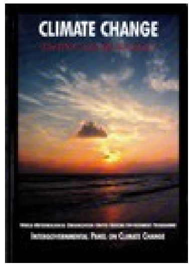
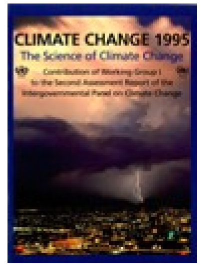
Numbers for policy: practical problems in quantification

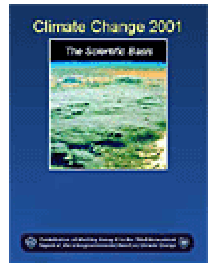
Bergen, 14 March 2017

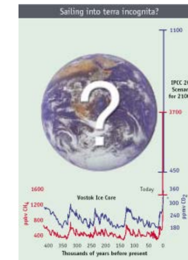
Climate change and the struggle with the uncertainty monster

Joseph Fourier
1768 - 1830



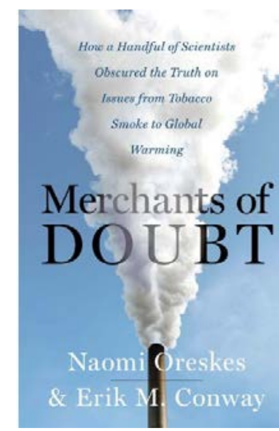






Global climate 2100?

Jeroen P. van der Sluijs *@Jeroen_vdSluijs*



Senter for vitenskapsteori

1824

MÉMOIRE

SUR

LES TEMPÉRATURES DU GLOBE TERRESTRE ET DES ESPACES PLANÉTAIRES.

PAR M. FOURIER.

La question des températures terrestres, l'une des plus importantes et des plus difficiles de toute la philosophie naturelle, se compose d'éléments assez divers qui doivent être considérés sous un point de vue général. J'ai pensé qu'il serait utile de réunir dans un seul écrit les conséquences principales de cette théorie; les détails analytiques que l'on omet ici se trouvent pour la plupart dans les ouvrages que j'ai déja publiés. J'ai désiré surtout présenter aux physiciens, dans un tableau peu étendu, l'ensemble des phénomènes et les rapports mathématiques qu'ils ont entre eux.

La chaleur du globe terrestre dérive de trois sources qu'il est d'abord nécessaire de distinguer.

1° La terre est échauffée par les rayons solaires, dont l'inégale distribution produit la diversité des climats.

2° Elle participe à la température commune des espaces planétaires, étant exposée à l'irradiation des astres innombrables qui environnent de toutes parts le système solaire.

1856

ART. XXXI.—*Circumstances affecting the Heat of the Sun's Rays;* by EUNICE FOOTE.

(Read before the American Association, August 23d, 1856.)

MY investigations have had for their object to determine the different circumstances that affect the thermal action of the rays of light that proceed from the sun.

Thirdly. The highest effect of the sun's rays I have found to be in carbonic acid gas.

One of the receivers was filled with it, the other with common air, and the result was as follows:

In Common Air.		In Carbonic Acid Gas.	
In shade.	In sun.	In shade.	In sun.
80	90	80	90
81	94	84	100
80	99	84	110
81	100	85	120

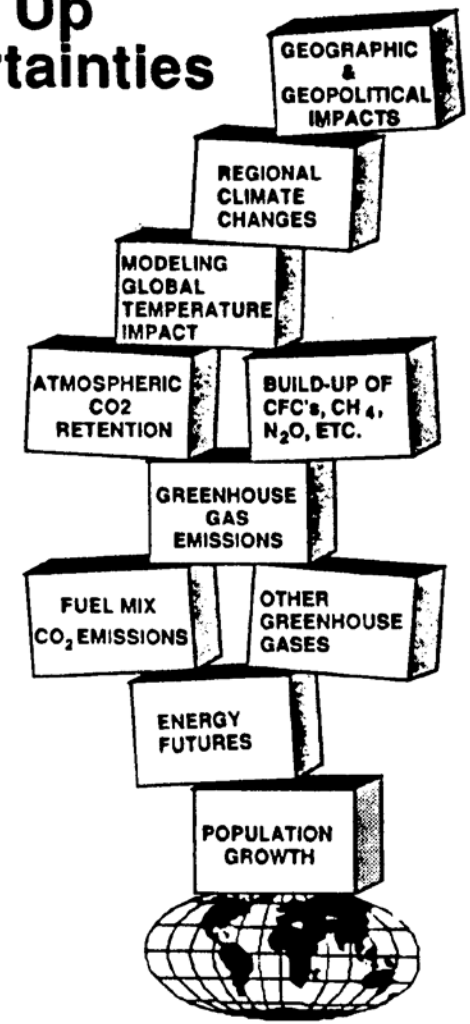
The receiver containing the gas became itself much heated—very sensibly more so than the other—and on being removed, it was many times as long in cooling.

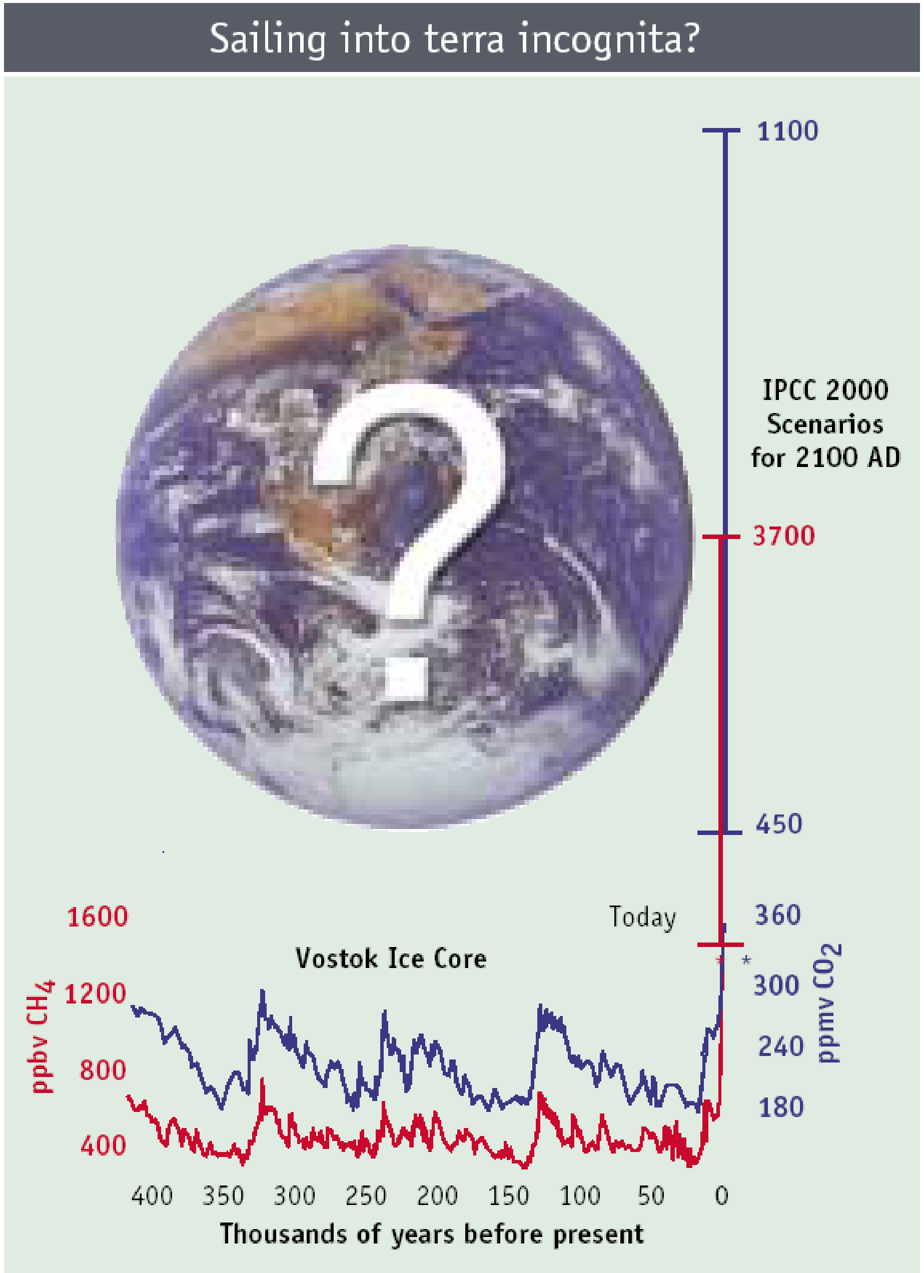
An atmosphere of that gas would give to our earth a high temperature; and if as some suppose, at one period of its history the air had mixed with it a larger proportion than at present, an increased temperature from its own action as well as from increased weight must have necessarily resulted.

On comparing the sun's heat in different gases, I found it to be in hydrogen gas, 104°; in common air, 106°; in oxygen gas, 108°; and in carbonic acid gas, 125°.

GLOBAL CLIMATE CHANGE

Piling Up Uncertainties





How does science-policy interface cope with uncertainties

Two strategies dominate:

- **Overselling certainty**
  - to promote political decisions (enforced consensus), or
- **Overemphasising uncertainty**
  - to prevent political action

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

- Need for a third voice next to alarmists and skeptics: coping with uncertainty, scientific dissent & plurality in science for policy.

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 in dispute
- Knowledge base 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

A practical problem:

Protecting a strategic fresh-water resource

5 scientists 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)

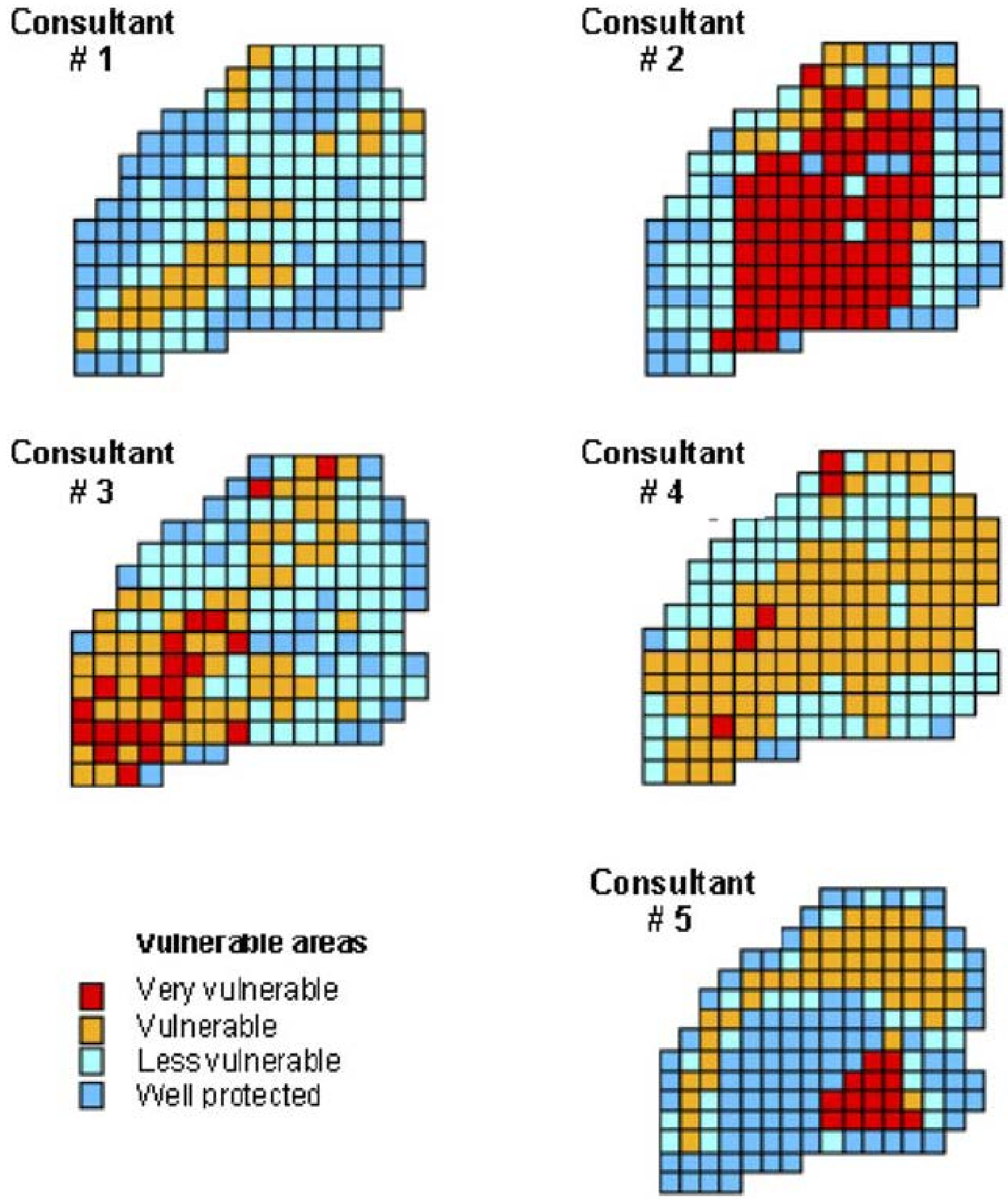


Fig. 1. Model predictions on aquifer vulnerability towards nitrate pollution for a 175 km^2 area west of Copenhagen [11].

3 framings of uncertainty

'deficit view'

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

'evidence evaluation view'

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

'complex systems view / *post-normal* view'

- Uncertainty is intrinsic to complex systems
- Openly deal with deeper dimensions of uncertainty
- *Tools:* Knowledge Quality Assessment
  - ***Working deliberatively within imperfections***

How to act upon such uncertainty?

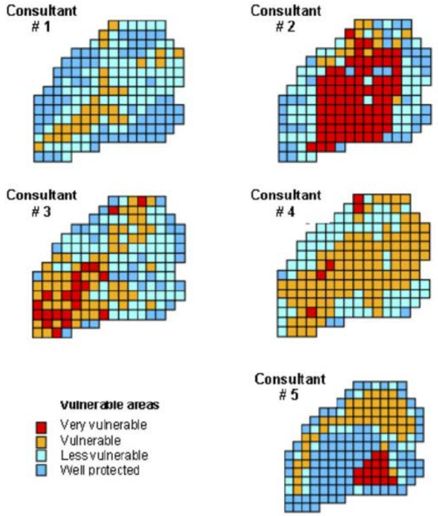


Fig. 1. Model predictions on aquifer vulnerability towards nitrate pollution for a 175 km^2 area west of Copenhagen [11].

- **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**

Uncertainty as a monster in the science–policy interface: four coping strategies

2005

Jeroen van der Sluijs

Copernicus Institute for Sustainable Development and Innovation, Utrecht University, Heidelberglaan 2, 3584 CS Utrecht, The Netherlands (E-mail: *j.p.vandersluijs@chem.uu.nl*)

Abstract Using the metaphor of monsters, an analysis is made of the different ways in which the scientific community responds to uncertainties that are hard to tame. A monster is understood as a phenomenon that at the same moment fits into two categories that were considered to be mutually excluding, such as knowledge versus ignorance, objective versus subjective, facts versus values, prediction versus speculation, science versus policy. Four styles of coping with monsters in the science–policy interface can be distinguished with different degrees of tolerance towards the abnormal: monster-exorcism, monster-
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the learning pro
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CLIMATE SCIENCE AND THE UNCERTAINTY MONSTER

BY J. A. CURRY AND P. J. WEBSTER

An exploration of ways to understand, assess and reason about uncertainty in climate science, with specific application to the IPCC assessment process.

2011

http://www.nusap.net/spe/UPEMmonsters.pdf
http://journals.ametsoc.org/doi/pdf/10.1175/2011BAMS3139.1

Uncertainty as a “monster”

- A monster is a phenomenon that at the same moment fits into two categories that were considered to be mutually excluding

(Smits, 2002; Douglas 1966)

  - knowledge – ignorance
  - objective – subjective
  - facts – values
  - prediction – speculation
  - science - policy

Responses to monsters

Different degrees of tolerance towards the abnormal:

- monster-exorcism (expulsion)
- monster-adaptation (transformation)
- monster-embracement (acceptance)
- monster-assimilation (rethinking)

There are many uncertainties in our predictions particularly with regard to the timing, magnitude and regional patterns of climate change, due to our incomplete understanding of:

- sources and sinks of greenhouse gases, which affect predictions of future concentrations
- clouds, which strongly influence the magnitude of climate change
- oceans, which influence the timing and patterns of climate change
- polar ice sheets which affect predictions of sea level rise

These processes are already partially understood, and we are confident that the uncertainties can be reduced by further research However, the complexity of the system means that we cannot rule out surprises

(IPCC AR1 Policy Makers Summary, 1990)
http://www.ipcc.ch/ipccreports/far/wg_I/ipcc_far_wg_I_spm.pdf

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)

[Prof. Bert Bolin,
15 March 1925 – 30 December 2007]
Bolin B (1994) *Ambio* 23 (1) 25-29

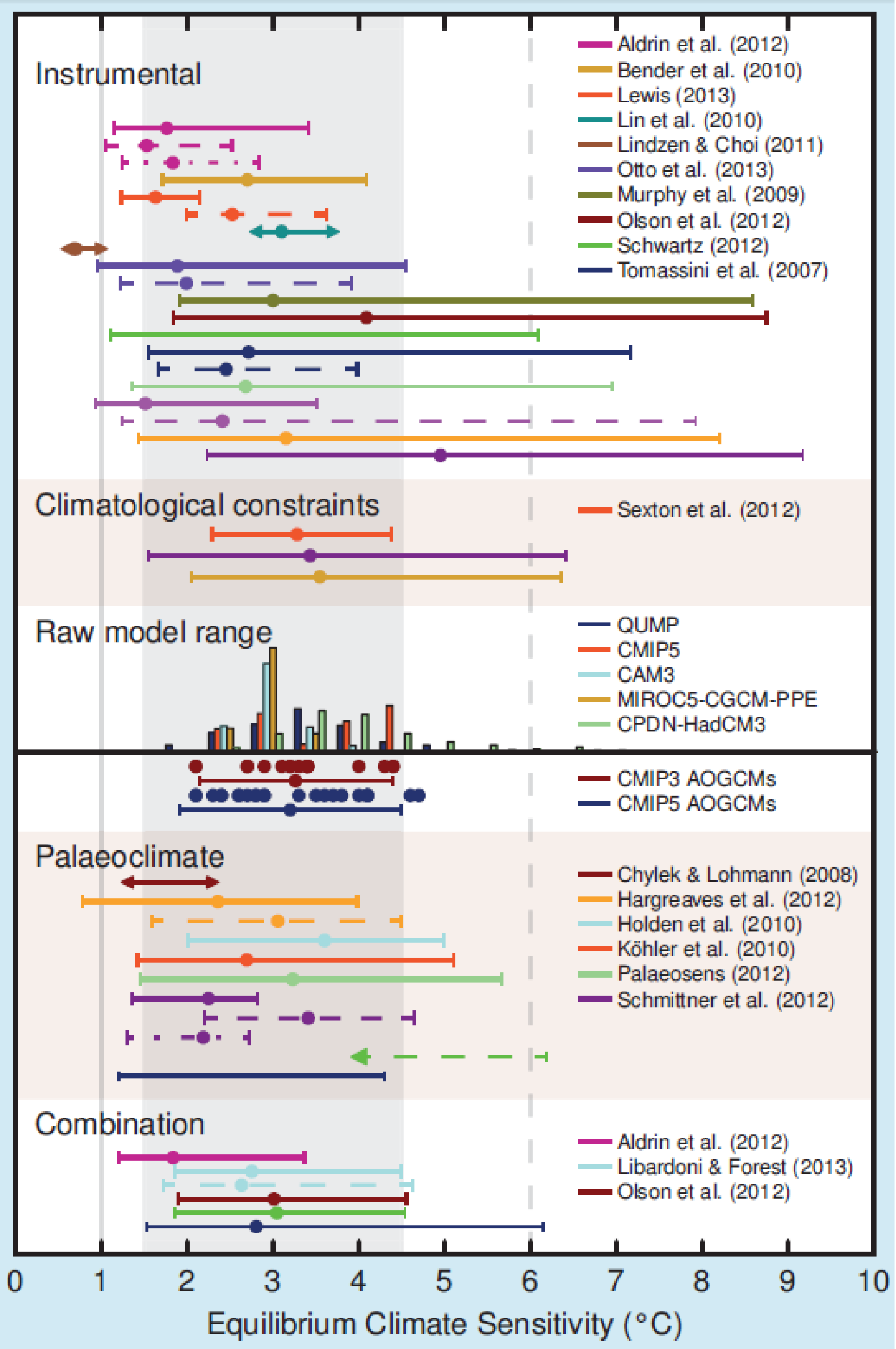
26 years after "we are confident that the uncertainties can be reduced..."

Evolution of knowledge on Climate Sensitivity over past 35 years

Assessment report	Range of GCM results (°C)	Concluded Range (°C)	Concluded best guess (°C)
NAS 1979	2-3.5	1.5-4.5	3
NAS 1983	2-3.5	1.5-4.5	3
Villach 1985	1.5-5.5	1.5-4.5	3
IPCC AR1 1990	1.9-5.2	1.5-4.5	2.5
IPCC AR2 1995	MME	1.5-4.5	2.5
IPCC AR3 2001	MME	1.5-4.5	Not given
IPCC AR4 2007	MME	2.5-4.5	3
IPCC AR5 2013	MME (0.5-9)	1.5-4.5*	Not given

*"Likely" (17-83%) range. Prior to AR4 ranges were not clearly defined.
MME = Multi Model Ensemble

(Van der Sluijs e.a. 1998, updated 2014)
http://sss.sagepub.com/content/28/2/291.short



IPCC AR5 Chapter 12

Probability density functions, distributions and ranges for equilibrium climate sensitivity

Grey shaded range:
likely 1.5°C to 4.5°C range

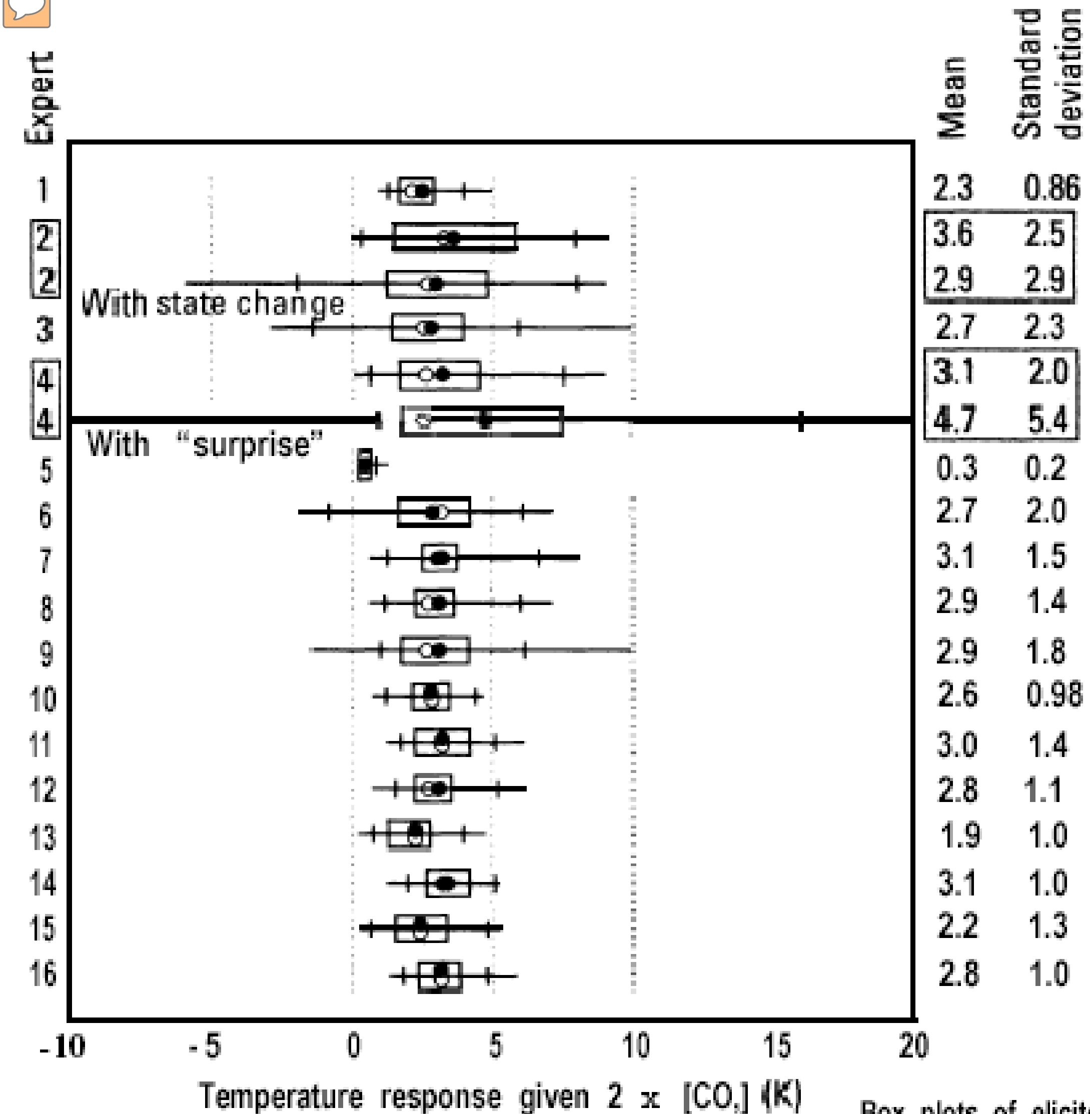
Grey solid line:
extremely unlikely less than 1°C

Grey dashed line:
very unlikely greater than 6°C.

http://www.climatechange2013.org/images/report/WG1AR5_Chapter12_FINAL.pdf

Subjective judgments by top 16 climate experts USA

(Morgan & Keith, 1995)



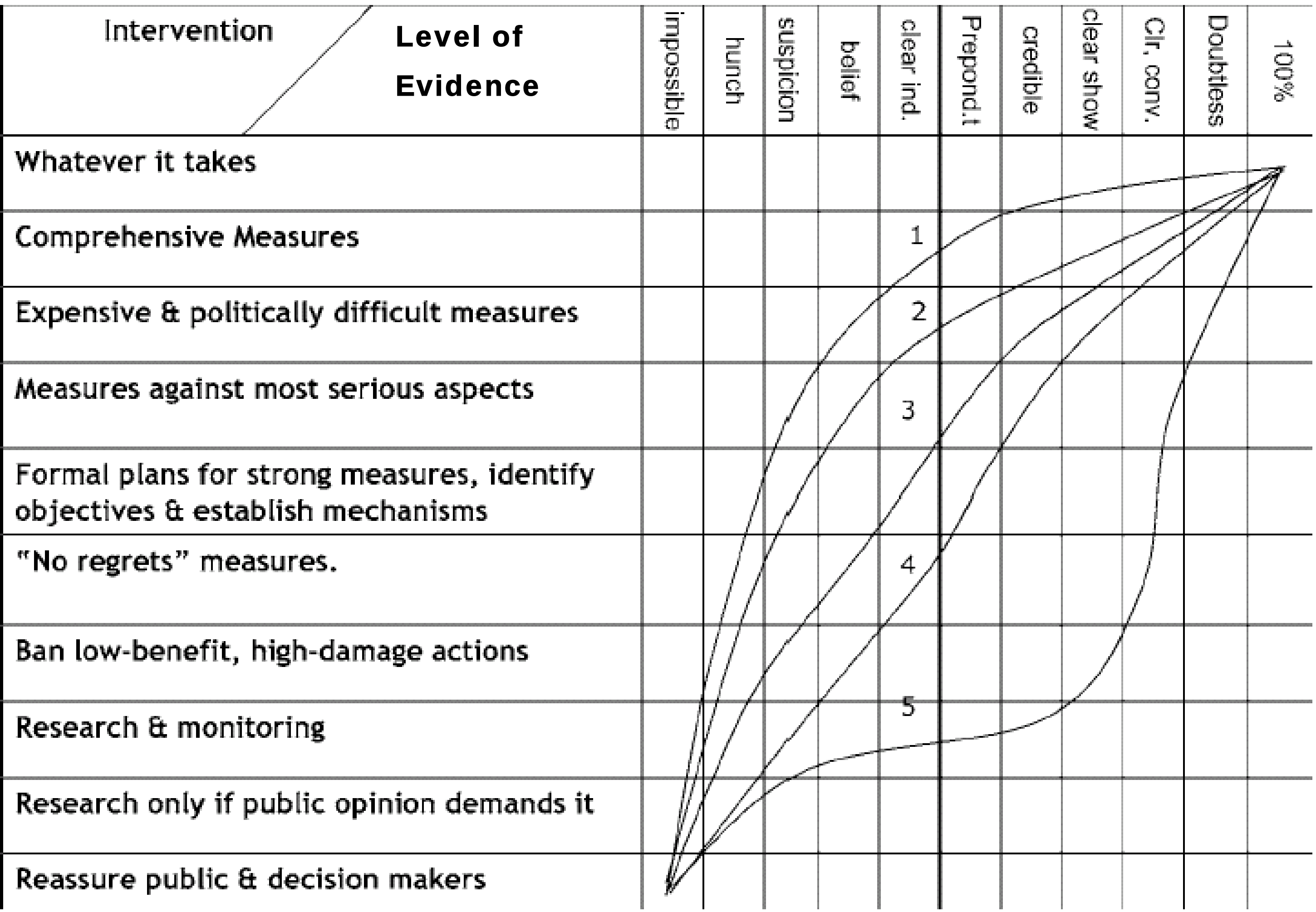
Box plots of elicited probability distributions of climate sensitivity, the change in globally averaged surface temperature for a 2 x [CO_2] forcing. Horizontal line denotes range from minimum to maximum assessed possible values. Vertical tick marks indicate locations of lower 5 and upper 95 percentiles. Box indicates interval spanned by 50% confidence interval. Solid dot is the mean and open dot is the median. The two columns of numbers on right side of the figure report values of mean and standard deviation of the distributions.

http://dx.doi.org/10.1021/es00010a753

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. Hunch
0. No suspicion

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



Attitudes according to Weiss 2003:

1. Environmental absolutist

2. Cautious environmentalist

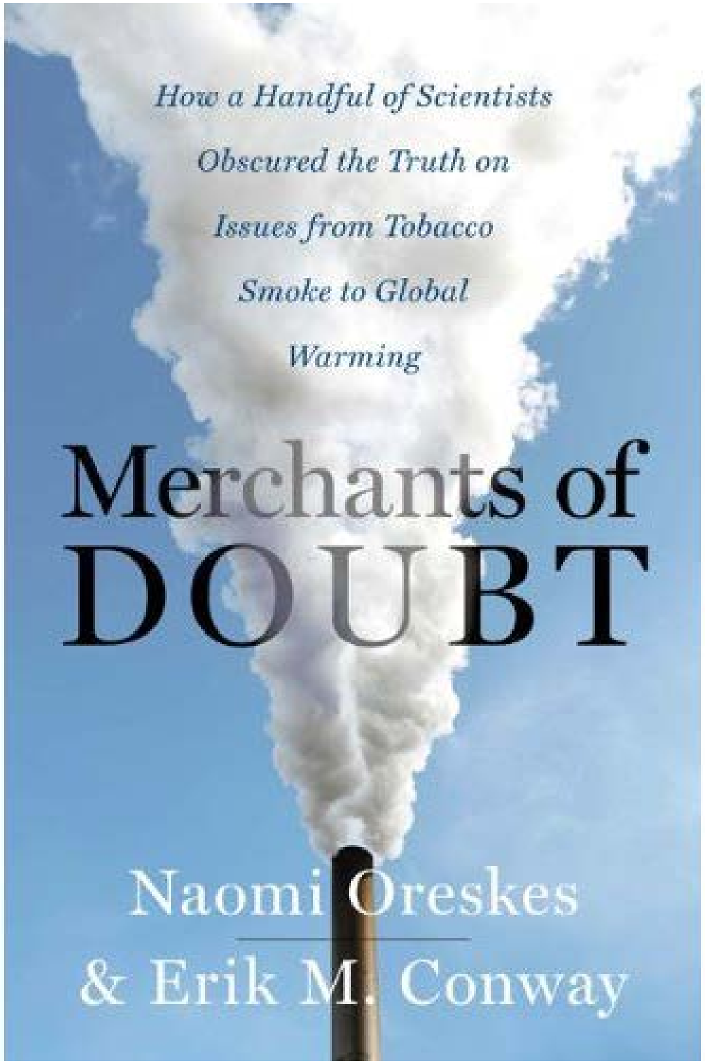
3. Environmental centrist

4. Technological optimist

5. Scientific absolutist

3 sources that fuel dissent in scientific community

Conflicts of interests

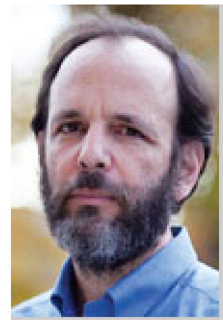


Institutionalized practices

Published online 5 October 2011 | *Nature* **478**, 7 (2011) |
doi:10.1038/478007a

Column: World View

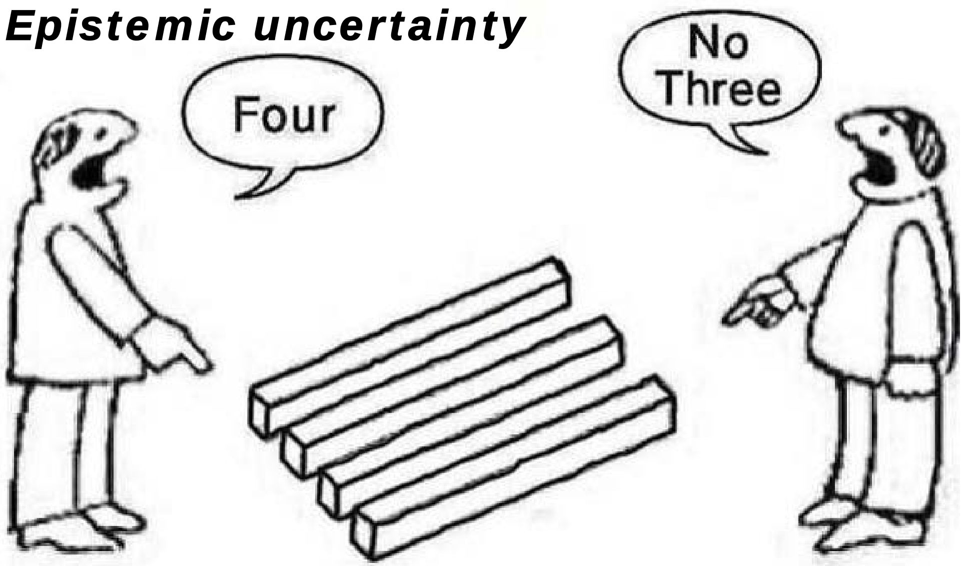
The voice of science: let's agree to disagree

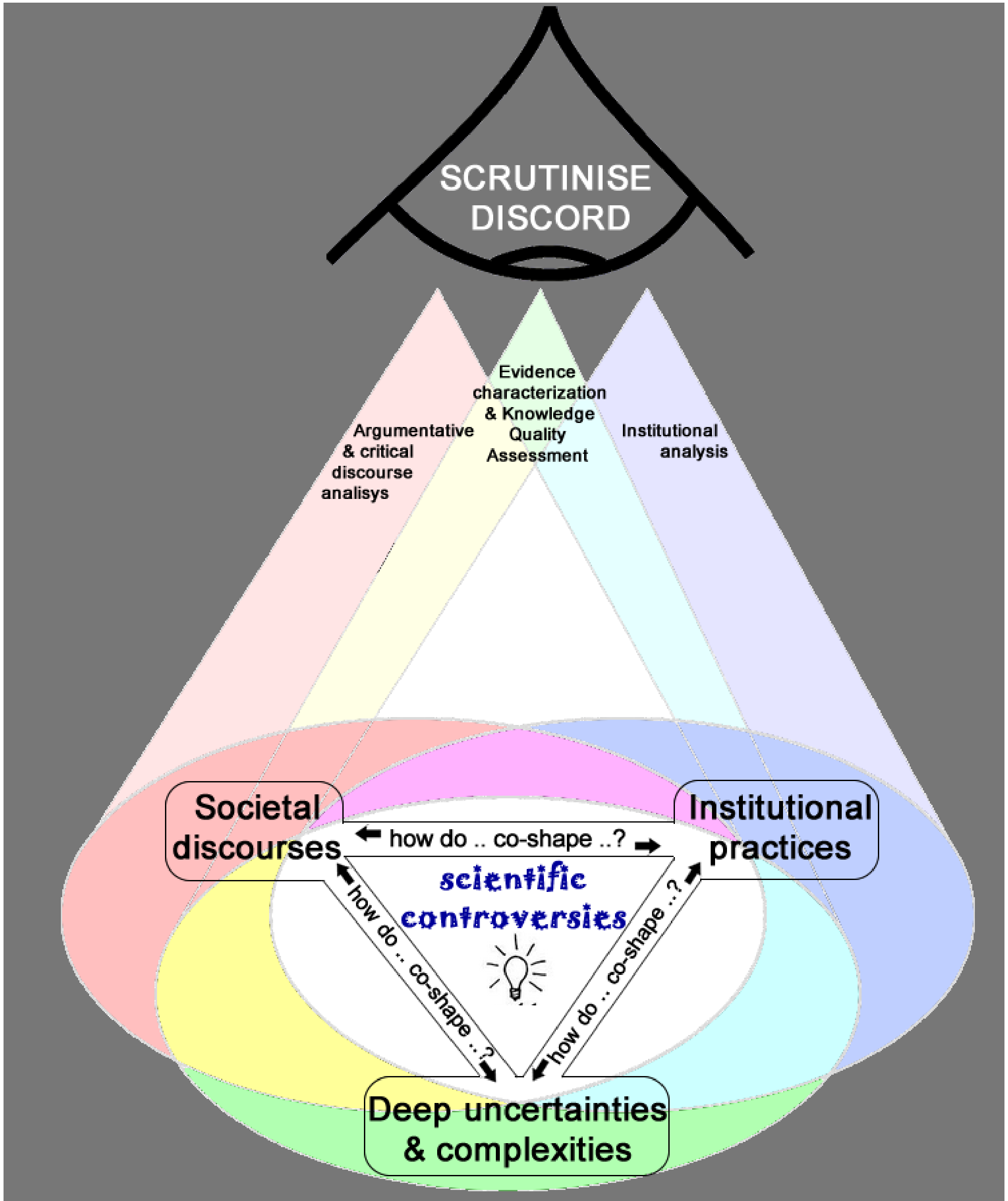


Consensus reports are the bedrock of science-based policy-making. But disagreement and arguments are more useful, says Daniel Sarewitz.

Daniel Sarewitz

Epistemic uncertainty





New way of looking at scientific controversies

"By shining light on its dynamics from 3 different perspectives (**discourse analysis, evidence characterization**, **institutional analysis**) it seeks to reveal how 3 key factors (**deep uncertainties; societal discourses; institutional practices**) co-shape one another to produce the typical patterns that can be observed in scientific controversies."

Van der Sluijs, 2014