Climate Treaties and Approaching Catastrophes

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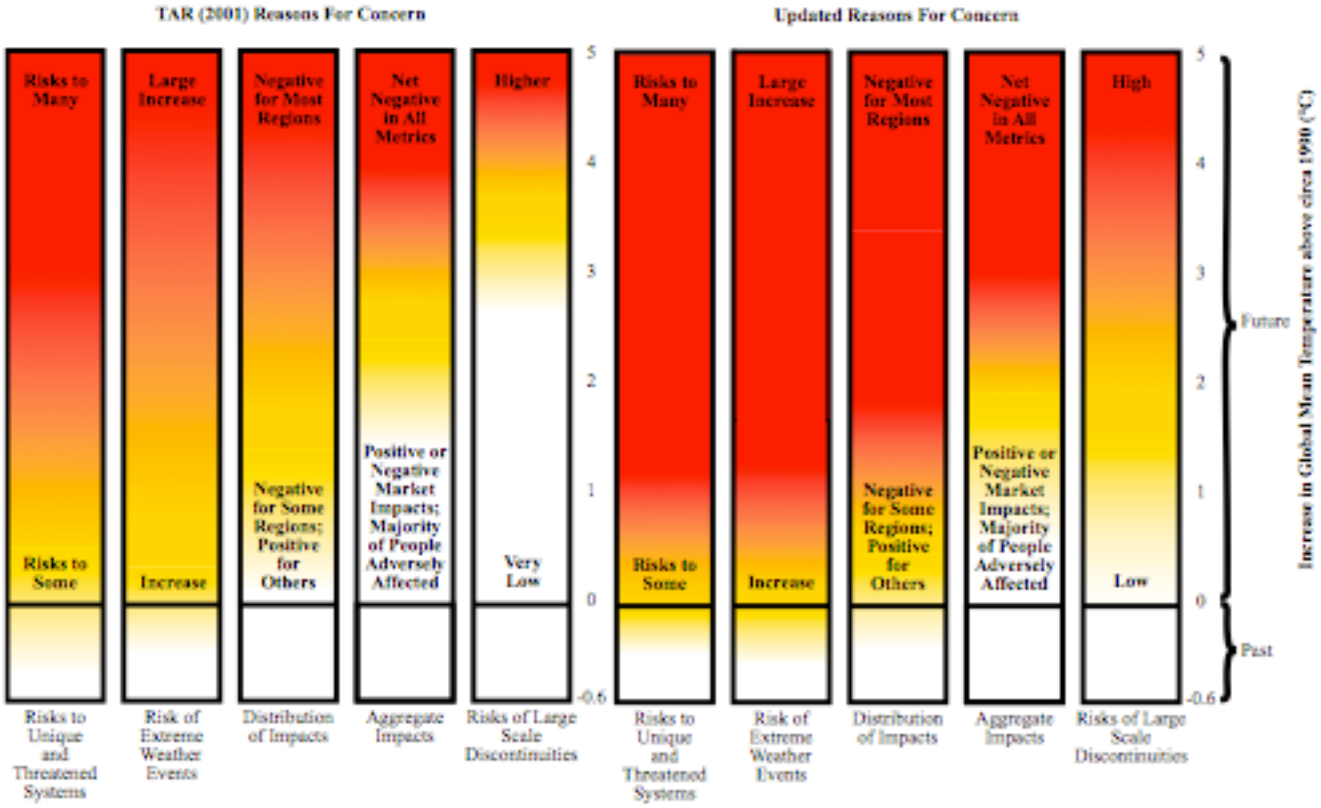
Politics of "dangerous" climate change

- Framework Convention says that atmospheric concentrations of greenhouse gases should be stabilized "at a level that would prevent *dangerous* [my emphasis] anthropogenic interference with the climate system."
- Copenhagen Accord recognizes "*the scientific view* that the increase in global temperature should be below 2 degrees Celsius."

Science of "dangerous" climate change

- IPCC TAR identified "reasons for concern," and constructed the "burning embers diagram," which **Smith et al. (2009)** updated.
- Lenton *et al.* (2008) identify a number of tipping points, mainly clustering around 0.5-2 °C and 3-5 °C.
- Rockstrom *et al.* (2009) recognize the political primacy of the 2 °C target, but propose a "climate boundary" of 350 ppm CO_2 by volume and an increase in radiative forcing not to exceed 1 W/m^2 above pre-industrial levels.

“Burning embers diagram”



Smith et al. (2009). “Assessing Dangerous Climate Change through an Update of the Intergovernmental Panel on Climate Change (IPCC) “Reasons for Concern” PNAS 106: 4133-4137.

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Possible thresholds due to "global warming"

Change	Threshold
Disappearance of Arctic summer ice	0.5-2°C
Loss of Greenland Ice Sheet	1-2°C
Disintegration of West Antarctic Ice Sheet	3-5°C
Shutoff of Atlantic Thermohaline Circulation	3-5°C
Shift in El Nino-Southern Oscillation	3-6°C
Shift in Sahara/Sahel and West African monsoon	3-5°C
Amazon rainforest dieback	3-4°C
Boreal forest dieback	3-5°C

Source: Lenton *et al*. (2008).

Note: thresholds are uncertain; impacts are uncertain; the table is not exhaustive.

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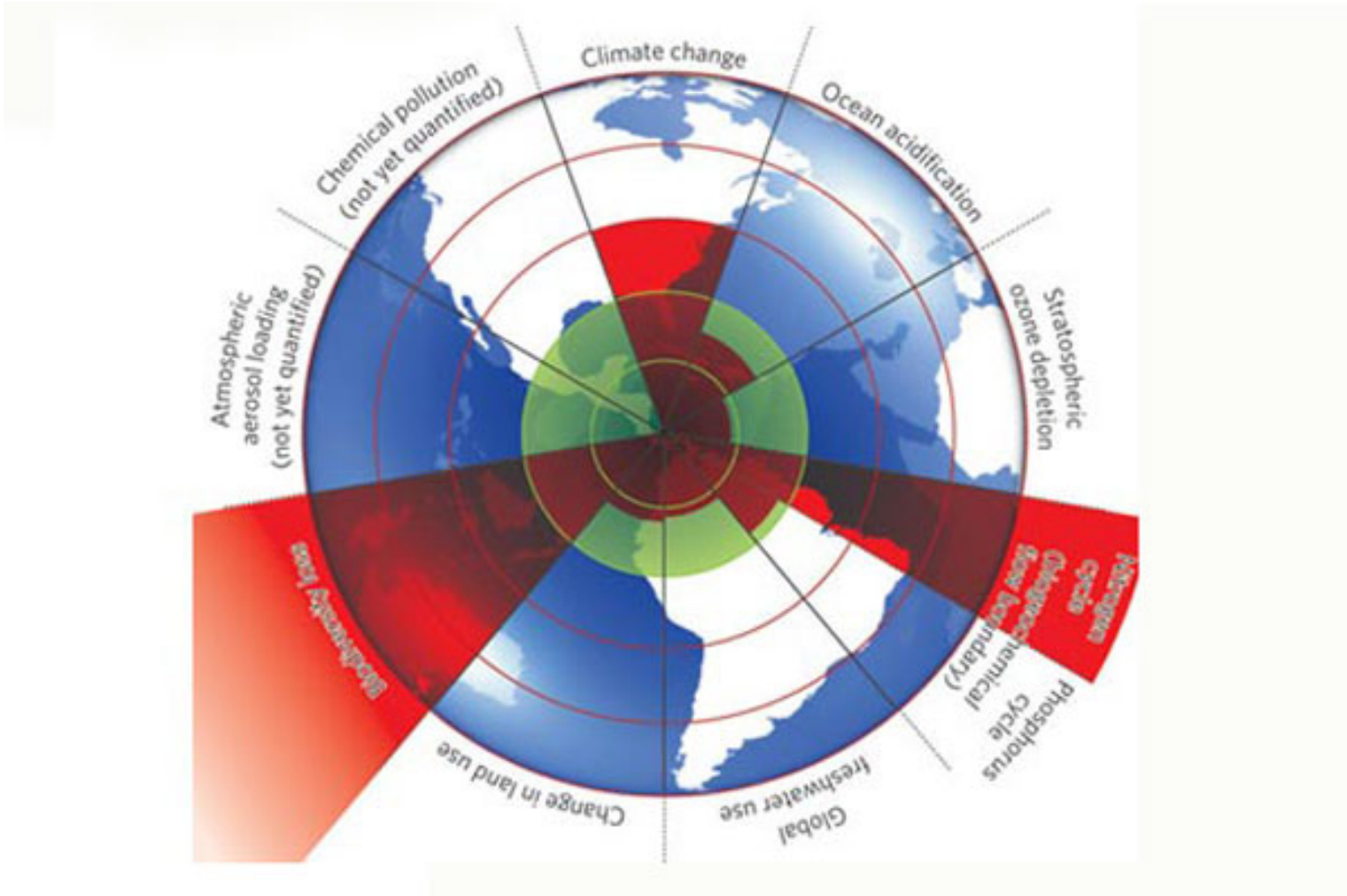
Planetary boundary



350 ppm CO_2

Planetary boundary

- One reason for picking this threshold is stability of the large polar ice sheets.
- "…the planet was largely ice-free until CO2 concentrations fell below 450 ppmv (± 100 ppmv), suggesting that there is a critical threshold between 350 and 550 ppmv.
- "Our boundary of 350 ppmv aims *to ensure* the continued existence of the large polar ice sheets."

Meanwhile….

- Durban Decisions note "*with grave concern* the significant gap between the aggregate effect of Parties' mitigation pledges in terms of global annual emissions of greenhouse gases by 2020 and aggregate emission pathways consistent with having a likely chance of holding the increase in global average temperature below 2 °C… above pre-industrial levels."

What will happen at 2°C?

If the consequences were *truly* catastrophic, would cooperation be any easier?

Would the US even contribute

under these circumstances?

Would treaties be more effective

if their purpose were to avert catastrophe?

A game!

- There are 10 players.
- Everyone starts with two operating funds.

Everyone has two operating funds

£1 in Account A

Up to 10 windmills at 10p each.

£10 in Account B

Up to 10 AC machines at £1 each.

Everyone also has an endowment fund

- Worth £20.
- This cannot be spent.

Payoffs

- Everyone gets to keep the money they don't spend from these accounts.
- Plus everyone gets 5p for every machine deployed by anyone.
- So, if you give 6 windmills and nothing from Account B, and everyone else contributes 50 machines, you get
- 56×£.05 + 4×£.1 + 10×£1 + £20 = £33.20.

Analysis

- Collective best—everyone contributes all of Account A, none of Account B.
- Every player gets 100×£.05 + £10 + £20 = £35.
- Self-interest makes everyone want to keep their money, yielding everyone £31.

What kind of game is this?

A Prisoners' Dilemma!

Catastrophic climate change

- Suppose there will be a catastrophe if fewer than 150 machines are deployed.
- If there is a catastrophe, everyone loses £15.
- So, if you give 6 windmills and nothing from Account B, and everyone else contributes 50 machines, you get
- 56×£.05 + 4×£.1 + 10×£1 + £20 - £15 = £18.20.

Analysis

- Collective best—everyone contributes all of Account A and 5 units from Account B.
- Every player gets 150×£.05 + £5 + £20 = £32.50.
- Self-interest makes everyone want to hold onto their money, yielding everyone £16.

But wait

- Self-interest also makes everyone want to contribute some machines, provided everyone else contributes *enough* machines.
- For example, suppose everyone else contributes 138 machines.
  - If you contribute 0, you get 138×£.05 + £1 + £10 + £20 - £15 = £22.90.
  - If you contribute 12 machines, you get 150×£.05 + £8 + £20 = £35.50.

Two compelling outcomes

- One is where no one contributes.
- The other is where the total contribution averts catastrophe.
  - Everyone can be better off in this second situation.
  - For example, if everyone contributes 15 machines, everyone gets £32.50.
  - If everyone contributes 0 machines, everyone gets £16.

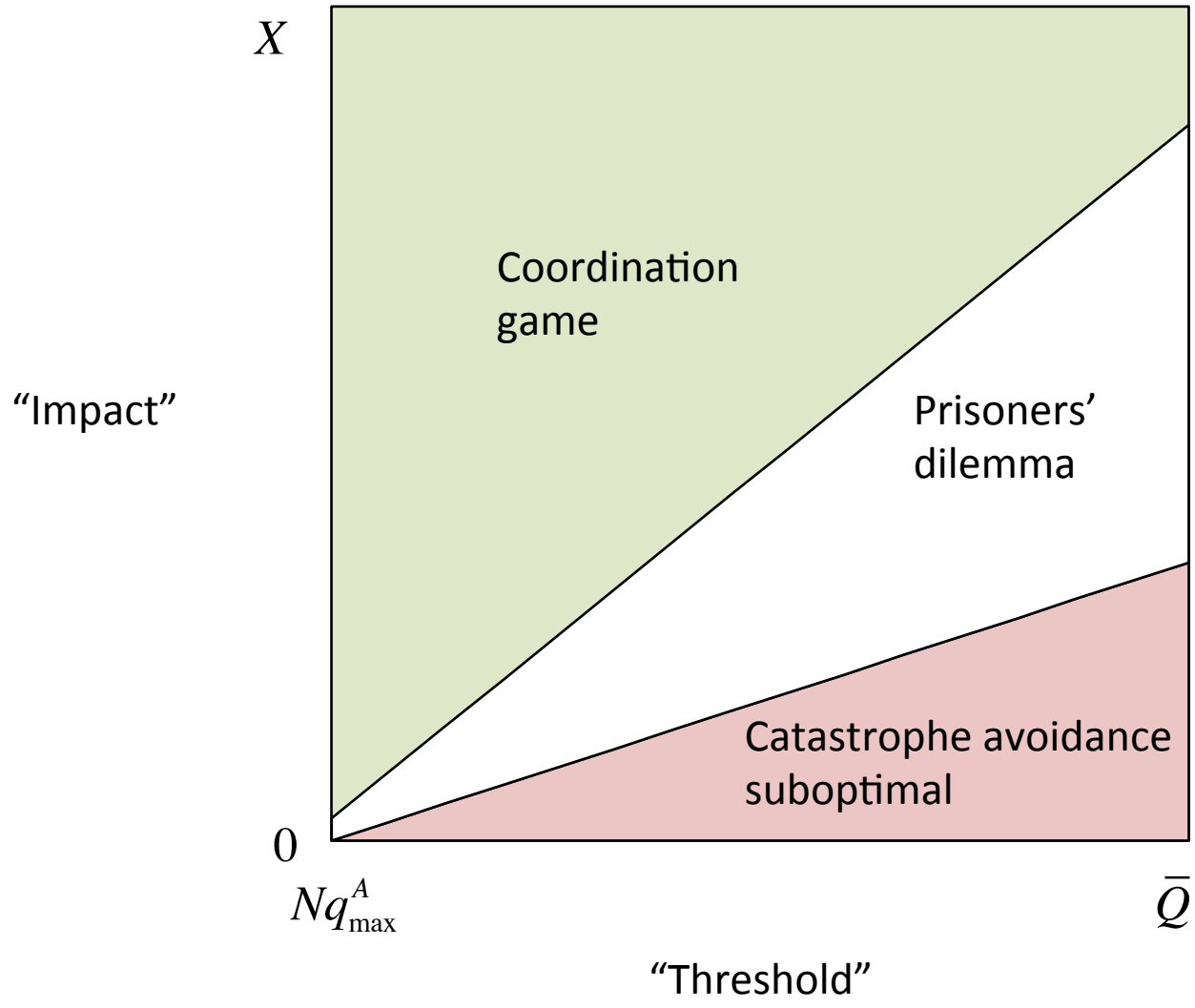
What kind of game is this?

A Coordination Game

The difference

- In the Prisoners' Dilemma, the central challenge is enforcement.

- In the Coordination game, enforcement is provided by Mother Nature!


X
Coordination game
Prisoners' dilemma
Catastrophe avoidance suboptimal
0
$Nq^{A}_{\max}$
$\bar{Q}$
"Impact"
"Threshold"

Uncertainty

- **Threshold Uncertainty.** From Rockström *et al*. (2009), the last time the Earth was ice-free, CO_2 concentrations were at 450 ppmv ± 100. To be sure to preserve the large ice sheets, they recommend 350 ppmv.
- **Impact Uncertainty**. From Lenton *et al*. (2008), Loss of Greenland Ice Sheet might add 2-7 meters to sea level and take 300 to more than 1,000 years.

What does theory say?

- Impact uncertainty should make no difference.
  - Suppose the loss wasn't £15 but somewhere between £10 and £20.
  - Then countries will act as if the loss were £15.
  - This is especially true for our example because even if the impact is "low," this remains a coordination game.

What does theory say?

- Threshold uncertainty should be transformative.
  - Suppose threshold somewhere between 100 and 200.
  - Then, if you cut your contribution a tiny bit, starting from 150 units, you increase the probability of catastrophe by a tiny bit.
  - For our example,
    - if everyone else contributes 15 and you contribute 15 you get an expected payoff of 150×£.05 + £5 + £20 – (200 – 150)/(200 – 100)×£15 = £25.
    - If you contribute 14 you get an expected payoff of 149×£.05 + £6 + £20 – (200 – 149)/(200 – 100)×£15 = £25.80.

Full cooperation

- If countries cooperate, they can't do better than to *eliminate* the probability of catastrophe.
  - Each would then get 200×£.05 + £20 = £30 or £300 in total.
- Suppose you cut back by one unit.
  - The others would then get 199×£.05 + £20 – (200 – 199)/(200 – 100)×£15 = £29.80 or £268.20 in total.
  - You would get 199×£.05 + £1 + £20 – (200 – 199)/(200 – 100)×£15 = £30.80
  - or £299 in total.

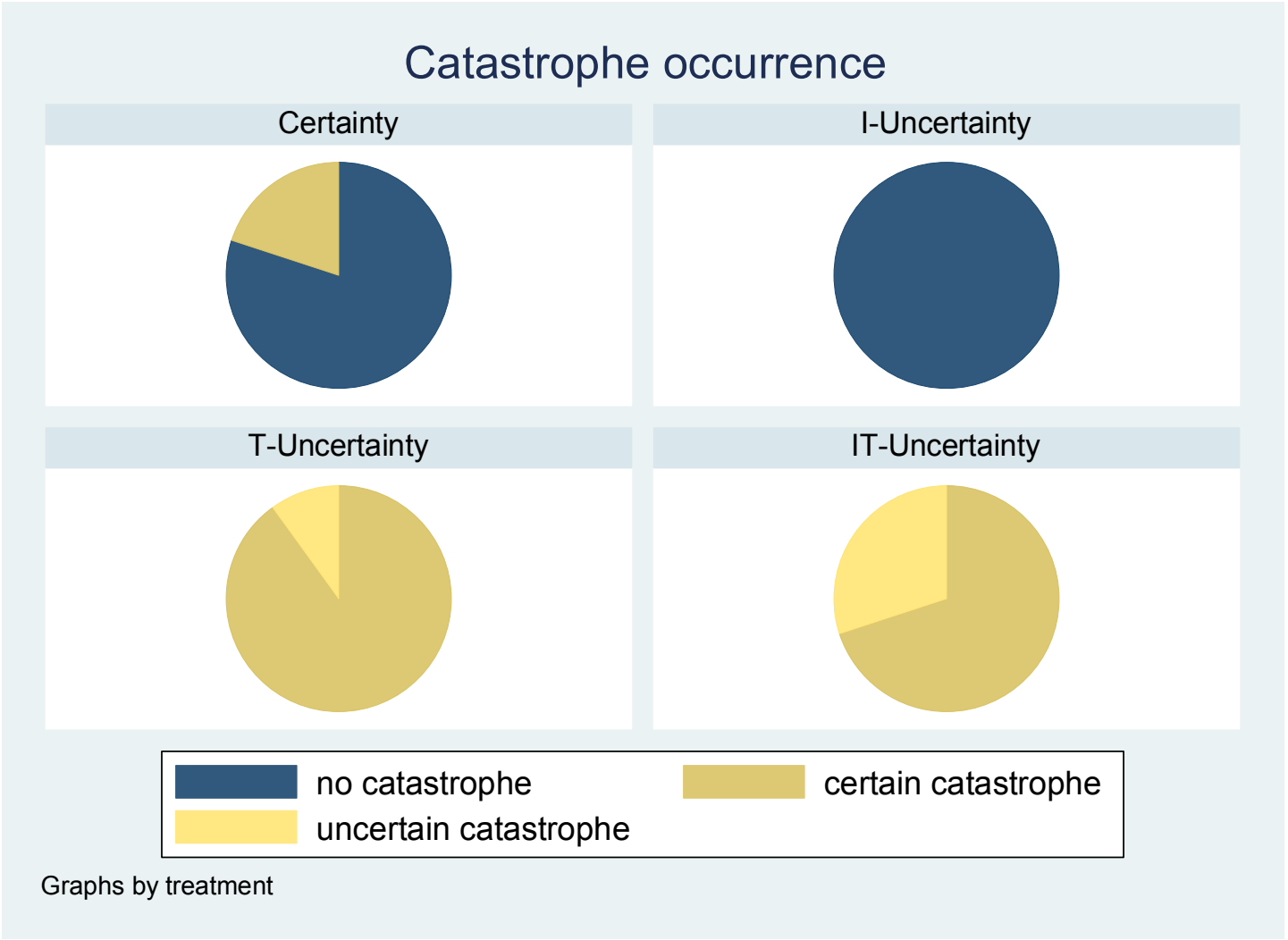
Planetary boundary

- So Rockström *et al*. are applying the right collective logic.
- Application of the "precautionary principle" without risk aversion!
- But self-interest impels countries to cut back on their contributions.

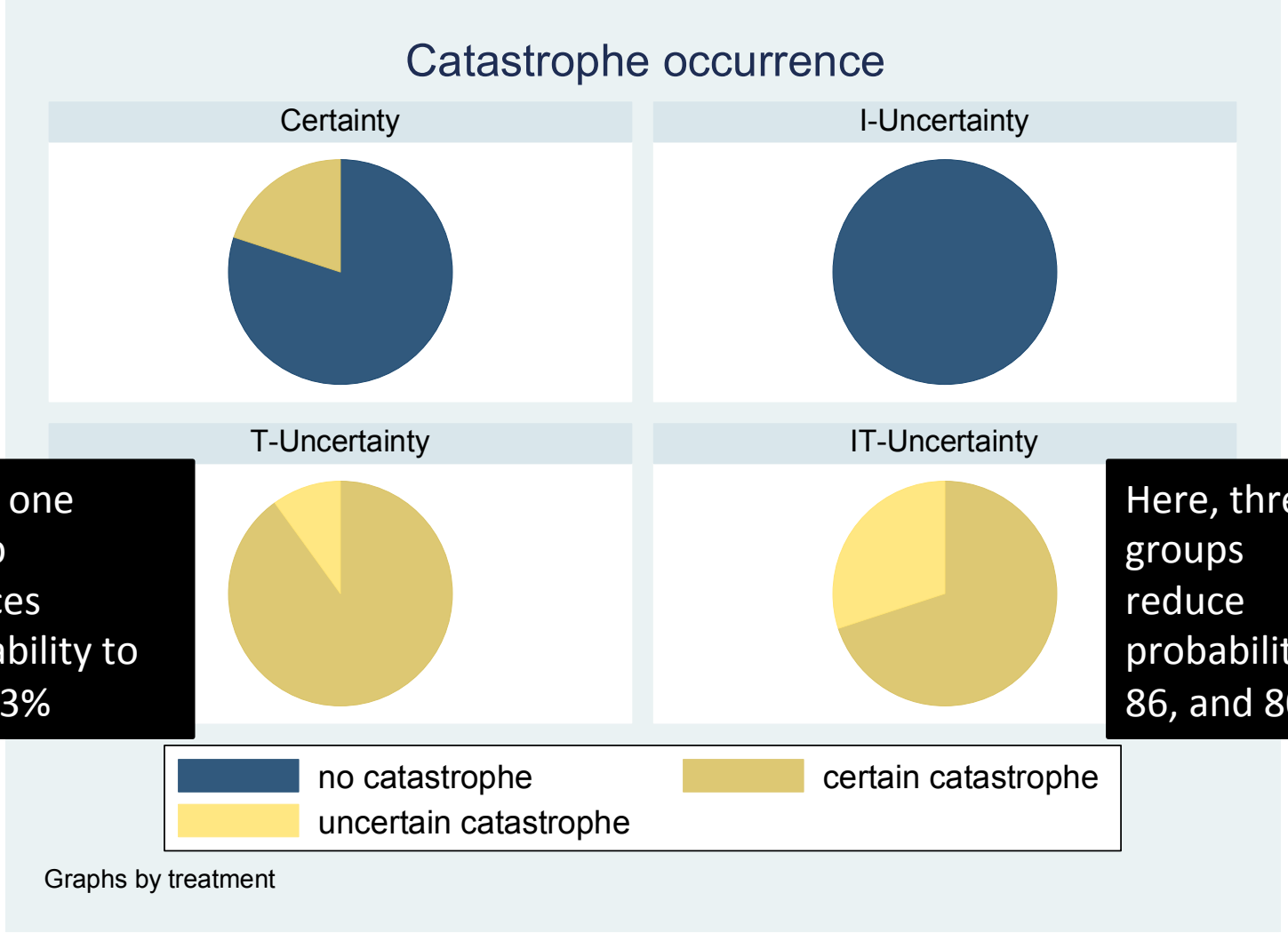
Not convinced?

- An experiment with Astrid Dannenberg, University of Gothenburg.
- The same game I described here.
- Four treatments: Certainty, Impact Uncertainty, Threshold Uncertainty, Impact and Threshold Uncertainty.
- Each game played by 10 people.
- 10 different groups play for each treatment.

Results


Catastrophe occurrence
Certainty
I-Uncertainty
T-Uncertainty
IT-Uncertainty
no catastrophe
certain catastrophe
uncertain catastrophe
Graphs by treatment

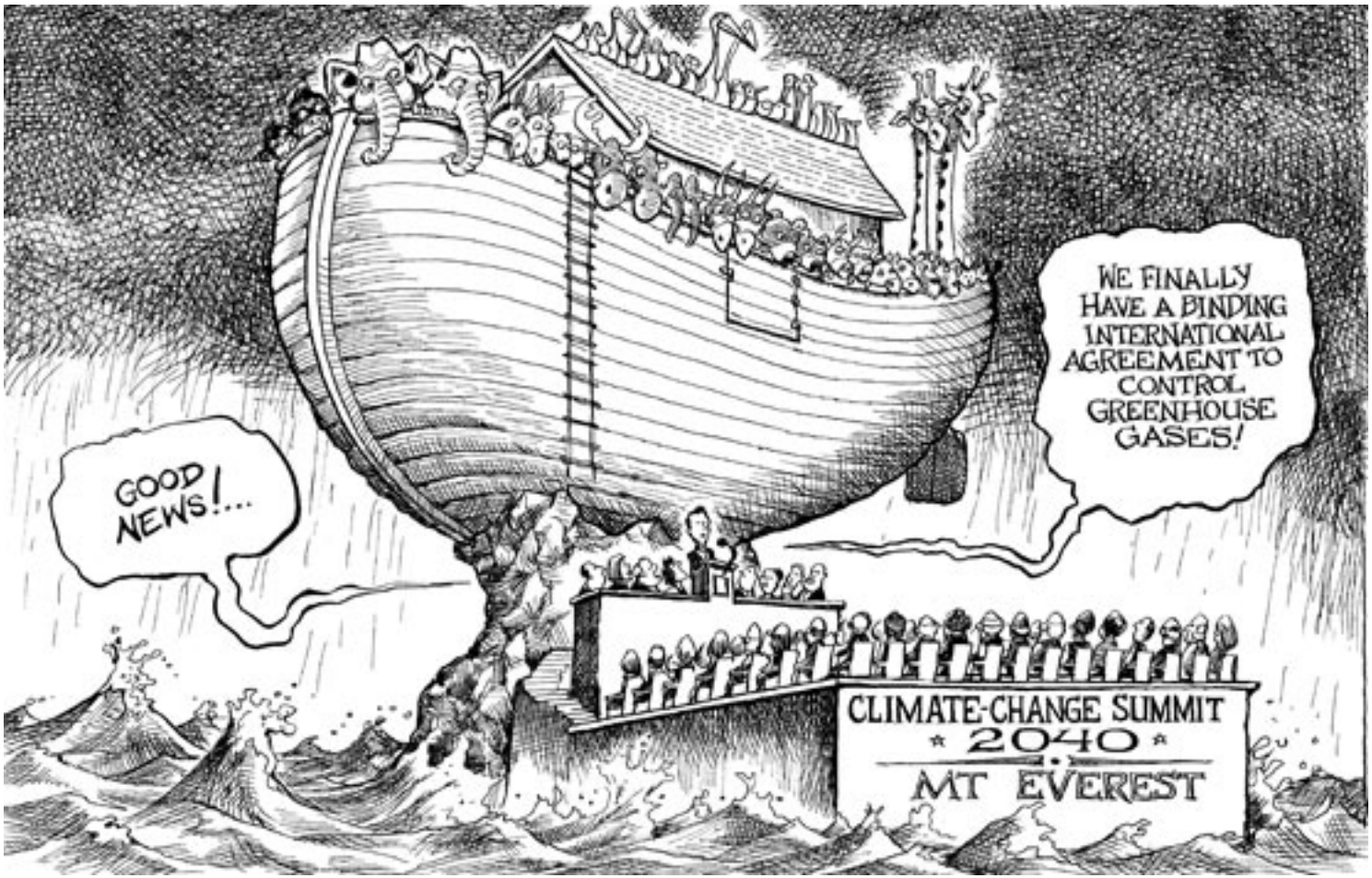
Results



Here, one group reduces probability to just 93%

Here, three groups reduce probability to 91, 86, and 80%

When will we succeed?



What can we do?

Devise other means for enforcement.

By taking a different approach to treaty design.

Starting with a new protocol for limiting HFCs.

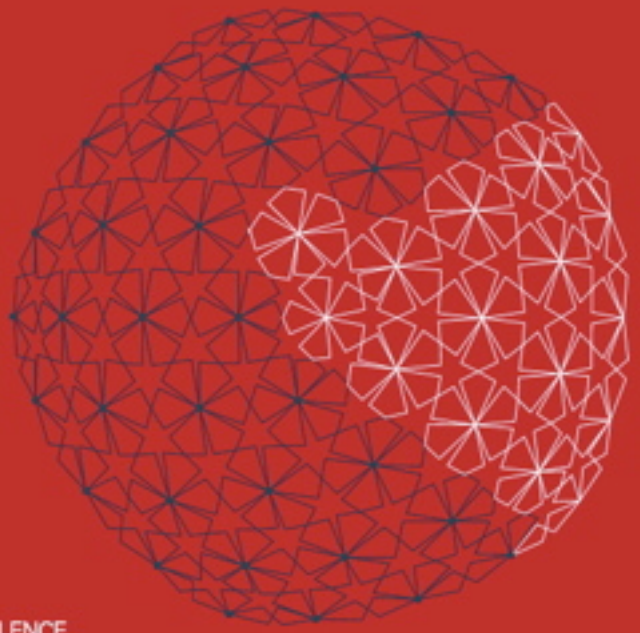
What will we do if/when catastrophe strikes?

Geoengineering

Geoengineering the climate

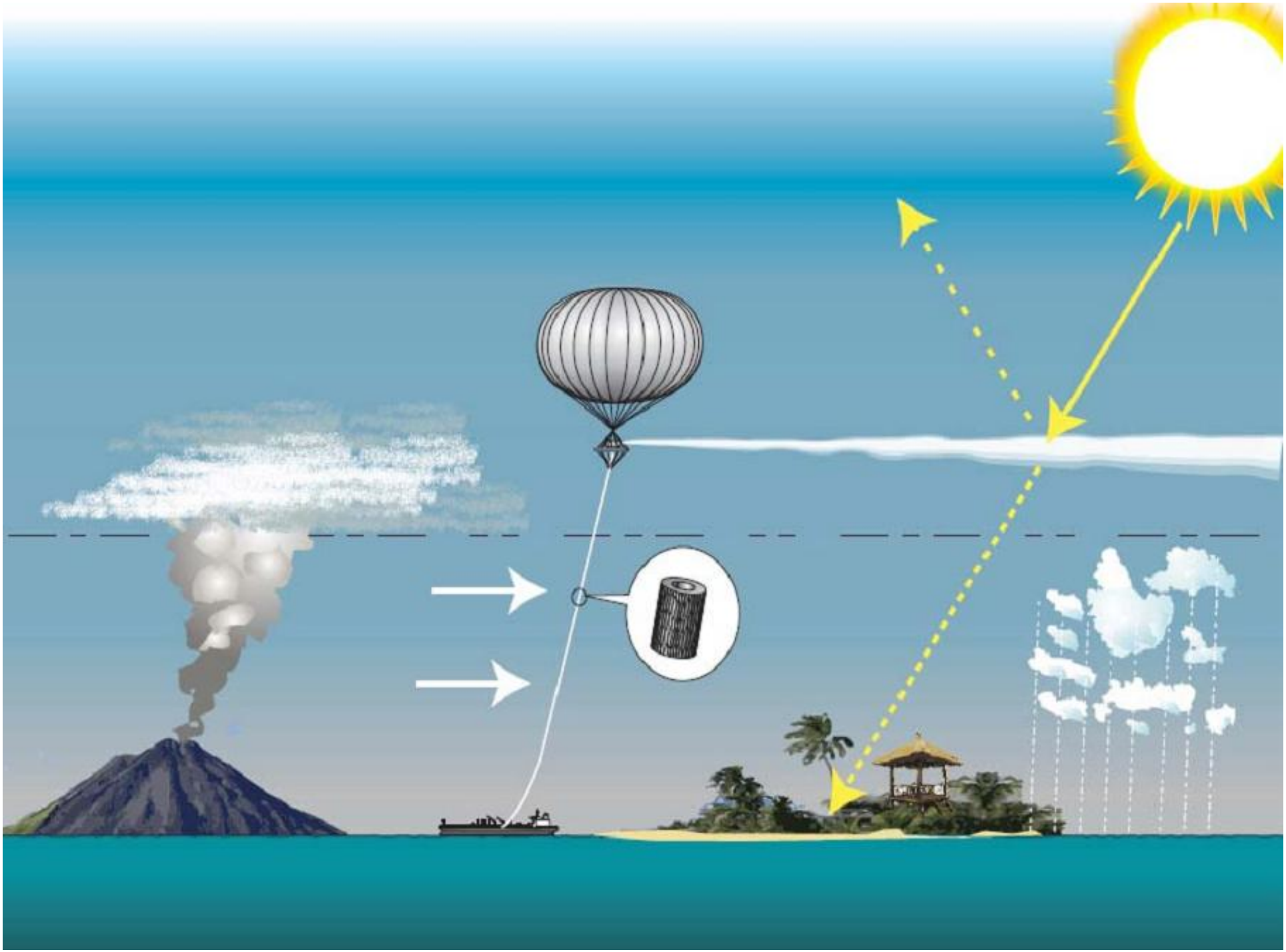
Science, governance and uncertainty

September 2009



EXCELLENCE IN SCIENCE

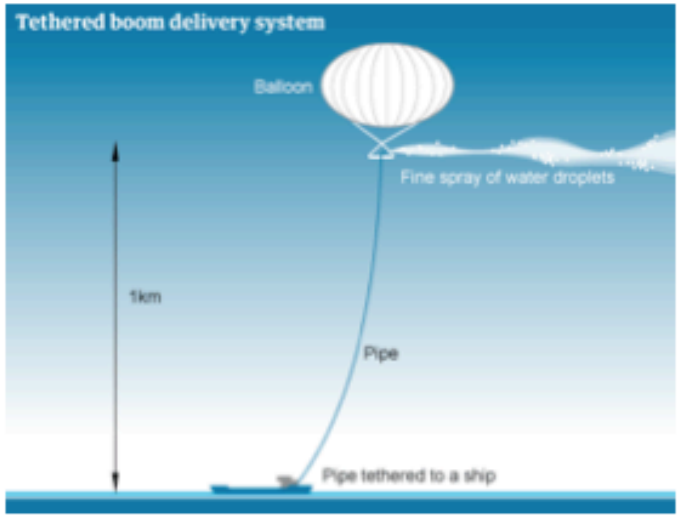
THE ROYAL SOCIETY



Giant pipe and balloon to pump water into the sky in climate experiment

Field test by British academics marks first step towards recreating an artificial volcano that would inject particles into the stratosphere and cool the planet

John Vidal, environment editor
guardian.co.uk, Wednesday 31 August 2011 11.00 EDT



It sounds barmy, audacious or sci-fi: a tethered balloon the size of Wembley stadium suspended 20km above Earth, linked to the ground by a giant garden hose pumping hundreds of tonnes of minute chemical particles a day into the thin stratospheric air to reflect sunlight and cool the planet.

But a team of British academics will next month formally announce the first step towards creating an artificial volcano by going ahead with the world's first major "geo-engineering" field-test in the next few months. The ultimate aim is to mimic the cooling effect that volcanoes have when they inject particles into the stratosphere that bounce some of the Sun's energy back into space, so preventing it from warming the Earth and mitigating the effects of man-made climate change.

theguardian

Public supports geoengineering research, survey finds

First international survey on the perception of geoengineering finds 72% of respondents approve of research

Hanna Gersmann
guardian.co.uk, Monday 24 October 2011 06.43 EDT

The British, American and Canadian public is largely in favour of research into engineering the planet's climate to combat global warming, according to the study. Photograph: Gallo Images/Getty Images

The British, American and Canadian public is largely in favour of research into engineering the planet's climate to combat global warming, according to a study published on Monday. But critics said the paper was "not exactly disinterested science" because one of the authors is the founder and president of a geoengineering company.

The first international survey on the perception of geoengineering, published in the Environmental Research Letters of the Institute, comes at a critical stage as a major UK test project was recently postponed.

But

- While geoengineering works fast, it probably can’t avert every catastrophe.
- It may not work well.
- It will impose other risks.
- It does not address the root cause of climate change.

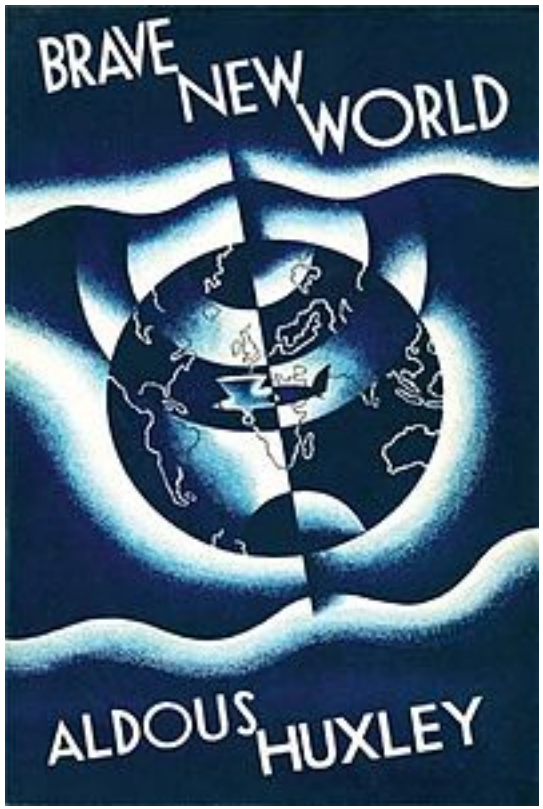
So we may wish to try something else

Air capture on a huge scale

Brief economics of air capture

- Currently, the SCC might be around £50/tCO_2.
- Estimates of the cost of air capture vary; a recent high estimate about £375/tCO_2.
- Currently, air capture is not economic.
- But air capture is the only true "backstop technology."

- In a crisis, we may want to use it.



Thank you!