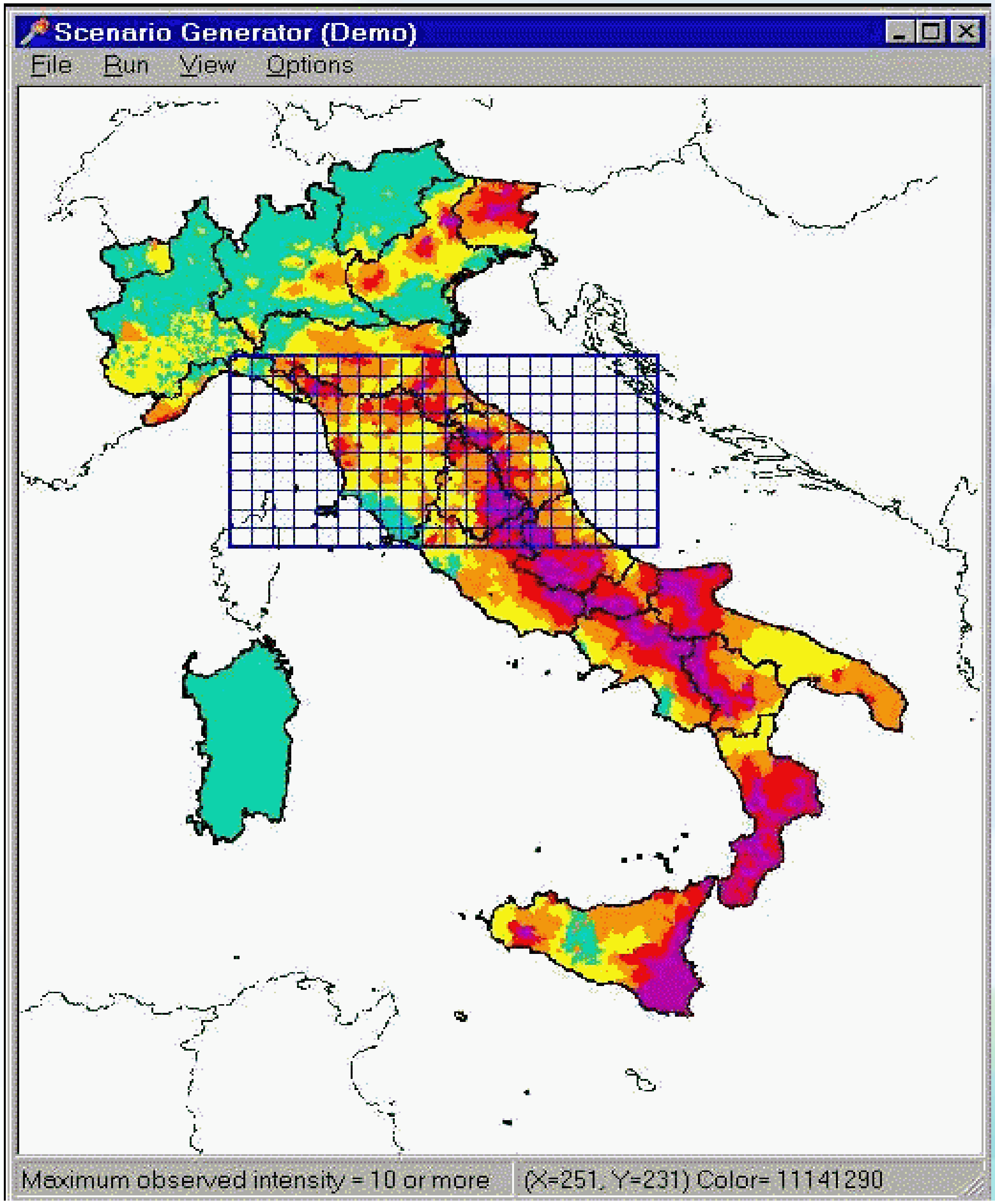


Protective clothing for railway passengers (1847)

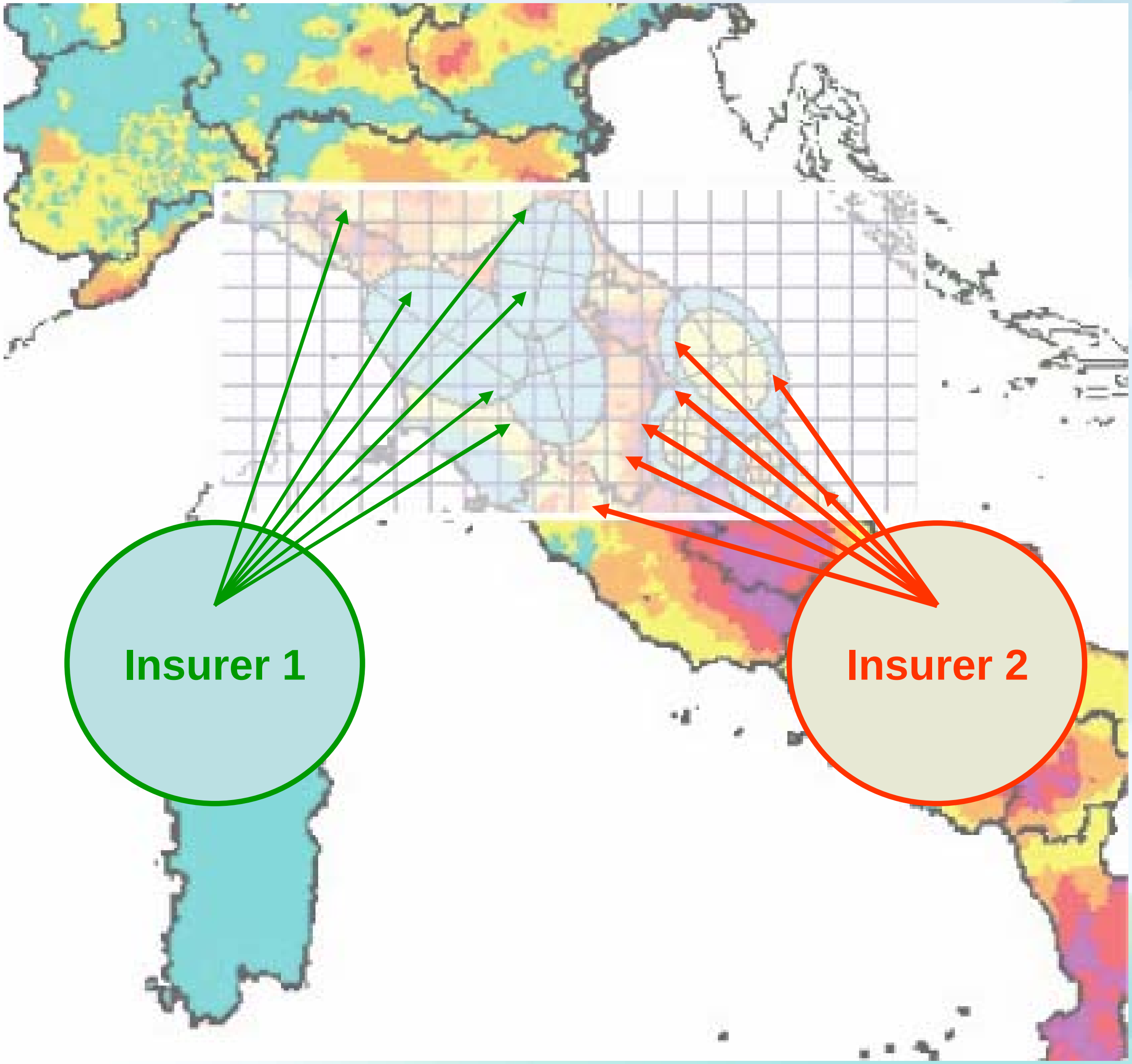
Improved Decisions under Uncertainty

- Catastrophic risk management (e.g. floods, disease, earthquakes)
- Multi-agent and spatially explicit analysis
- Probabilistic "catastrophe generators" coupled with risk management (stochastic optimization)
- Example: Earthquake insurance risk management in Italy
- IIASA colleagues: T. Ermolieva, Y. Ermoliev, F. Fischer, G. MacDonald, et al.

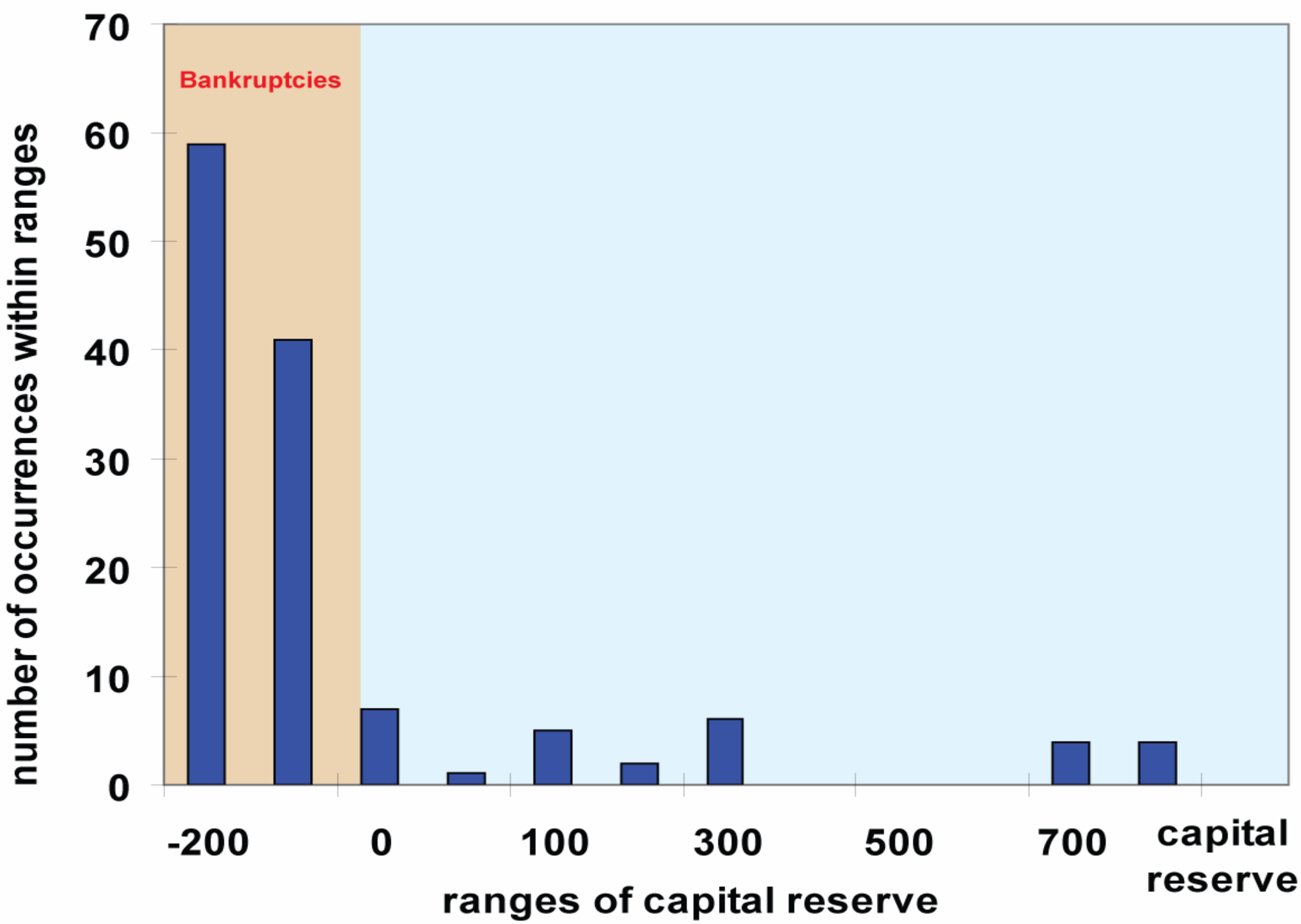
Study Region and Earthquake Scenario Generator



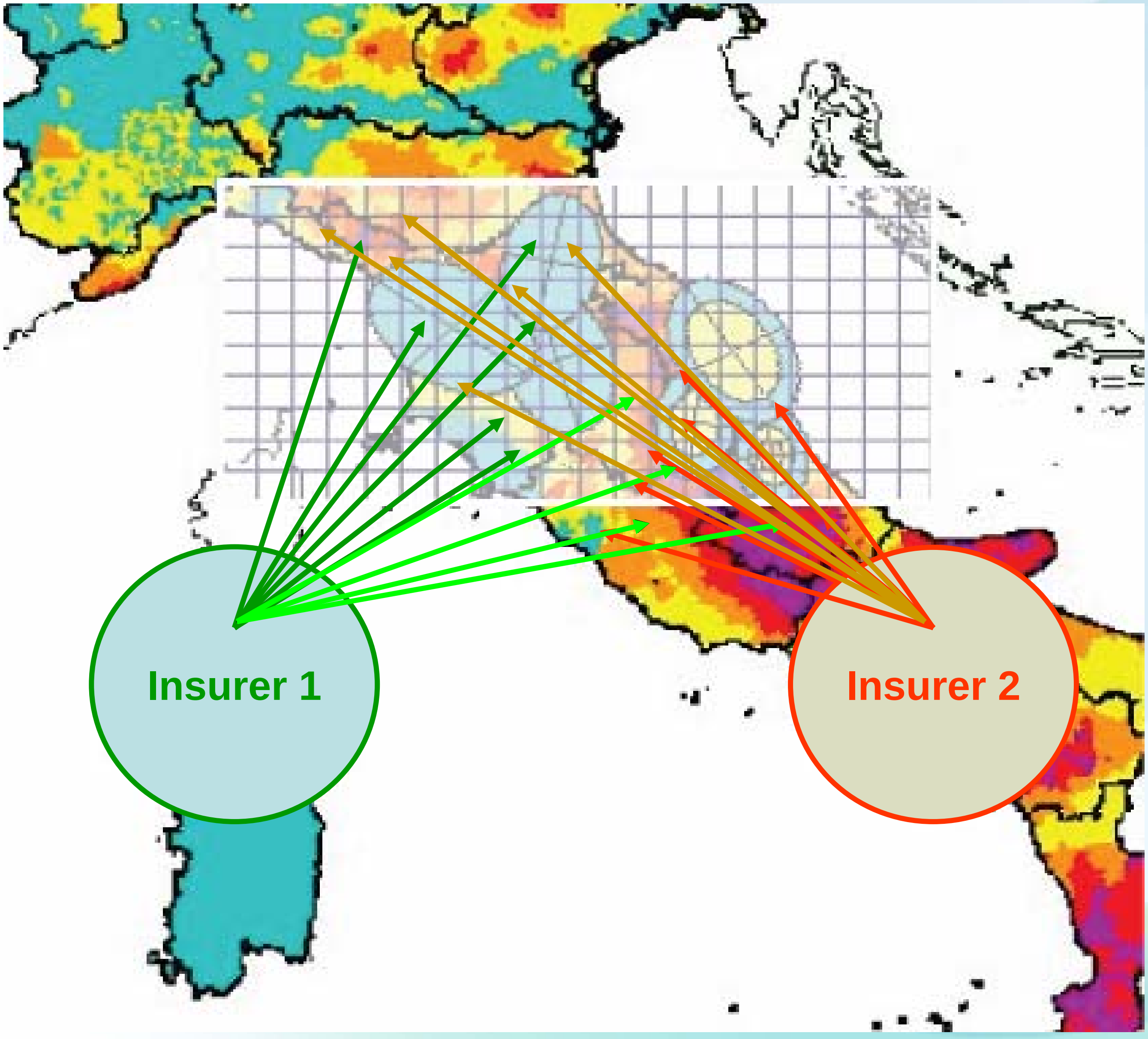
Initial Spread of Insurers' Coverage



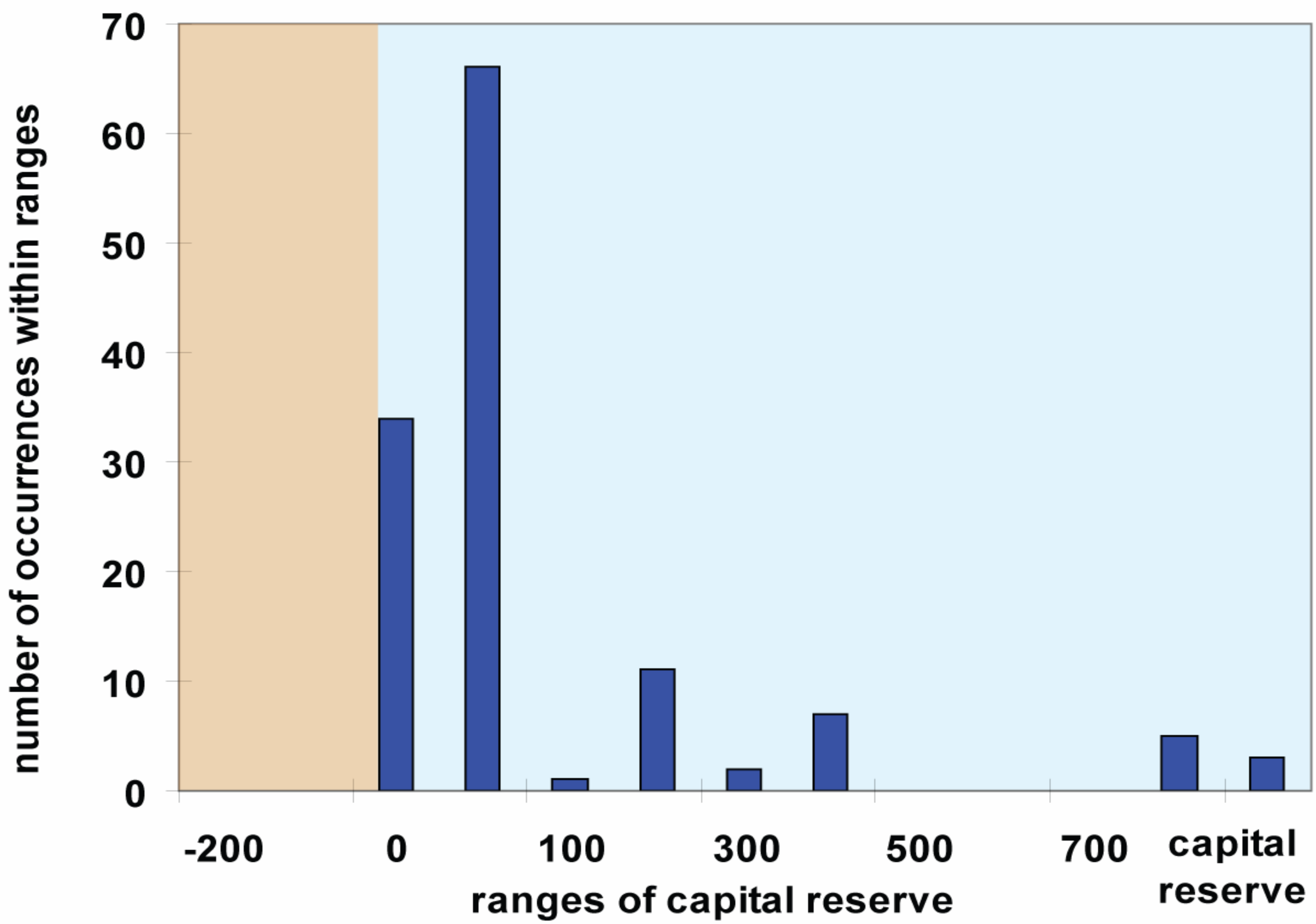
Initial Spread with Insufficient Diversification



Optimized Spread



Optimized Spread: No Risk of Bankruptcies



Summary and Conclusion

- Important IIASA achievements
- Recurrent threads:
  -- multi-models, multi-disciplines
  -- treatment of risk as decision variable
  -- risk hedging
  -- address public goods problem
  (environment, knowledge, spillovers)
- Importance of patient, long-term basic research strategy, recognizing long diffusion time