Lunchlezing Studium Generale Utrecht, 21 oktober 2009

Postnormale Wetenschap

als wetenschap niet eenduidig maar onzeker is…

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Daily practice of dealing with uncertain science in policy making

Two dominant strategies: uncertainties are either

- **downplayed** to promote political decisions (enforced consensus), or
- **overemphasised** to prevent political action

- Both promote decision strategies that are **not fit for meeting the challenges** posed by the uncertainties and complexities faced.

- This delays a transition to sustainability.

- We need a theory of uncertainty, scientific dissent & **plurality** in sustainability science.

A practical problem:

Protecting a strategic fresh-water resource

5 scientific consultants addressed same question:

"which parts of this area are most vulnerable to nitrate pollution and need to be protected?"

(Refsgaard, Van der Sluijs et al, 2006)

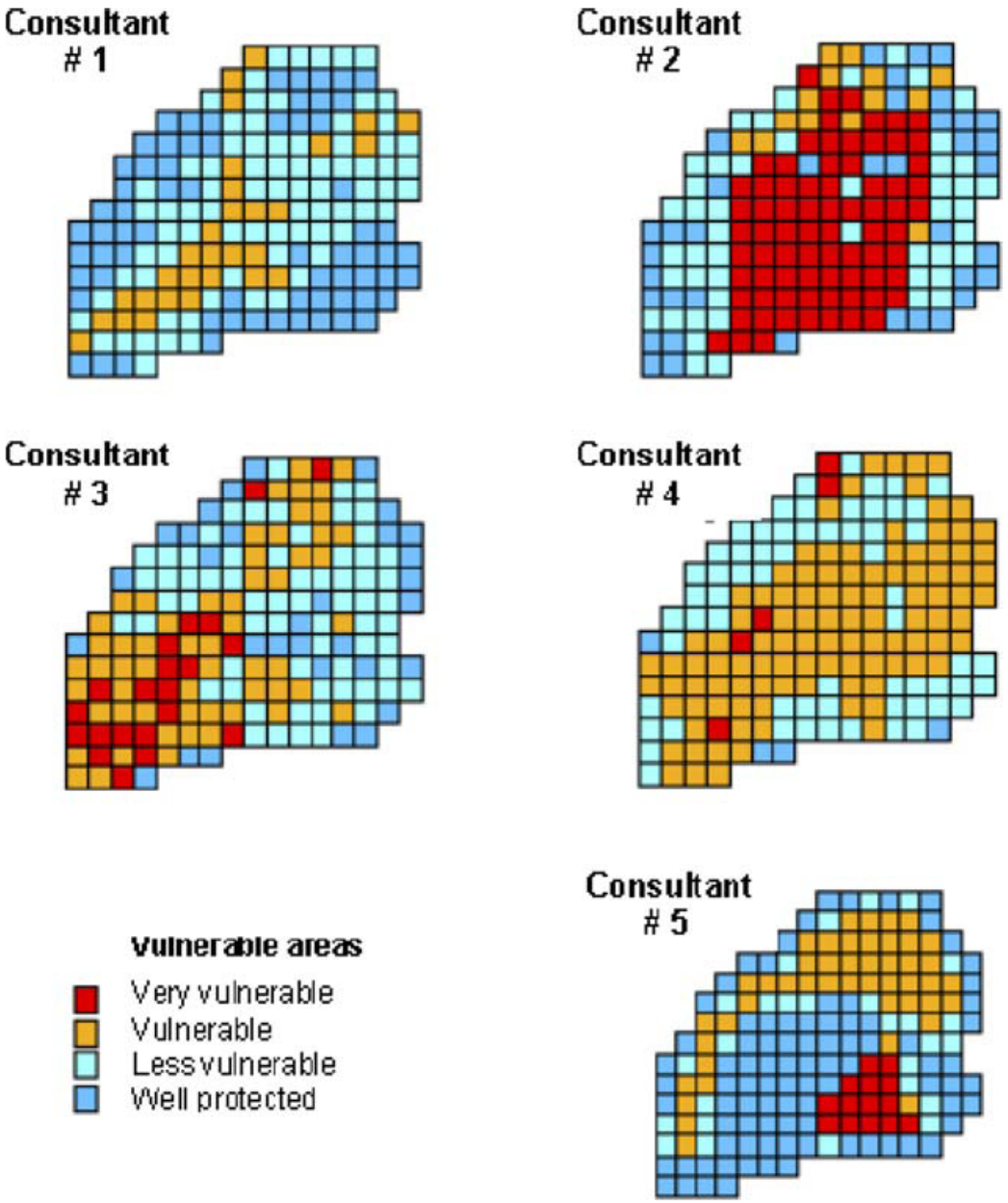


Fig. 1. Model predictions on aquifer vulnerability towards nitrate pollution for a 175 km^2 area west of Copenhagen [11].

3 framings of uncertainty (Van der Sluijs, 2006)

'deficit view'

- Uncertainty is provisional
- Reduce uncertainty, make ever more complex models
- *Tools:* quantification, Monte Carlo, Bayesian belief networks

'evidence evaluation view'

- Comparative evaluations of research results
- *Tools:* Scientific consensus building; multi disciplinary expert panels
- focus on robust findings

'complex systems view'

- Uncertainty is intrinsic to complex systems: permanent
- Uncertainty can be result of new ways of knowledge production
- Acknowledge that not all uncertainties can be quantified
- Openly deal with deeper dimensions of uncertainty
- *Tools:* Knowledge Quality Assessment

"*speaking truth to power*" vs "working deliberatively within imperfections"

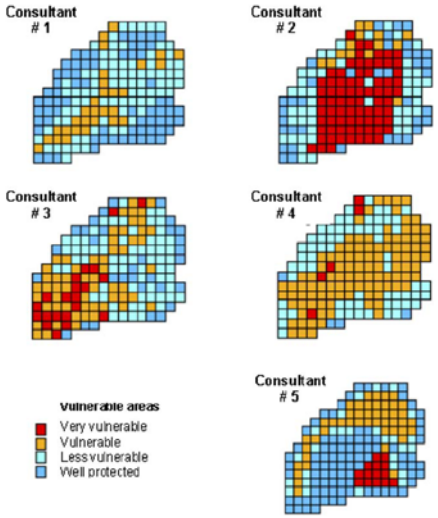


Fig. 1. Model predictions on aquifer vulnerability towards nitrate pollution for a 175 km^2 area west of Copenhagen [11].

How to act upon such uncertainty?

- Bayesian approach: 5 priors. Average and update likelihood of each grid-cell being red with data (but oooops, there is no data and we need decisions now)
- IPCC approach: Lock the 5 consultants up in a room and don't release them before they have consensus
- Nihilist approach: Dump the science and decide on an other basis
- Precautionary robustness approach: protect all grid-cells
- Academic bureaucrat approach: Weigh by citation index (or H-index) of consultant.
- Select the consultant that you trust most
- Real life approach: Select the consultant that best fits your policy agenda
- Post normal: explore the relevance of our ignorance: working deliberatively within imperfections

RIVM / De Kwaadsteniet (1999)

"RIVM over-exact prognoses based on virtual reality of computer models"

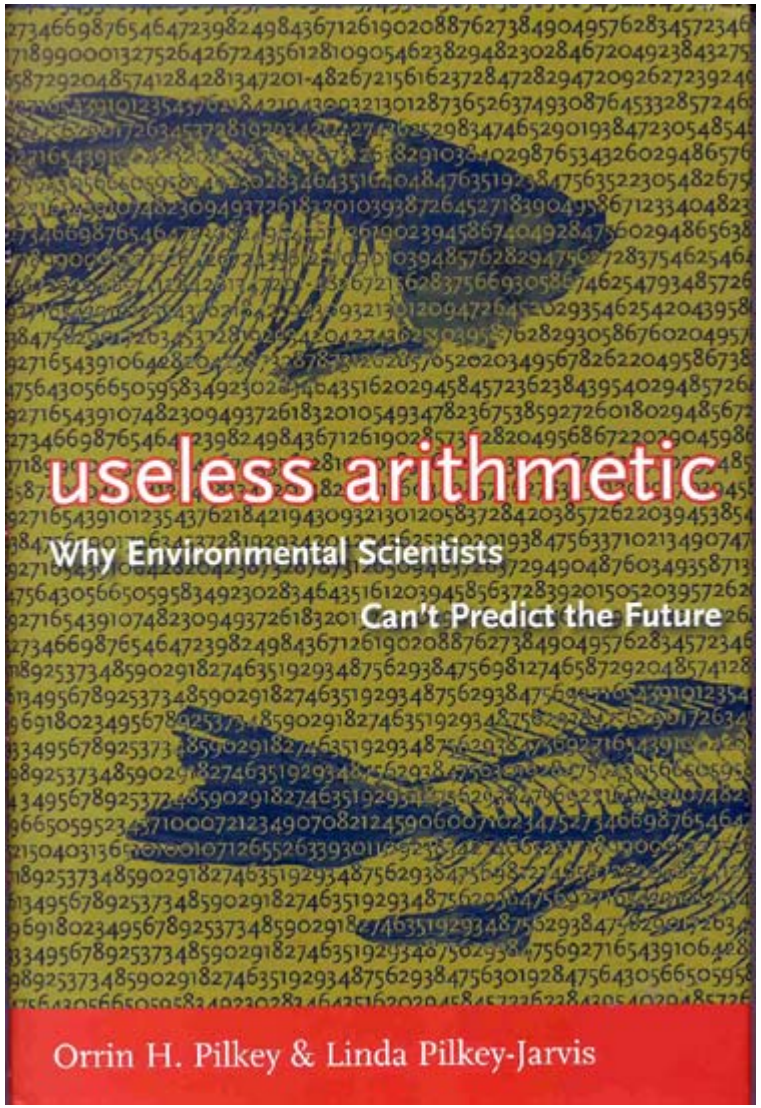
Newspaper headlines:

- Milieu-instituut liegt en bedriegt
- Het bankroet van de cijfers
- Ophef in Kamer na kritiek op milieucijfers
- De samenleving heeft recht op eerlijke informatie
- RIVM: geen kwade opzet
- Gezagscrisis rond milieugetallen
- Felle reactie RIVM op beschuldiging bedrog
- VVD: Pronk te laconiek over kritiek op RIVM
- Onaantastbare cijfers

Artikelen in Podium (Trouw) n.a.v. De Kwaadsteniet schandaal

- Publiceer RIVM-rapport tegelijk met kritiek
- Niet alles kan wetenschappelijk verantwoord zijn
- Overheid baseert haar beleid te vaak alleen op modellen
- Modellen geven meetresultaten betekenis
- Onafhankelijke toetsing milieucijfers noodzaak
- Gewenste resultaten zijn te makkelijk te koop

Pilkey & Pilkey, 2007 book



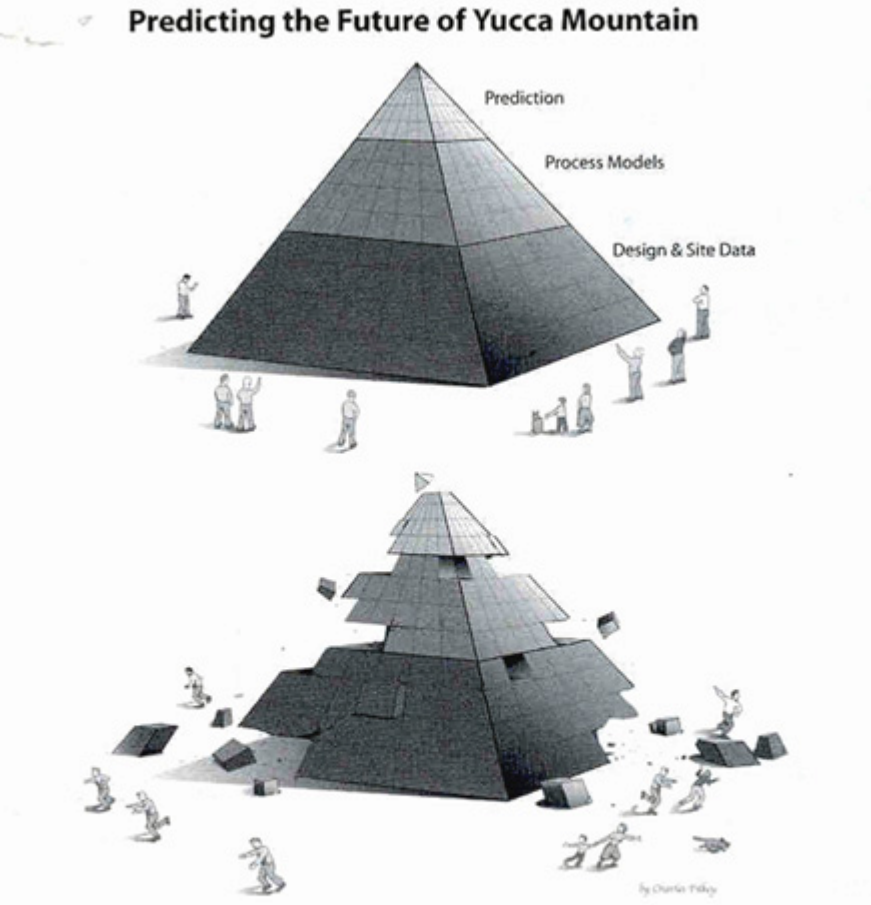


Figure 3.5 The Department of Energy views the modeling effort at Yucca Mountain as a pyramid. At the bottom are field observations. In the second layer are the hundreds of mathematical models that predict how natural processes will work over very long periods of time. At the top are the models that put it all together to predict the behavior of the repository over a long period of time. But a pyramid founded on limited data and faulty models projecting far into the future can never survive! Drawing by Charles Pilkey.

Yucca Mountain: bizarre mismatch

Regulatory standard implied need for scientific certainty for up to one million years

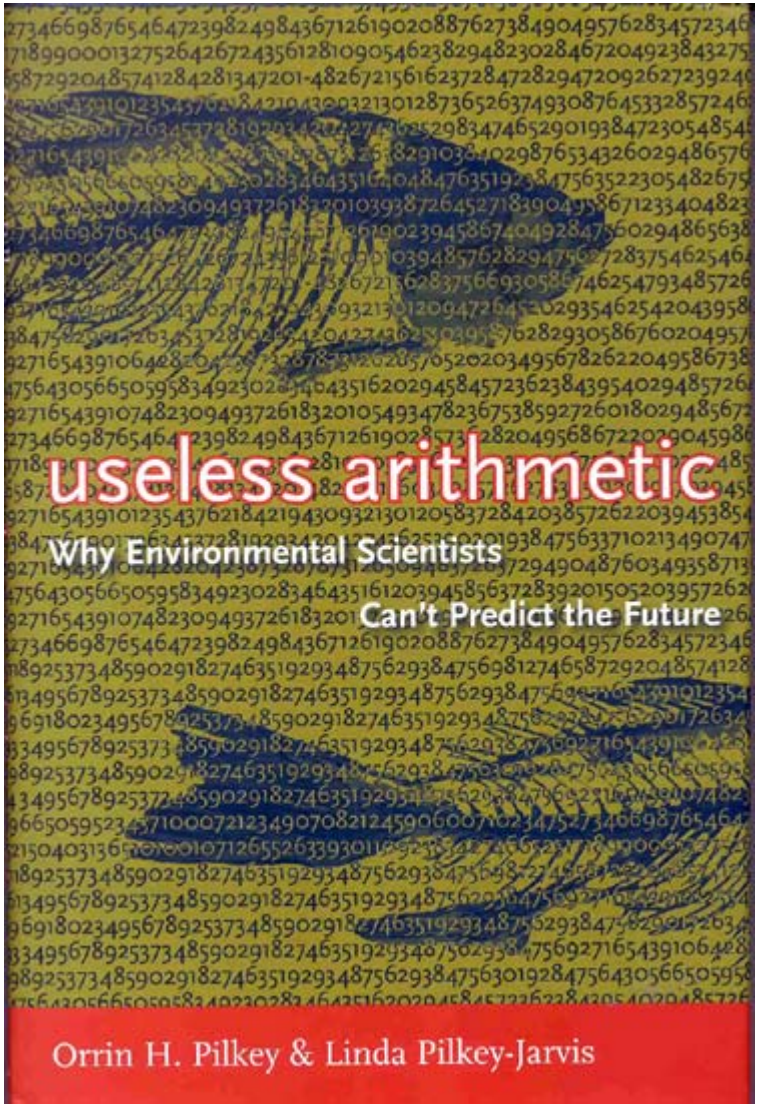
- **State of knowledge**
  - limitations of a quantitative modeling approach *(US-DOE's Total System Performance Assessment, TSPA)*
  - radical uncertainty and ignorance
  - uncontrolled conditions of very long term unknown and indeterminate future.

Ignorance:

Percolation flux: TSPA model assumed 0.5 mm per year (expert guess)

Elevated levels of Chlorine-36 isotope in faults uncovered by tunnel boring: percolation flux > 3000 mm per year over the past 50 yr...

Pilkey & Pilkey, 2007 book



Mathematical fishing

Two categories of Models in fish management

1. <u>Modeling blindfolded</u>: non-biologists or biologists deeply ensconced in the political system

-> politically acceptable optimistic answer

-> Uncertainties are hidden

2. <u>Models as "*Fig Leaves, Shields and Clubs*"</u>

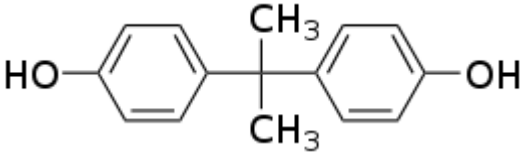
-> something to hide behind

-> device to create unchallengeable authority

-> insulator: protecting agency scientists and fishery managers from attack by politicians who want to please unhappy fisherman

'The use of a model to reduce fishing pressure on a species – even if model is wrong – is better than the alternative of just an expert opinion that can be refuted by an other expert'

Bisphenol A controversy



Science for sale – Bisphenol A

Congress: Science for Sale?

Congress Launches Probe Into Firm's Work on Chemical Used to Make Many Plastic Bottles

..a confidential Weinberg Group document ...in which the firm suggested to DuPont ... several ways it could ***help "shape the debate"*** *about one of its chemical products. The firm proposed ... "****constructing a study to establish" that DuPont's chemical was safe****, and arranging the publication of papers "dispelling the alleged nexus" between the company's chemical and its alleged harmful effects on humans."*

ABC News 6 Feb 2008

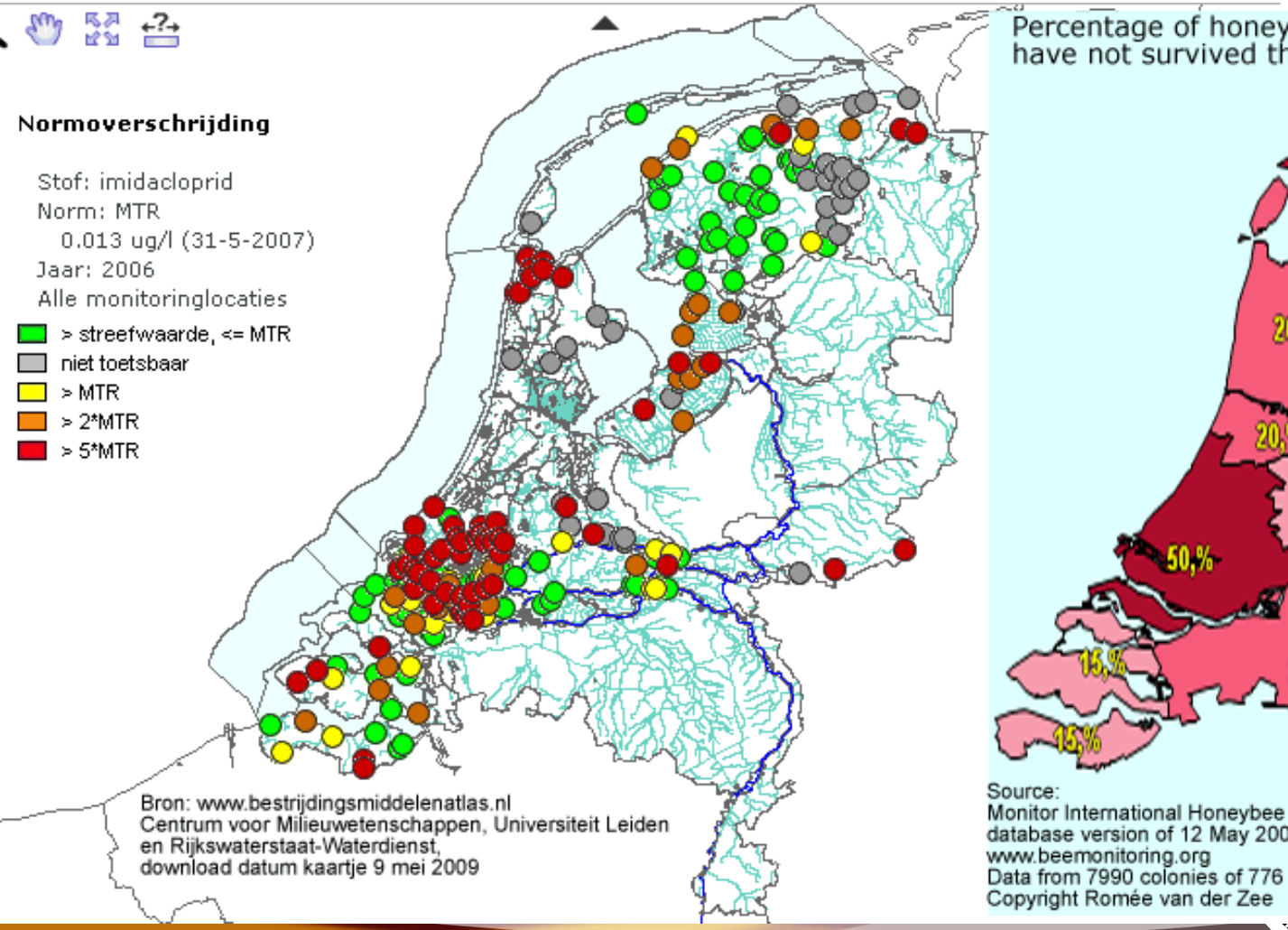
Exclusive: 'Science for Sale' Probe Deepens

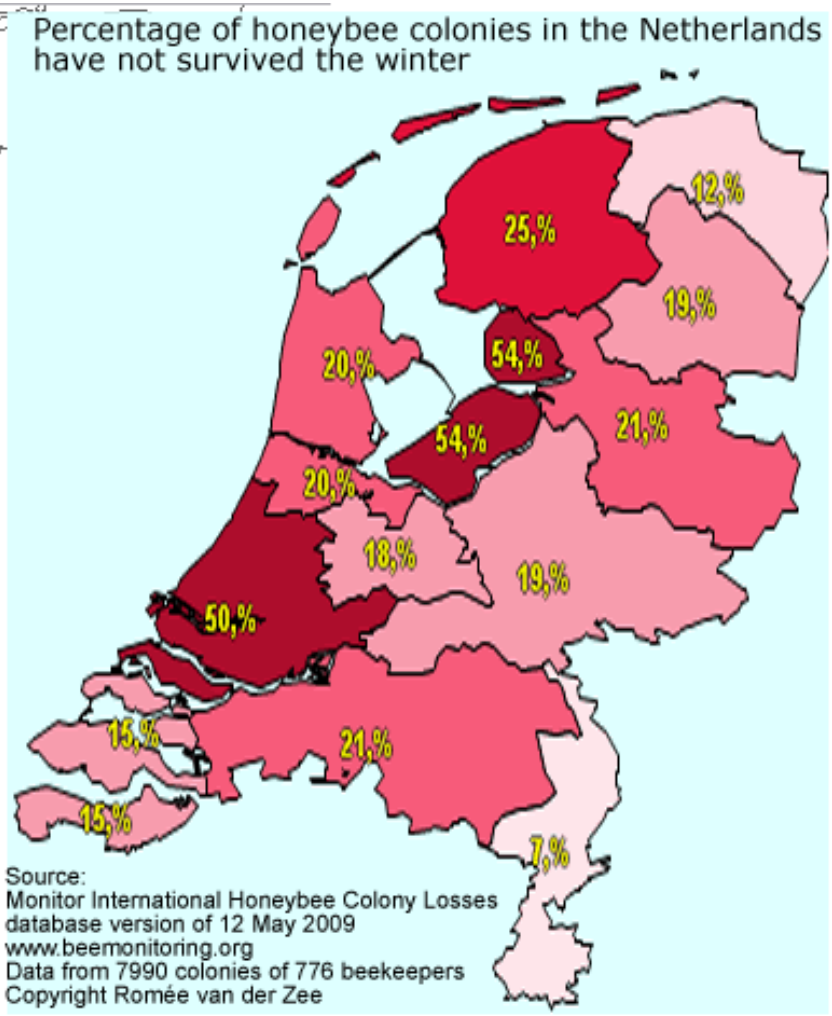
A scientific consulting firm once crowed of its success in delaying the cancellation of a harmful drug by 10 years, congressional investigators say.

Lawmakers have more tough questions for the Weinberg Group, which has been accused of "manufacturing uncertainty“ about research to benefit its corporate clients and their products.

ABCNews, March 11, 2008,

Bijensterfte en systemische insecticiden





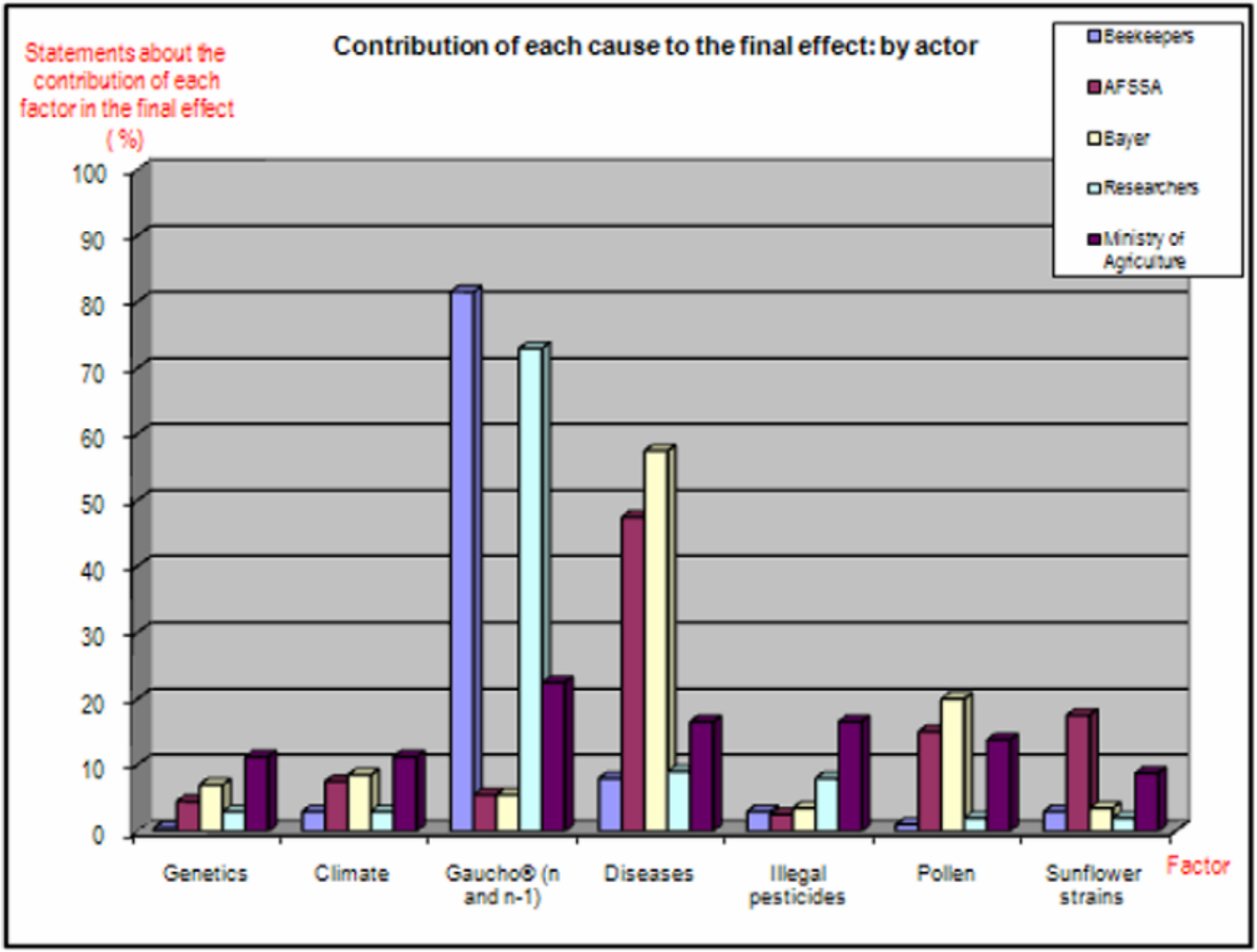


Figure 4. Contribution of each cause to the final effect: by actor, in percentage (%).

Top 10 Products 2007

Active Ingredient*	Major Brands	Application	Sales (€ million)
Imidacloprid	Confidor®, Admire®, Gaucho®, Merit®	Insecticide, Seed Treatment, Environmental Science	556
Trifloxystrobin	Flint®, Stratego®, Sphere®	Fungicide	243
Glufosinate	Basta®, Liberty®	Herbicide	241
Clothianidin	Poncho®	Seed Treatment	237
Tebuconazole	Folicur®, Raxil®	Fungicide, Seed Treatment	235
Mesosulfuron-methyl	Atlantis®	Herbicide	207
Fenoxaprop-P-ethyl	Puma®	Herbicide	187
Deltamethrin	Decis®, K-Othrine®	Insecticide, Environmental Science	178
Prothioconazole	Proline®	Fungicide	175
Ethofumesate/PMP/DMP	Betanal®	Herbicide	127

Pesticides : Toxicity / bees (DL50 ng/bee)

pesticide	®	utilisation	DL50 ng/ab	Tox/DDT
DDT	Dinocide	insecticide	27 000,0	1
amitraze	Apivar	i/acaricide	12 000,0	2
coumaphos	Perizin	i/acaricide	3 000,0	9
tau-fluvalinate*	Apistan	i/acaricide	2 000,0	13,5
methiocarb	Mesurol	insecticide	230,0	117
carbofuran	Curater	insecticide	160,0	169
λ-cyhalothrine	Karate	insecticide	38,0	711
deltamethrine	Décis	insecticide	10,0	2 700
thiaméthoxam	Cruiser	insecticide	5,0	5 400
fipronil	Regent	insecticide	4,2	6 475
clothianidine	Poncho	insecticide	4,0	6 750
imidaclopride	Gaucho	insecticide	3,7	7 297

Dr. JM Bonmatin (CNRS) France

Categories of Deceitful Tactics and Abuse of the Scientific Process

source: P.H. Gleick, Pacific Institute, 2007

http://www.pacinst.org/publications/testimony/Gleick_Senate_Commerce_2-7-07.pdf

- Appeal to Emotion (appeal to ridicule, fear etc)
- Personal ("Ad Hominem") Attacks
- Mischaracterizations of an Argument
- Inappropriate Generalization
- Misuse of Facts (inadequate sample)
- Misuse of Uncertainty
- False Authority
- Hidden Value Judgments (ideologies)
- Scientific Misconduct (fabrication etc.)
- Science Policy Misconduct (Packing Advisory Boards, selective funding)

Weiss 2003/2006 evidence scale

10. Virtually certain
9. Beyond a reasonable doubt
8. Clear and Convincing Evidence
7. Clear Showing
6. Substantial and credible evidence
5. Preponderance of the Evidence
4. Clear indication
3. Probable cause: reasonable grounds for belief
2. Reasonable, articulable grounds for suspicion
1. No reasonable grounds for suspicion
0. Insufficient even to support a hunch or conjecture

Even where there is agreement on “level of evidence”, there usually is substantial societal disagreement on what level of intervention is justified.

Intervention / Level of Evidence	impossible	hunch	suspicion	belief	clear ind.	Prepond.t	credible	clear show	Clr. conv.	Doubtless	100%
Whatever it takes											
Comprehensive Measures					1						
Expensive & politically difficult measures					2						
Measures against most serious aspects					3						
Formal plans for strong measures, identify objectives & establish mechanisms											
“No regrets” measures.					4						
Ban low-benefit, high-damage actions											
Research & monitoring					5						
Research only if public opinion demands it											
Reassure public & decision makers											

Attitudes according to Weiss 2003:

1. Environmental absolutist

2. Cautious environmentalist

3. Environmental centrist

4. Technological optimist

5. Scientific absolutist

Modern Model of Science & Policy

Perfection and perfectibility

- Facts determine correct policy
- The true entails the good
- No limits to progress of control over environment
- No limits to material & moral progress
- Technocratic view

- Science informs policy by producing ***objective***, ***valid*** and ***reliable*** knowledge:

"*Speaking truth to power*"

(Funtowicz, 2006; Funtowicz & Strand, 2007)

Modern model assumes that:

- Uncertainty can be eliminated or controlled
- Only one correct system description
  - *system and problem are not complex*
- Ethical question “is this new technology good for us?” can be reduced to Rational Cost Benefit Analysis

(Funtowicz, 2006; Funtowicz & Strand, 2007)

Normal science

Thomas Kuhn, Structure of Scientific Revolutions (1962)

- 'normal science' = uncritical puzzle solving within an unquestioned framework, or 'paradigm'.
- What all scientists do most of the time, and most scientists do all the time.

Complex - *uncertain* - risks

Typical characteristics (Funtowicz & Ravetz):

- Decisions will need to be made before conclusive scientific evidence is available;
- Potential impacts of 'wrong' decisions can be huge
- Values are in dispute
- Knowledge base is characterized by large (partly irreducible, largely unquantifiable) uncertainties, multi-causality, knowledge gaps, and imperfect understanding;
- More research ≠ less uncertainty; unforeseen complexities!
- Assessment dominated by models, scenarios, assumptions, extrapolations
- Many (hidden) value loadings reside in problem frames, indicators chosen, assumptions made

Knowledge Quality Assessment is essential

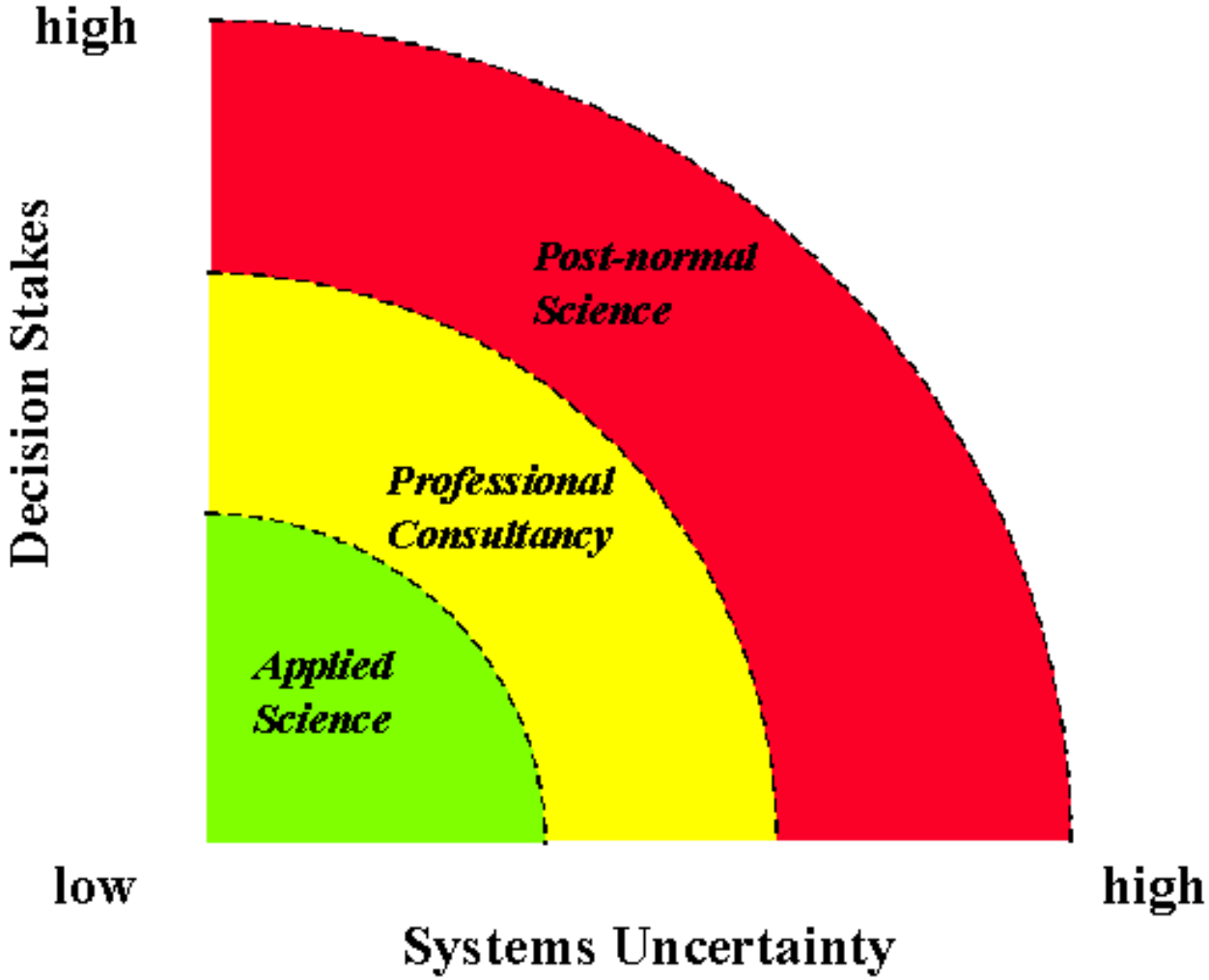
The alternative model: PNS

Extended participation:

working deliberatively within imperfections

- Science is only one part of relevant **evidence**
- Critical dialogue on strength and relevance of evidence
- Interpretation of evidence and attribution of policy meaning to knowledge is democratized
- **Tools for Knowledge Quality Assessment empower all stakeholders to engage in this deliberative process**

(Funtowicz, 2006; Funtowicz & Strand, 2007)



Funtowicz and Ravetz, Science for the Post Normal age, *Futures*, 1993

Elements of Post Normal Science

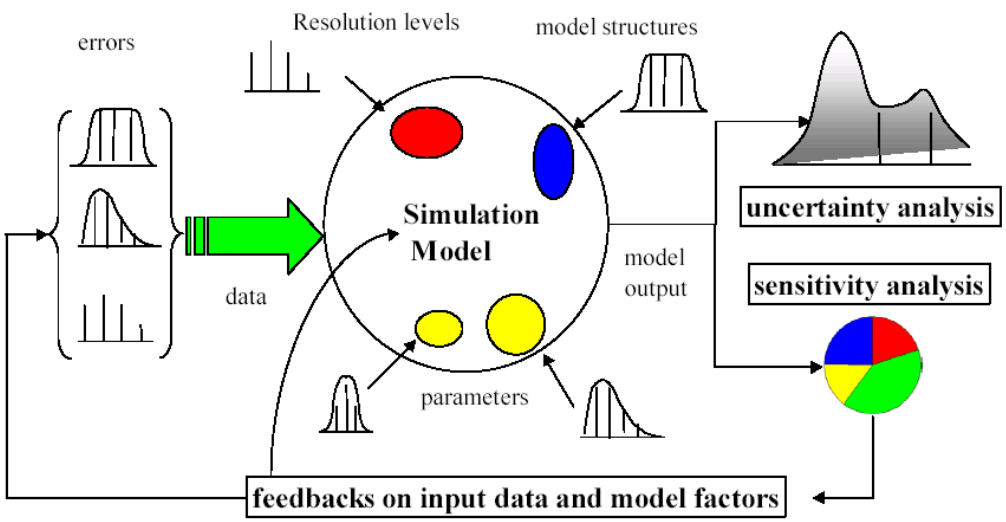
- Appropriate management of uncertainty quality and value-ladenness
- Plurality of commitments and perspectives
- Internal extension of peer community *(involvement of other disciplines)*
- External extension of peer community *(involvement of stakeholders in environmental assessment & quality control)*

Former chairman IPCC on objective to reduce climate uncertainties:

- "*We cannot be certain that this can be achieved easily and we do know it will take time. Since a fundamentally chaotic climate system is predictable only to a certain degree, our research achievements will always remain uncertain.* ***Exploring the significance and characteristics of this uncertainty is a fundamental challenge to the scientific community.***" (Bolin, 1994)

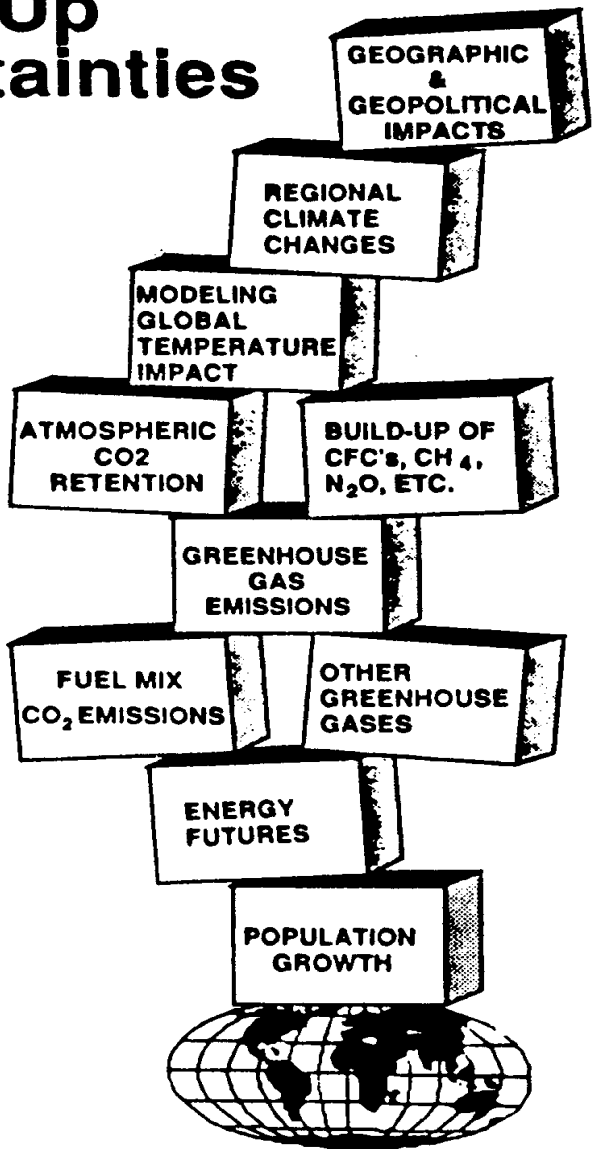
Examples of framings of uncertainty I

Cascade of statistical uncertainty



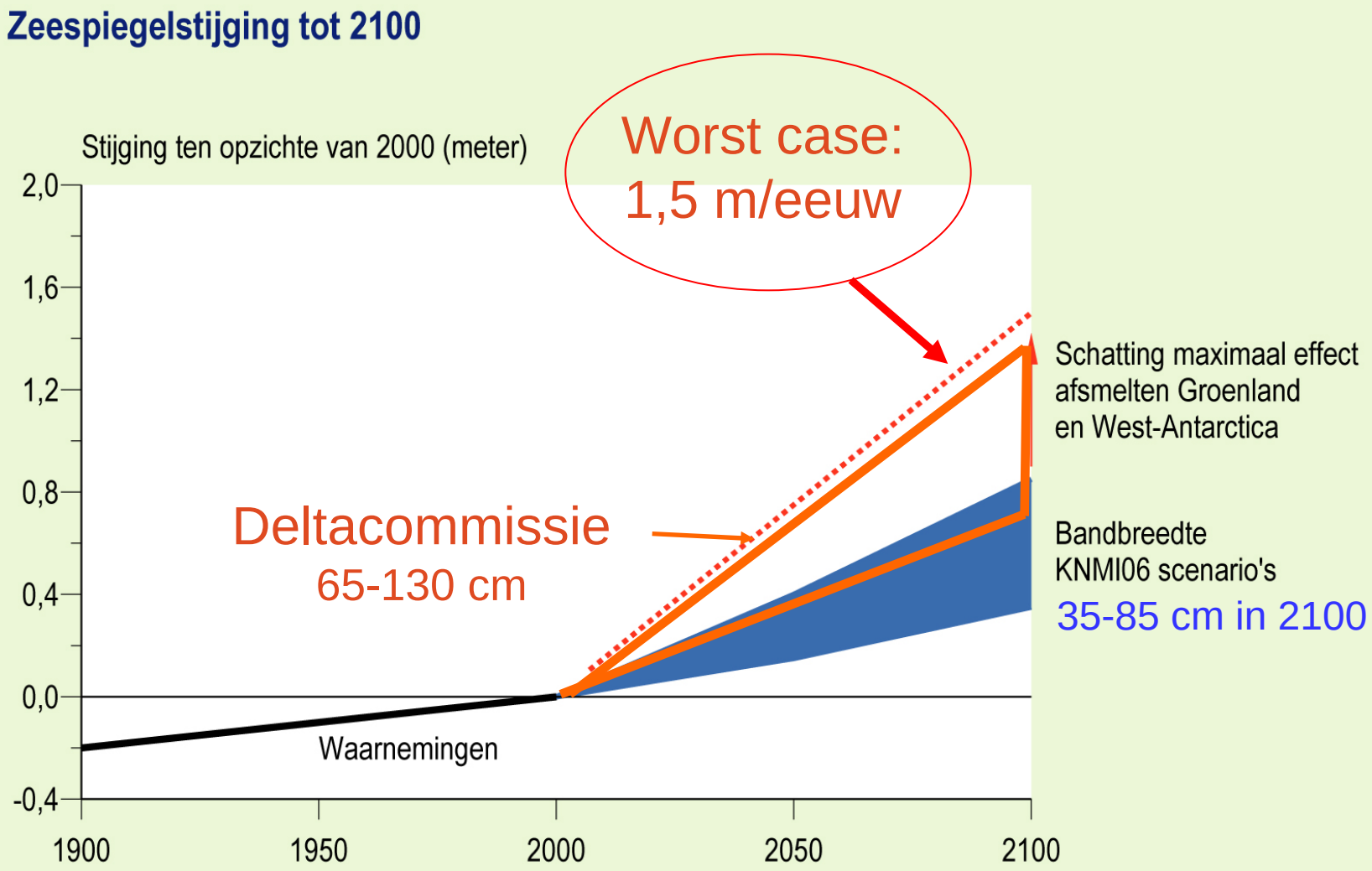
GLOBAL CLIMATE CHANGE

Piling Up Uncertainties



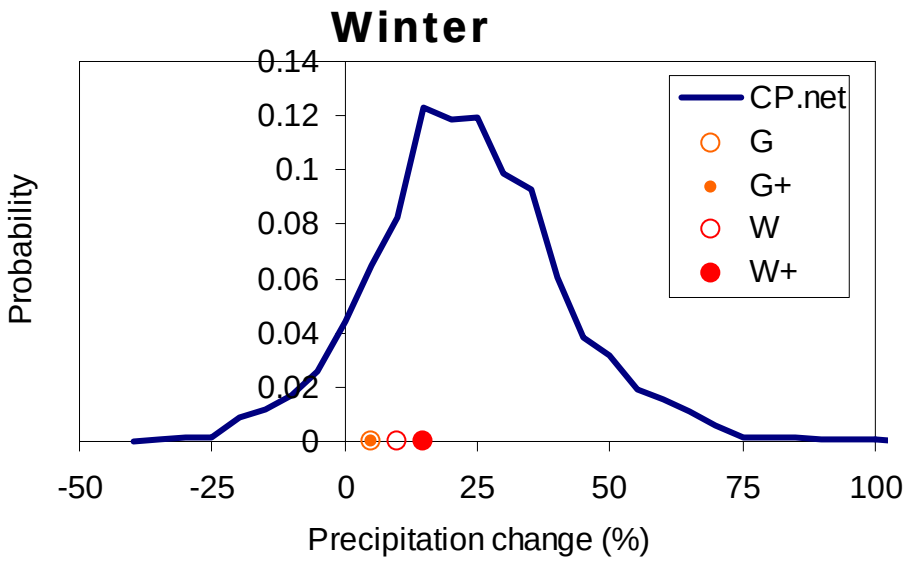
NL Later: Sealevel rise till 2100

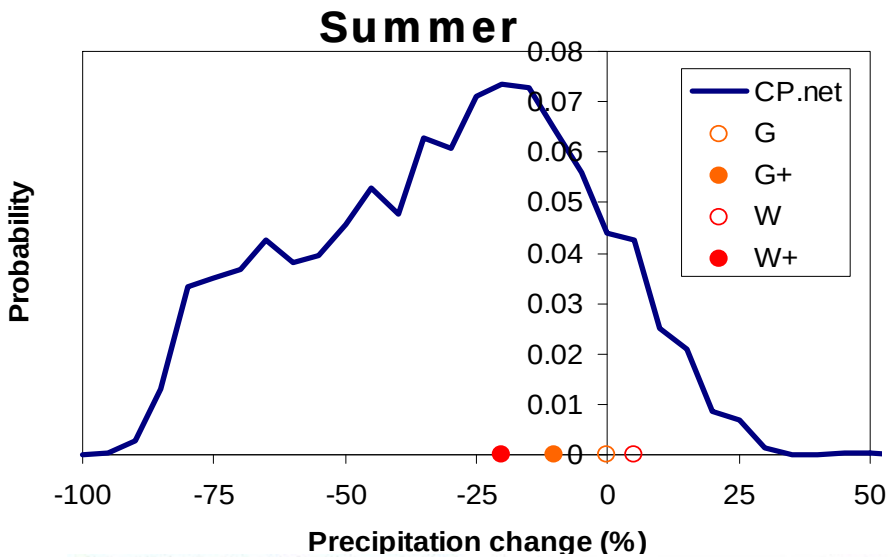
Scenario exploration



Scenarios can be wrong

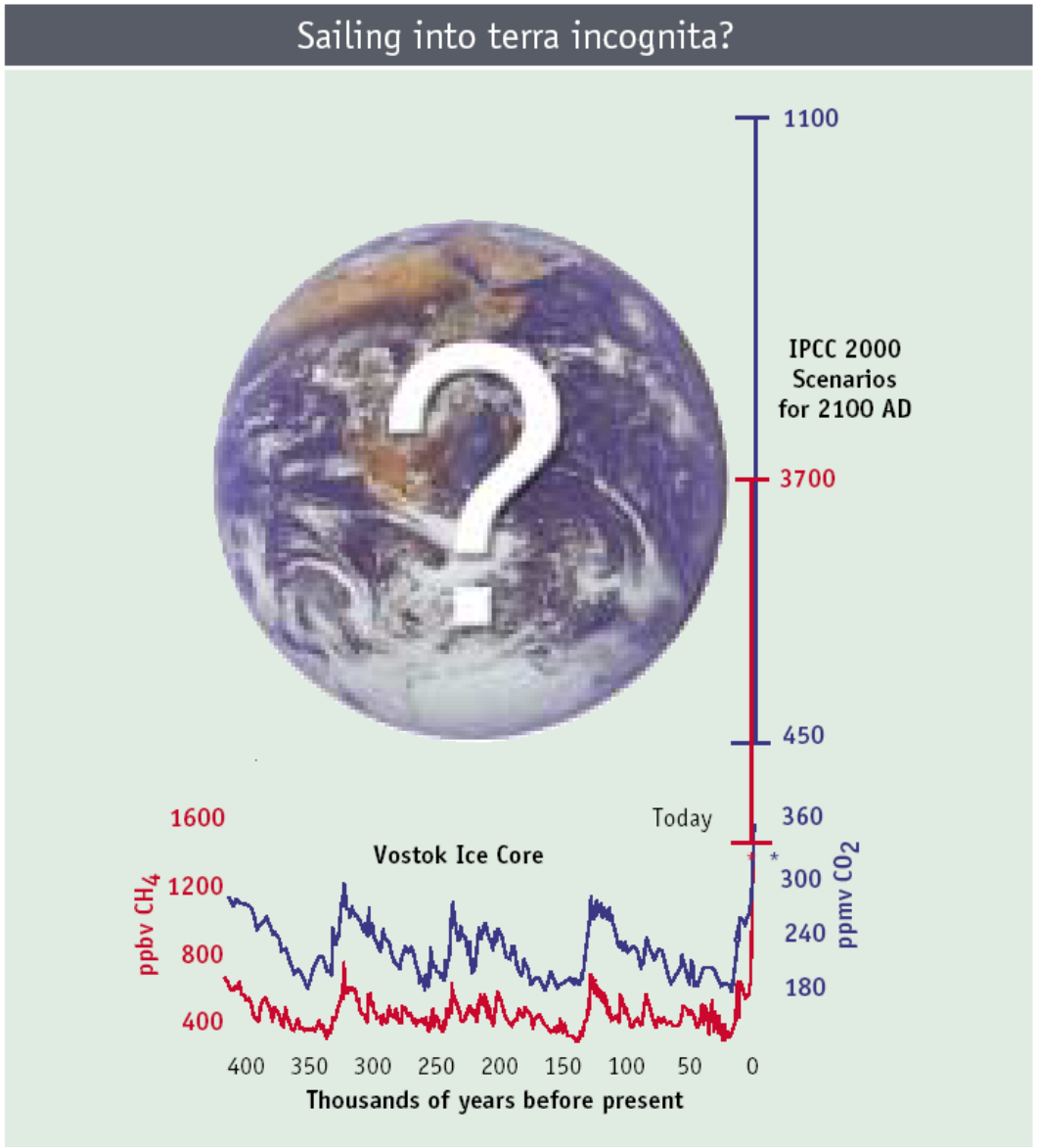
Statististical uncertainty precipitation
According to climateprediction.net
versus range KNMI scenarios





(Dessai & Van der Sluijs, 2007)

Examples of framings of uncertainty III: Terra Incognita

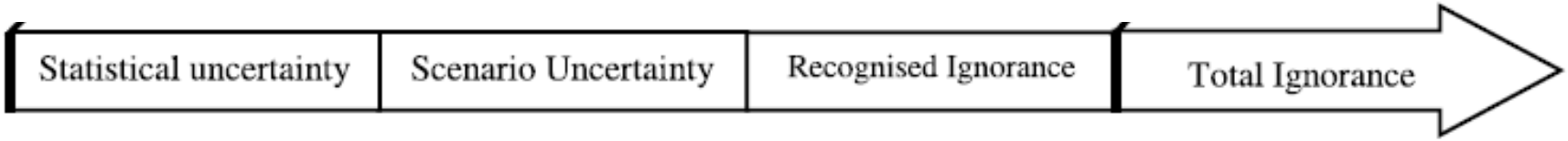


Atmospheric concentrations of the greenhouse gases CO_2 and CH_4 over the last four glacial-interglacial cycles from the Vostok ice core record. The present-day values and estimates for the year 2100 are also shown.

Adapted from Petit et al. (1999) Nature 399, 429-436 and the IPCC (Intergovernmental Panel on Climate Change) Third Assessment Report by the PAGES (Past Global Changes) International Project Office.

Adaptation under what uncertainty?

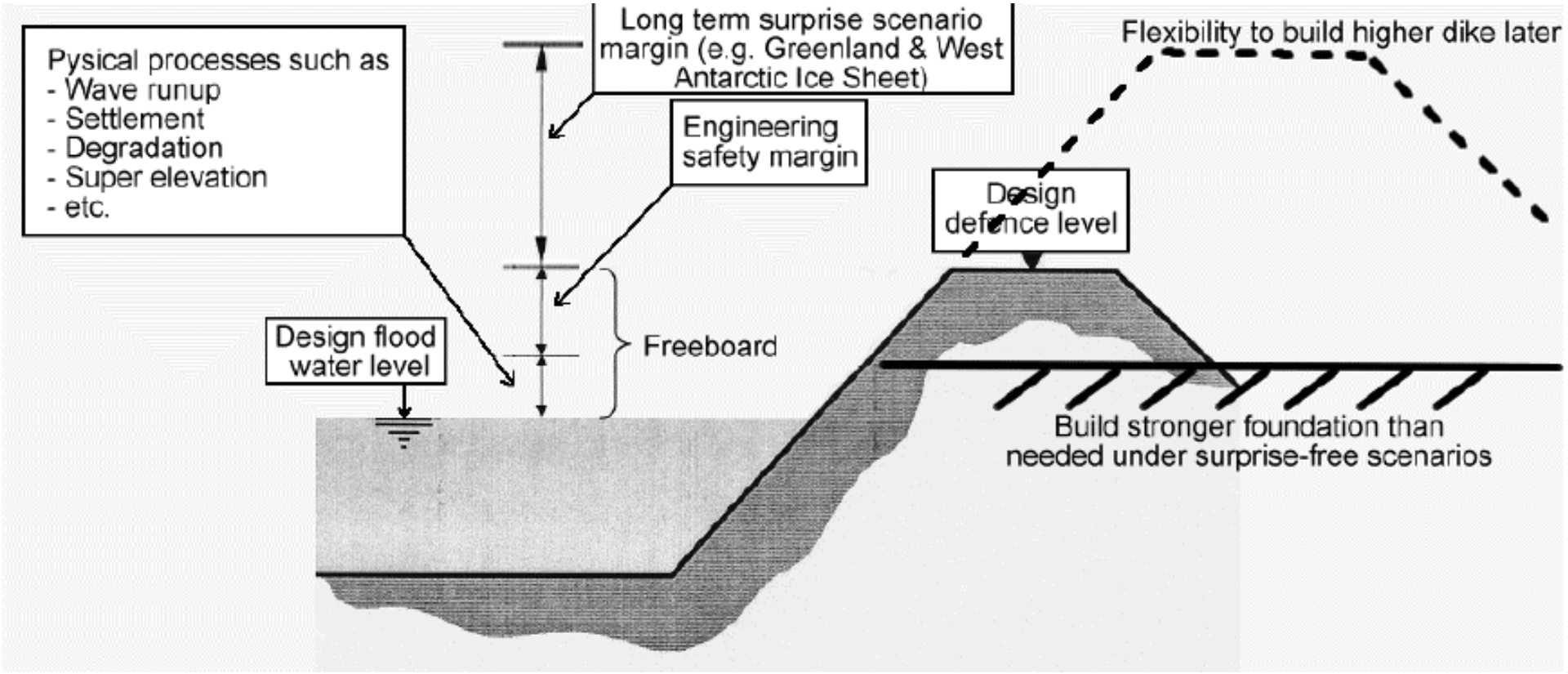
- Planned adaptation
  - to single scenario of anticipated climate impacts (KNMI 2000 scenario)
    no uncertainty
  - to single scenario of anticipated climate impacts + to variability
    statistical uncertainty (without epistemic unc.)
  - to range of scenario's of anticipated climate impacts (KNMI 2006 scenario's)
    scenario uncertainty
  - to range of scenario's of anticipated climate impacts + imaginable climate surprises (MNP Nederland Later)
    scenario uncertainty + recognized ignorance



Decision-making frameworks

- Top down approaches
  - Prevention Principle
  - IPCC approach
  - Risk approaches
- Bottom up approaches
  - Precautionary Principle
  - Engineering safety margin
  - Anticipating design
  - Resilience
  - Adaptive management
  - Human development approaches
- Mixed approaches
  - Adaptation Policy Framework
  - Robust decision making

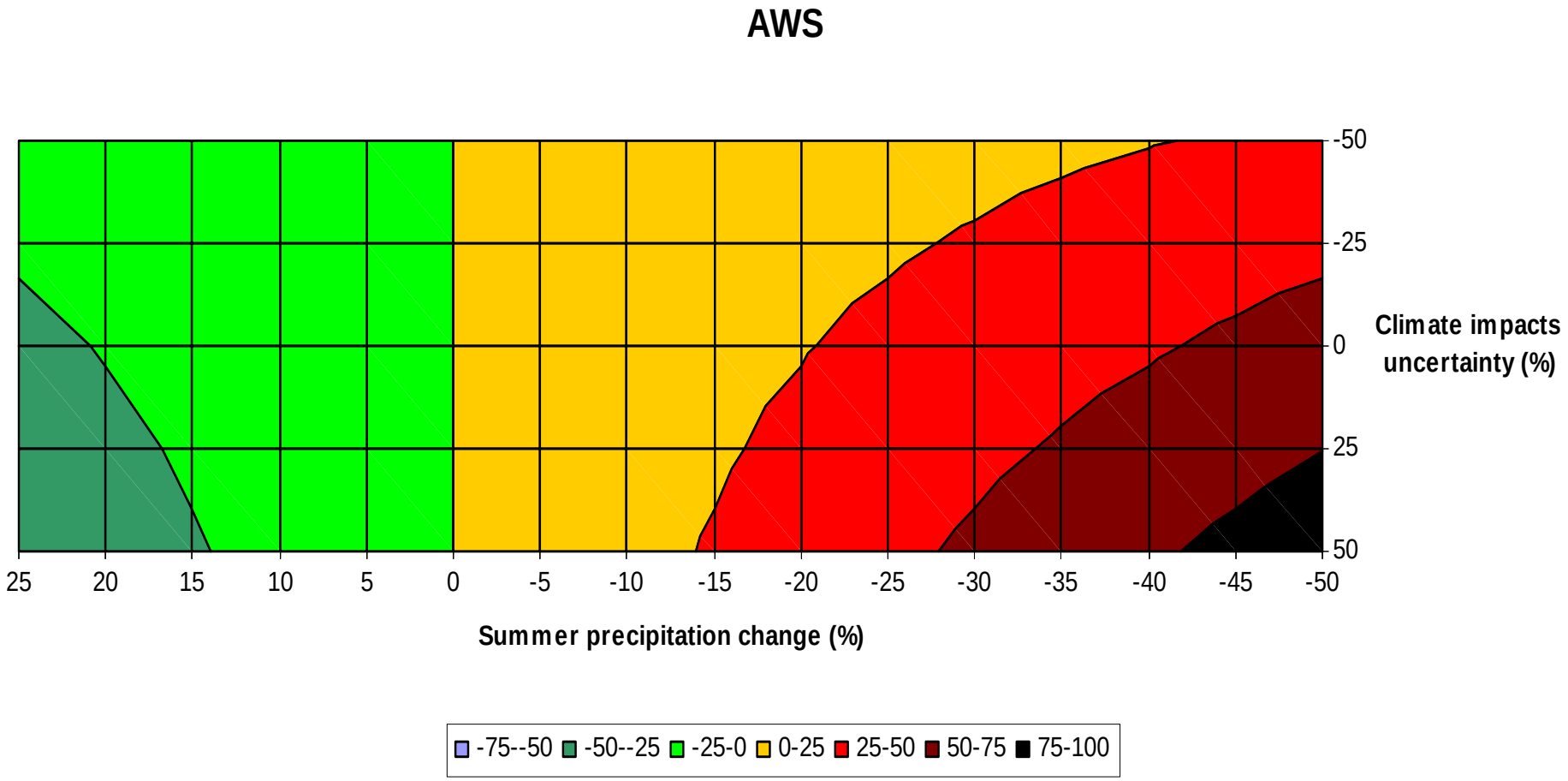
"Flexible design"
Anticipating imaginable surprises



Robustness exploration (Dessai, 2005)

Problem: Dimensioning of water supply system

Additional water required (Ml/d) to maintain levels of service in 2030 under different demand scenarios as a function of regional climate response uncertainty



Resilience

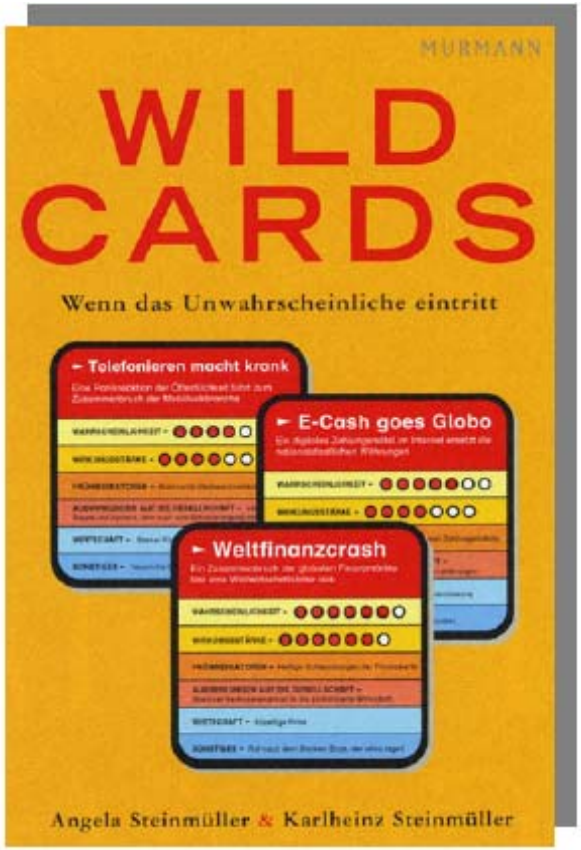
Figure 1 - Concept of resilience

- If uncertainties about climate cnange are large, one can still know how the resilience of social-ecological systems can be enhanced
- Resilience is the capacity of a system to tolerate disturbance without collapsing into a qualitatively different, usually undesired, state

Principles:

- **Homeostasis**
- **Omnivory**
- **High flux**
- **Flatness**
- **Buffering**
- **Redundancy**

www.resalliance.org



Verrassingsscenario's

- Trendbreuken / omslagpunten
- Veelal bepalend voor toekomst
- Vragen nieuwe manier van denken

www.steinmuller.de

Voorbeelden voor klimaatadaptatie:

- Stilvallen Oceaan Circulatie ("Warme Golfstroom" stopt)
- Extreem lage waterstand rivieren
- Langdurige hittegolven en aanhoudende droogte
- Extreme storm
- Invasie exoten

three types of wild cards

(1) extreme forms of expected trends,

(2) opposites of expected trends

(3) completely new issues (prepared for the wrong impact)

Most options remain beneficial under type-1 wildcards.

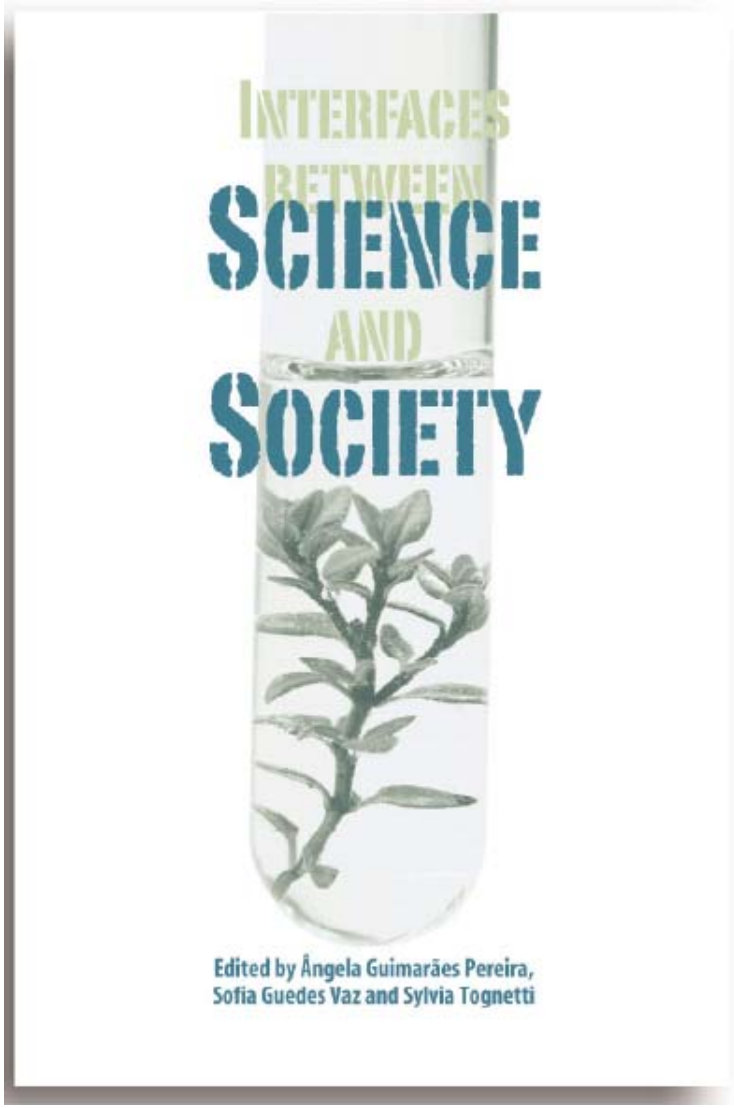
Under type-2 wildcards, options that enhance flexibility and responsiveness remain beneficial

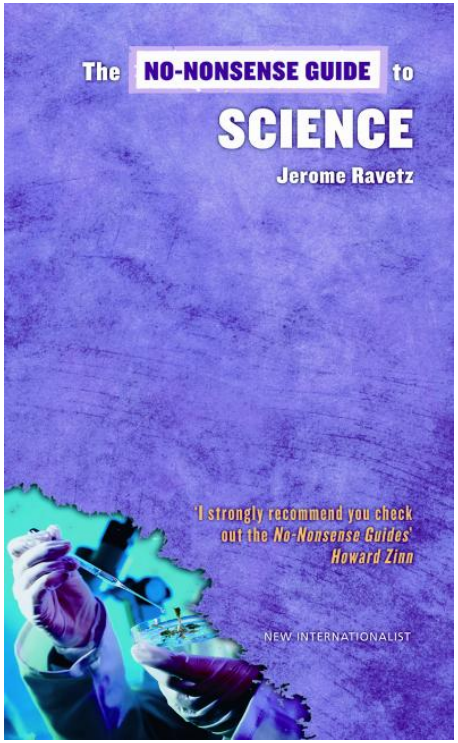
Few options protect against type-3 wildcards

Performance under different types of uncertainty

decision making under uncertainty frameworks	Statistical uncertainty	Scenario uncertainty	Recognized ignorance & surprises
IPCC scenario based approach	+	++	--
Prediction based risk approaches	++	+	--
Engineering safety margin	++	±	-
Anticipating design	++	+	+
Resilience	±	+	++
Precautionary Principle	+	++	++
Robust decision making	+	++	+

Books





Websites:

http://www.jvds.nl

http:// www.postnormaltimes.net

http:// www.nusap.net

http://alba.jrc.it/ibss

Boekverloting: Nieuw boek over Postnormale Wetenschap

- Edited by Dr. Angela Guimaraes Pereira and Dr. Silvio Funtowicz
- The essays deal with policy issues relating to environment governance in a situation where relevant scientific knowledge is uncertain and contextual. Recent debates in the context include climate change, genetically modified foods, and sustainable development. When stakes are high and decisions are urgent, new approaches are required for knowledge production and policy making.

  Divided into five parts, the volume features:
  I. methodological perspectives
  II. GMO policies covering bio-safety laws
  III. climate change policy
  IV. energy policy: nuclear waste, corporate energy strategies
  V. sustainable development: assessment tools, S&T Policymaking, and water governance
- **Readership :** Teachers and students of development economics, environmental studies, and sociology and policymakers seeking links between sustainability and development.

http://www.oupcanada.com/catalog/9780195698497.html

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