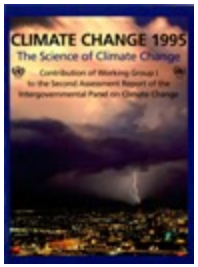
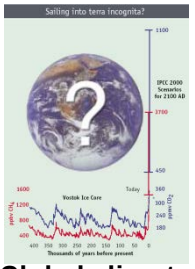
Climate change, the uncertainty monster and post normal science

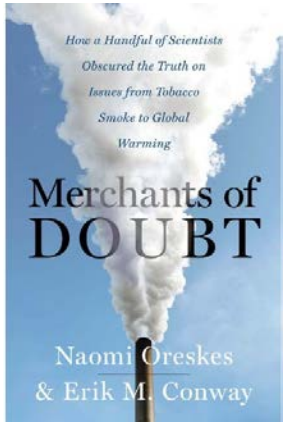
Joseph Fourier
1768 - 1830





Global climate 2100?

Jeroen P. van der Sluijs *@Jeroen_vdSluijs*



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.

http://gallica.bnf.fr/ark:/12148/bpt6k32227.image.r=memoires+de+l%27academie+des+sciences.f808.langEN

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°.

http://www.climatechangenews.com/2016/09/02/the-woman-who-identified-the-greenhouse-effect-years-before-tyndall/

Period	Phase	Characteristics
1856-1985	Foundational period	Scientific concern
1985-1988	Agenda-setting phase	Emerging policy issue
1988-1990	Pre-negotiation period	Government involvement
1990-1992	Intergovernmental negotiations	UN FCCC: Mitigation
1992-2009	Post agreement phase COP1 – COP15	Elaboration & implementation UN FCCC
2009/2010	Climate gate / Himalaya gate	Polarization & erosion of trust
2011- present	??? *Welcome in the Post normal age*	Working deliberatively within imperfections
>2015		Prepare for > +2°C Adaptation ? Negative emissions ? Geo-engineering

Post-normal science: / Peter Gluckman, *Nature* 12 Mar 2014
http://www.nature.com/news/policy-the-art-of-science-advice-to-government-1.14838?WT.ec_id=NATURE-20140313

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-adaptation, mon
the learning pro
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scientific comm
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Keywords Ano

CLIMATE SCIENCE AND THE UNCERTAINTY MONSTER

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

2011

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

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

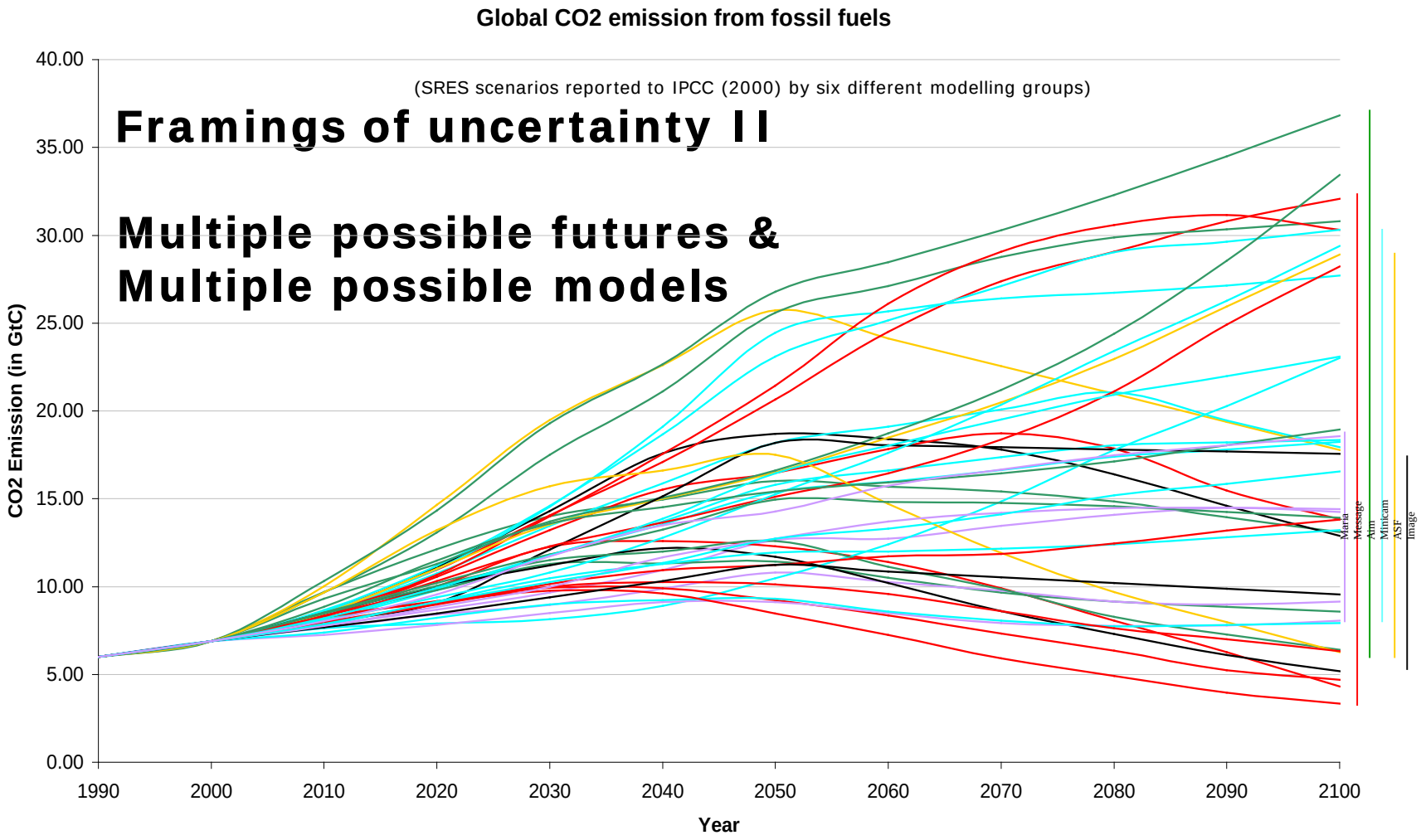
(IPCC AR1 Policy Makers Summary, 1990)
http://www.ipcc.ch/ipccreports/far/wg_I/ipcc_far_wg_I_spm.pdf

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]

IPCC 10 years after *"we are confident that the uncertainties can be reduced…"*

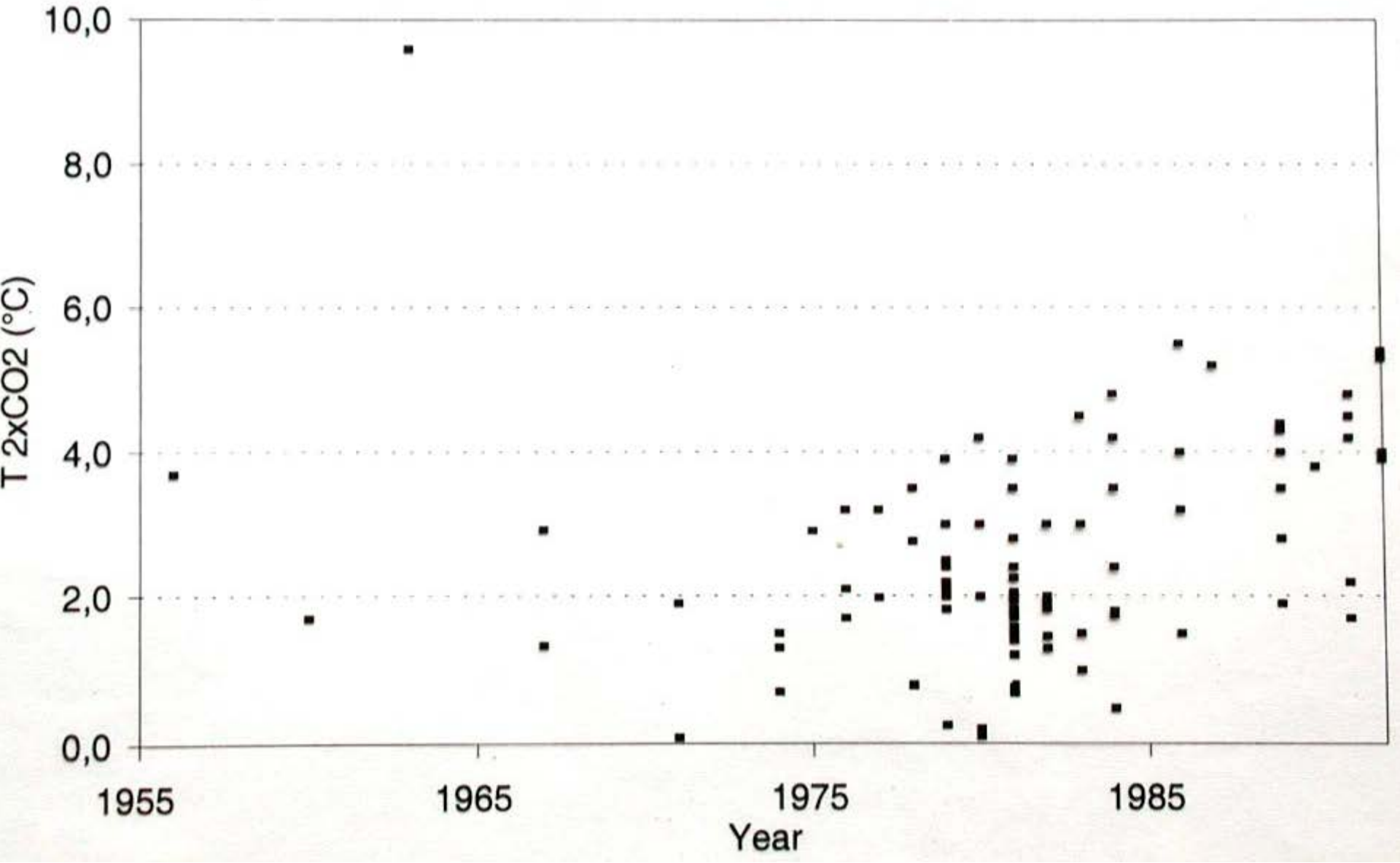


Climate sensitivity

IPCC definition

- The climate sensitivity is defined as the equilibrium change in global average surface air temperature due to a doubling of CO_2 … and is a measure of the response of a climate model to a change in radiative forcing.
- The climate sensitivity may be thought of as partly a direct effect (estimated to be of the order of 1.2°C for a doubling of CO_2) and partly the effect of feedbacks that act to enhance or suppress the radiative warming.

Results of climate model calculations CO_2 doubling temperature of the Earth plotted against year of publication



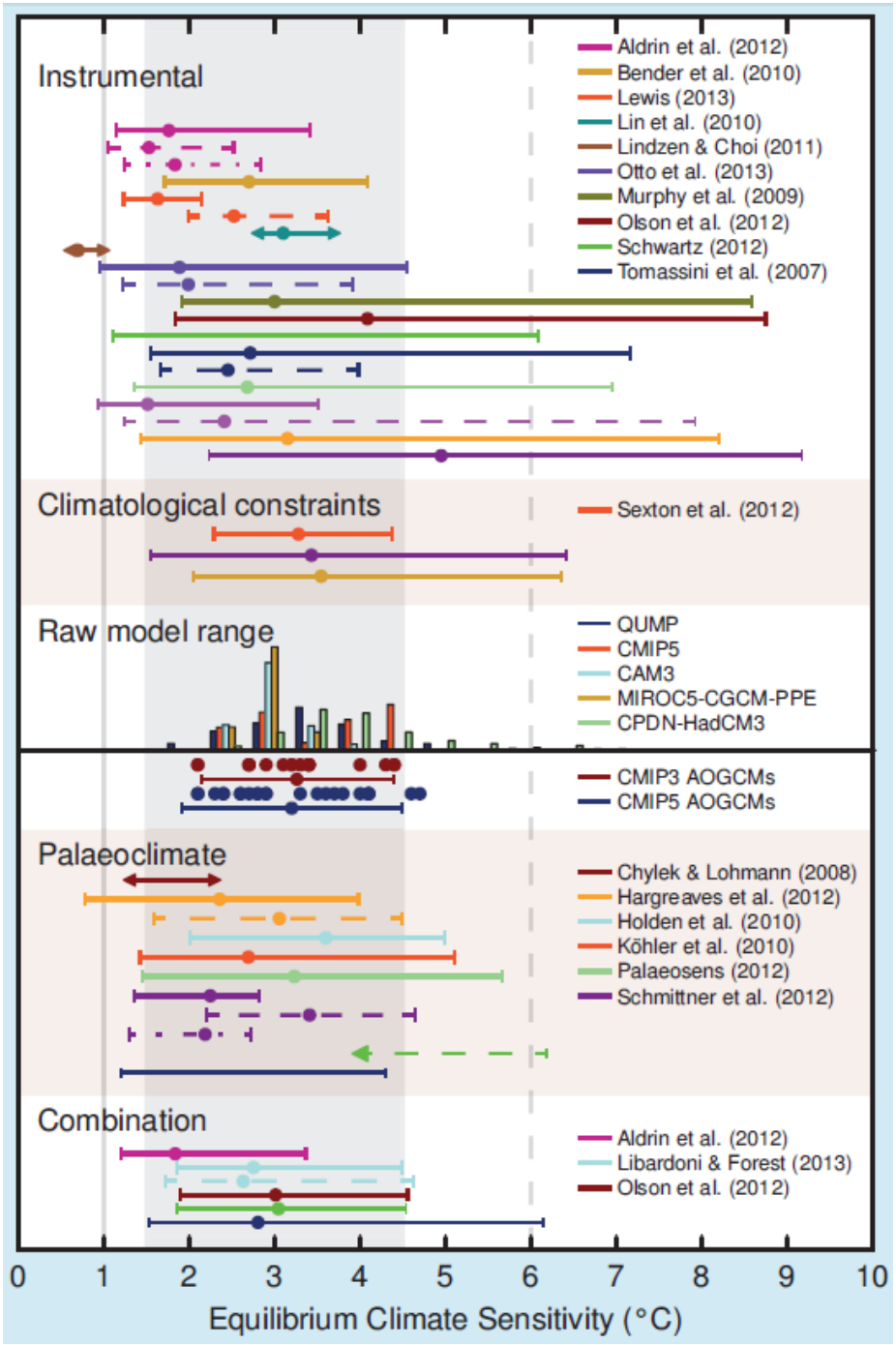
25 years after "we are confident that the uncertainties can be reduced…"

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 2015)
http://sss.sagepub.com/content/28/2/291.short



IPCC AR5 Chapter 12

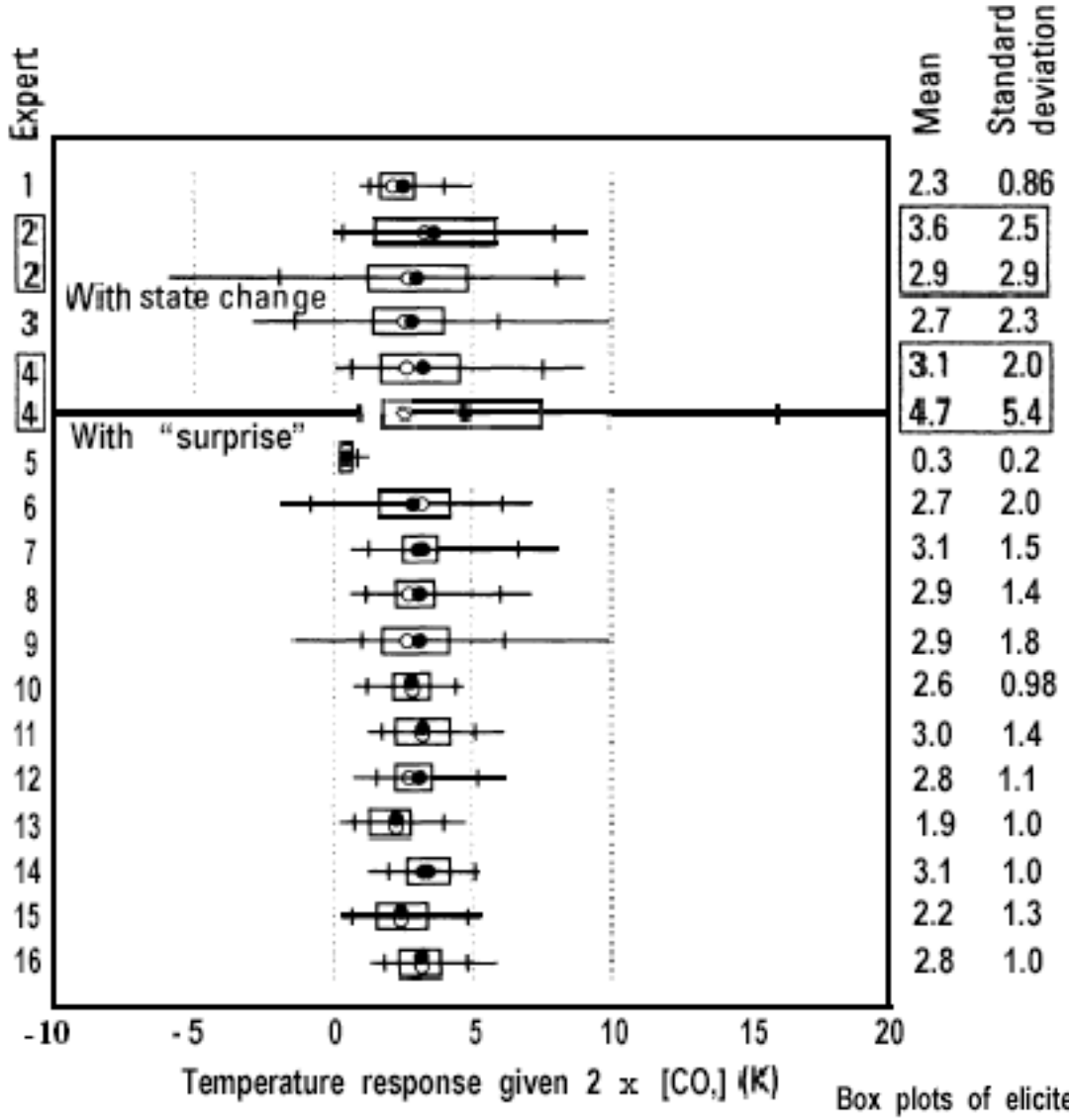
Probability density functions, distributions and ranges for equilibrium climate sensitivity

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

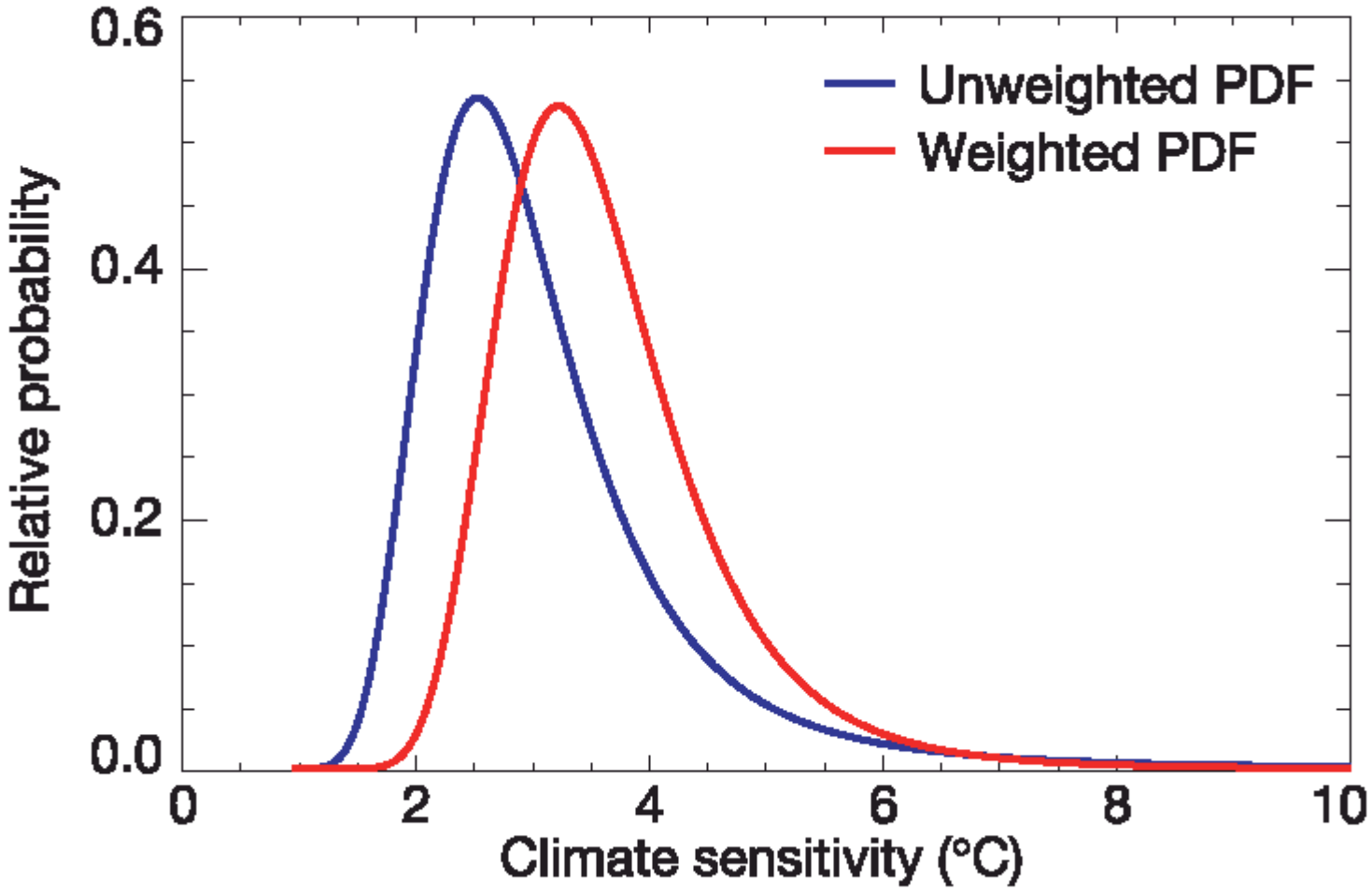


Subjective judgments by top 16 climate experts USA

(Morgan & Keith, 1995)

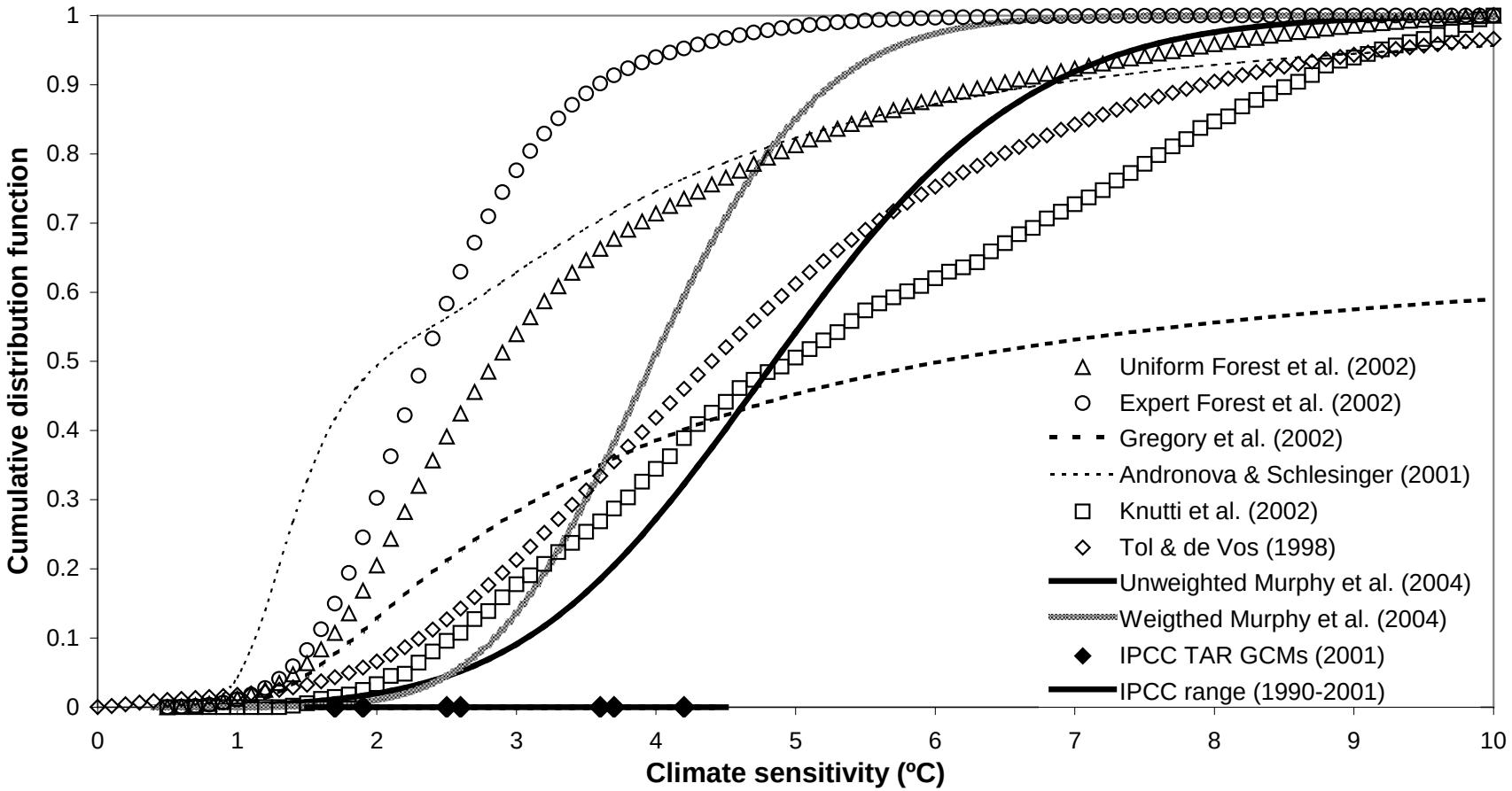
Box plots of elicited probability distributions of climate sensitivity, the change in globally averaged surface temperature for a 2 x [CO_2] forcing. Horizontal line denotes range from minimum to maximum assessed possible values. Vertical tick marks indicate locations of lower 5 and upper 95 percentiles. 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



Probability distributions of climate sensitivity. Obtained using linear statistical estimation of GCM predictions likely to result from a large "perturbed physics ensemble" sampling the model parameter space comprehensively, with (red) and without (blue) weighting according to the estimated reliability of model versions based on correspondence to observations. (Murphy et al., *Nature*, 11 Aug 2004)

CDFs Climate Sensitivity



Consensus approach IPCC problematic

- Undue certainty (high error costs!)
- promotes anchoring towards previously established consensus positions
- Hides diversity of perspectives
- Constrains decision-makers options
- Underexposes dissent
  - hampers both scientific debates and policy debates

http://dx.doi.org/10.1016/j.cosust.2010.10.003
http://www.nature.com/news/2011/111005/full/478007a.html

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

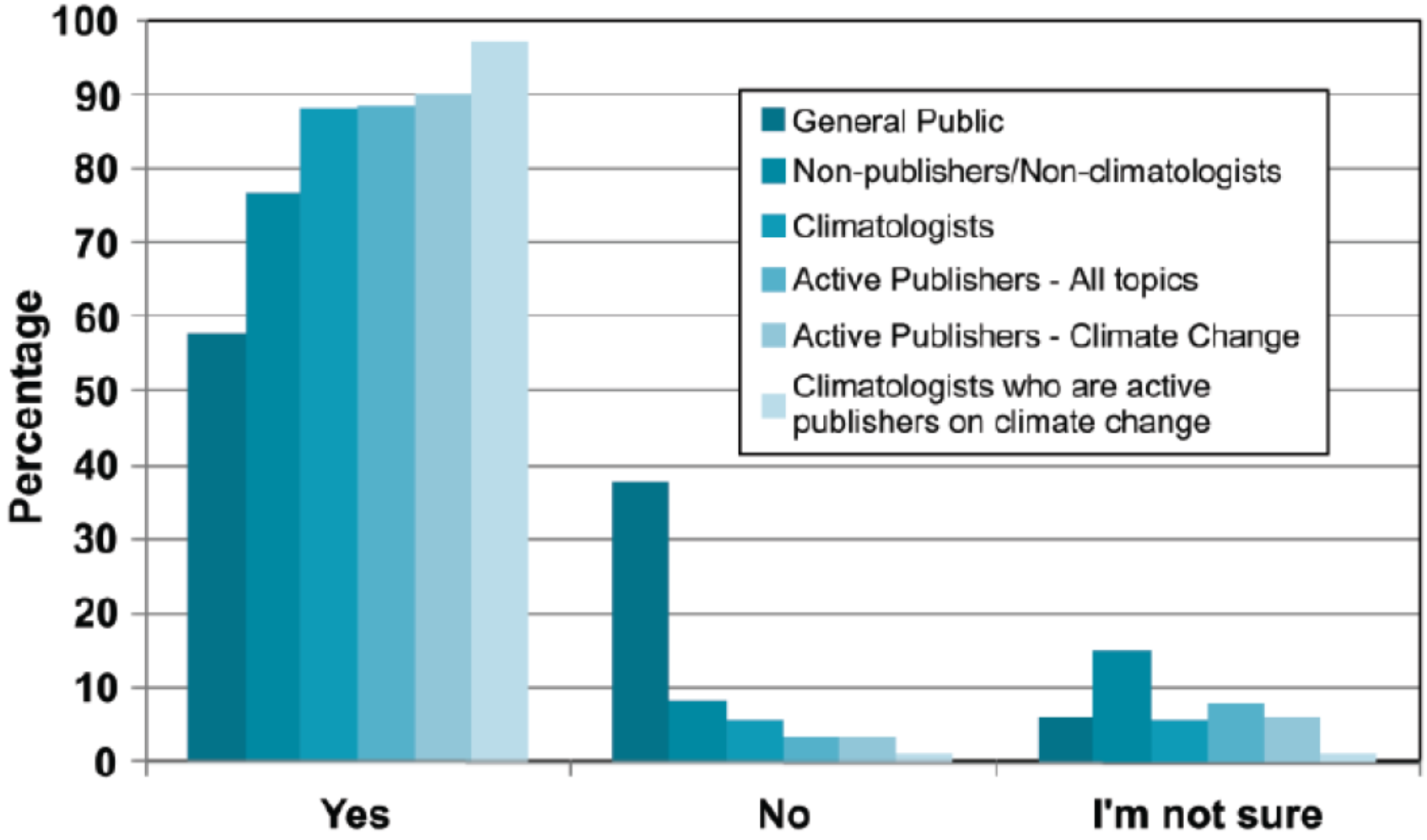
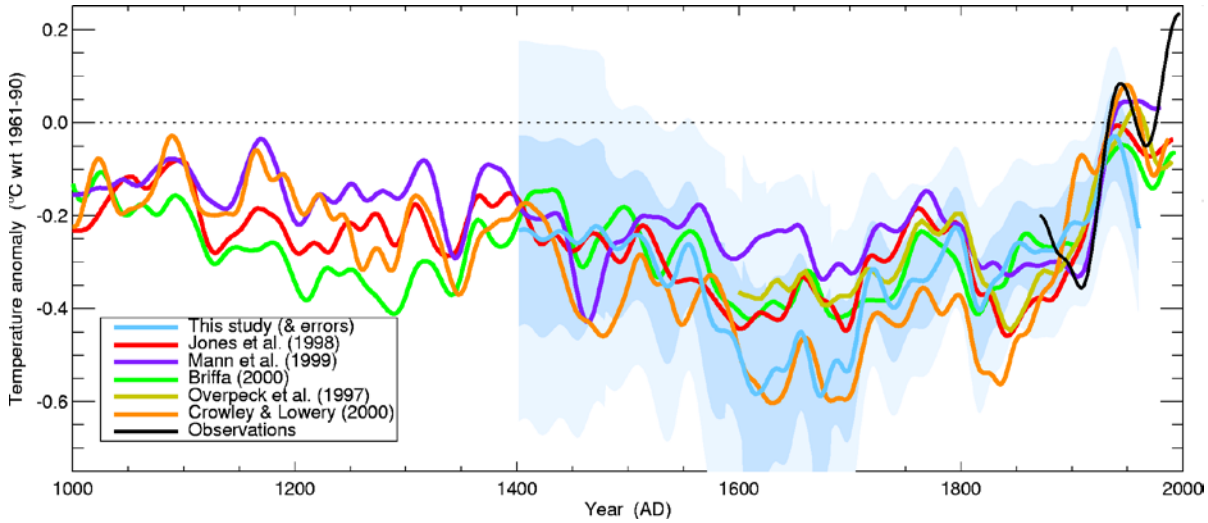


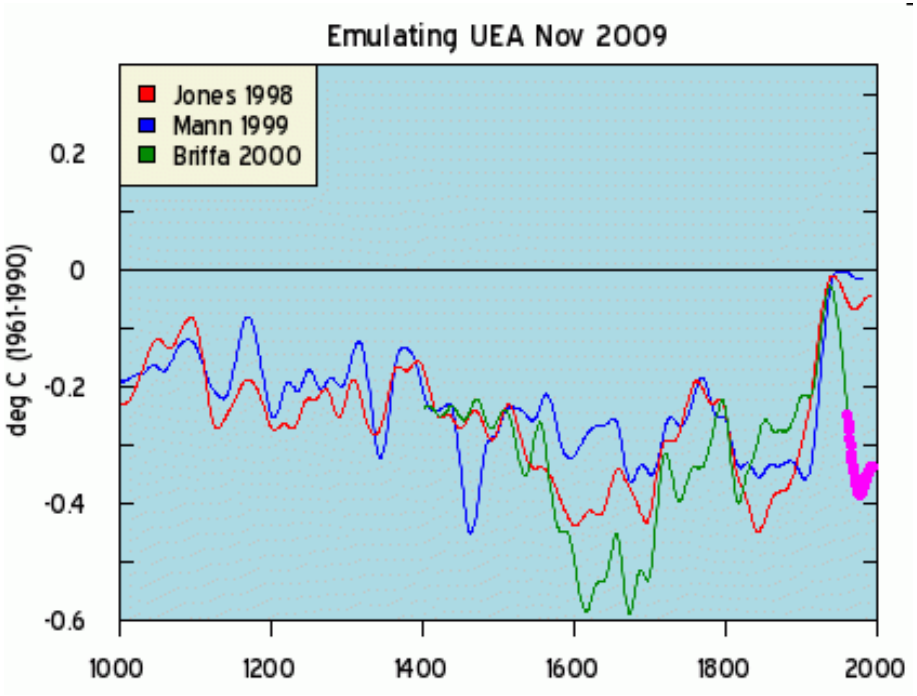
Fig. 1. Response distribution to our survey question 2. The general public data come from a 2008 Gallup poll (see http://www.gallup.com/poll/1615/Environment.aspx).

10257 scientists were asked "*Do you think human activity is a significant contributing factor in changing mean global temperatures?*". 3146 responded as above. (Doran & Zimmerman 2009 – EOS)

Hockystick Controversy



Climate Gate: Briffa reconstruction after 1960 left out of the diagram by UEA



"Here's what UEA appears to have done in the above diagram. While they've used the actual Briffa reconstruction after 1960 in making their smooth, even now, they deleted values after 1960 so that the full measure of the decline of the Briffa reconstruction is hidden. Deleted values are shown in magenta." (Steve McIntyre)

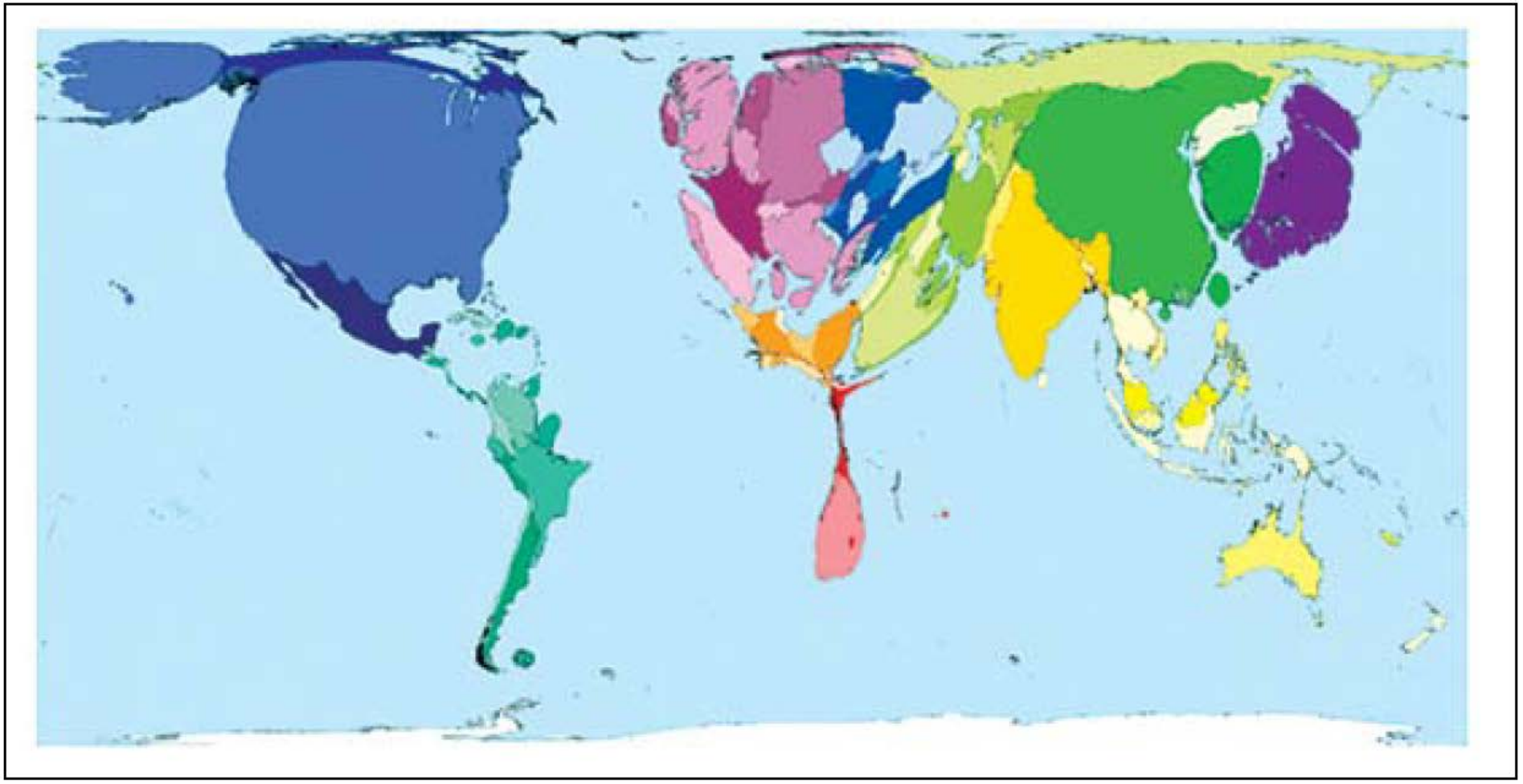
http://wattsupwiththat.com/2009/11/30/playing-hide-and-seek-behind-the-trees/

Lessons from climate gate

- **Overselling certainty creates vulnerabilities** in scientific basis for policy – *will be exploited!*
- **Quality control** & Fact checking essential
- **Openness about uncertainty and dissent** in the climate science policy interface avails democracy
- Climate debate would benefit from **clarification of values** at play in climate science & S-P interface

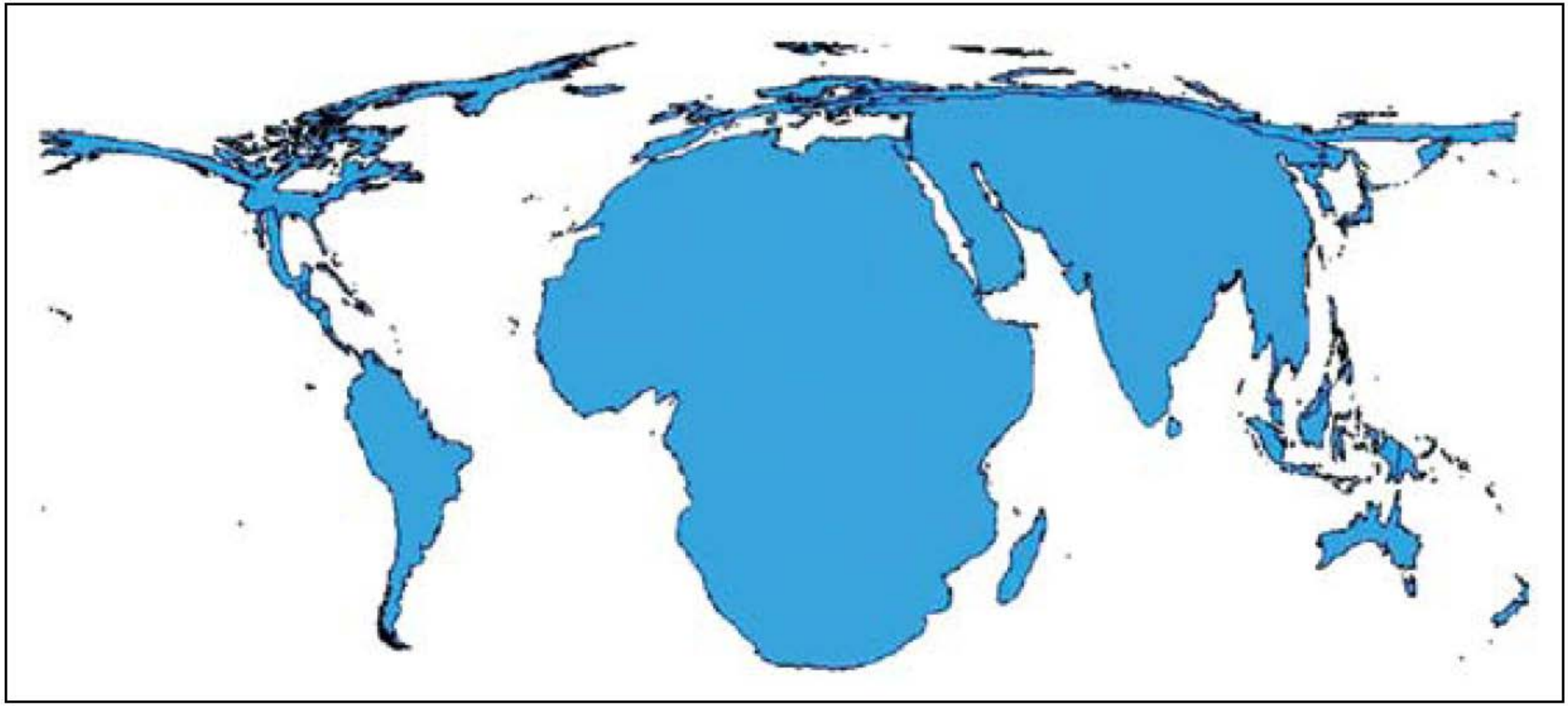
(Van der Sluijs e.a. 2010, 2012)
http://dx.doi.org/10.1016/j.cosust.2010.10.003
http://dx.doi.org/10.3167/nc.2012.070204

The world map reflecting carbon emissions

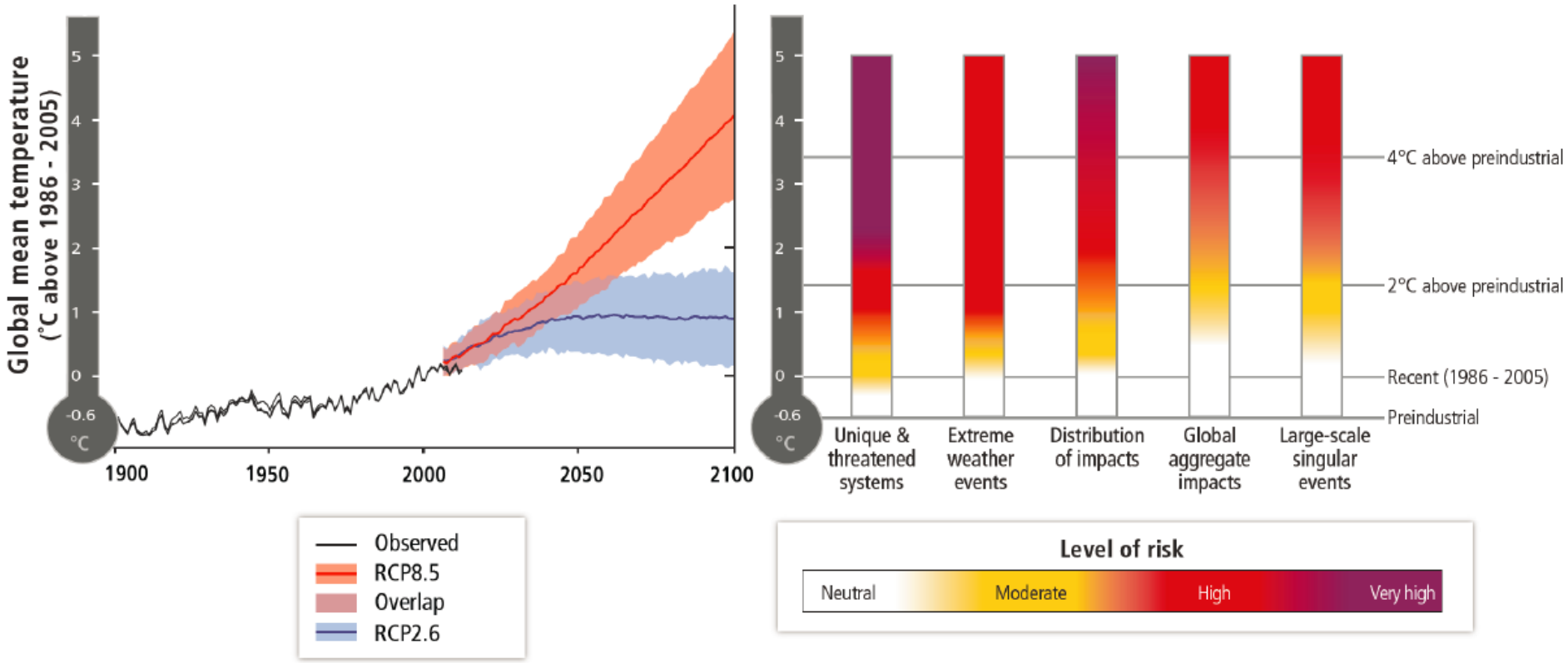


*Annual aggregate national CO_2 emissions 2000
Source: SASI Group (University of Sheffield) and Mark Newman (University of Michigan), 2006

The world map reflecting mortality related to climate change



Source: Climate Change and Global Health: Quantifying a Growing Ethical Crisis, 2007, Jonathan A. Patz, Holly K. Gibbs, Jonathan A. Foley, Jamesine V. Rogers, and Kirk R. Smith

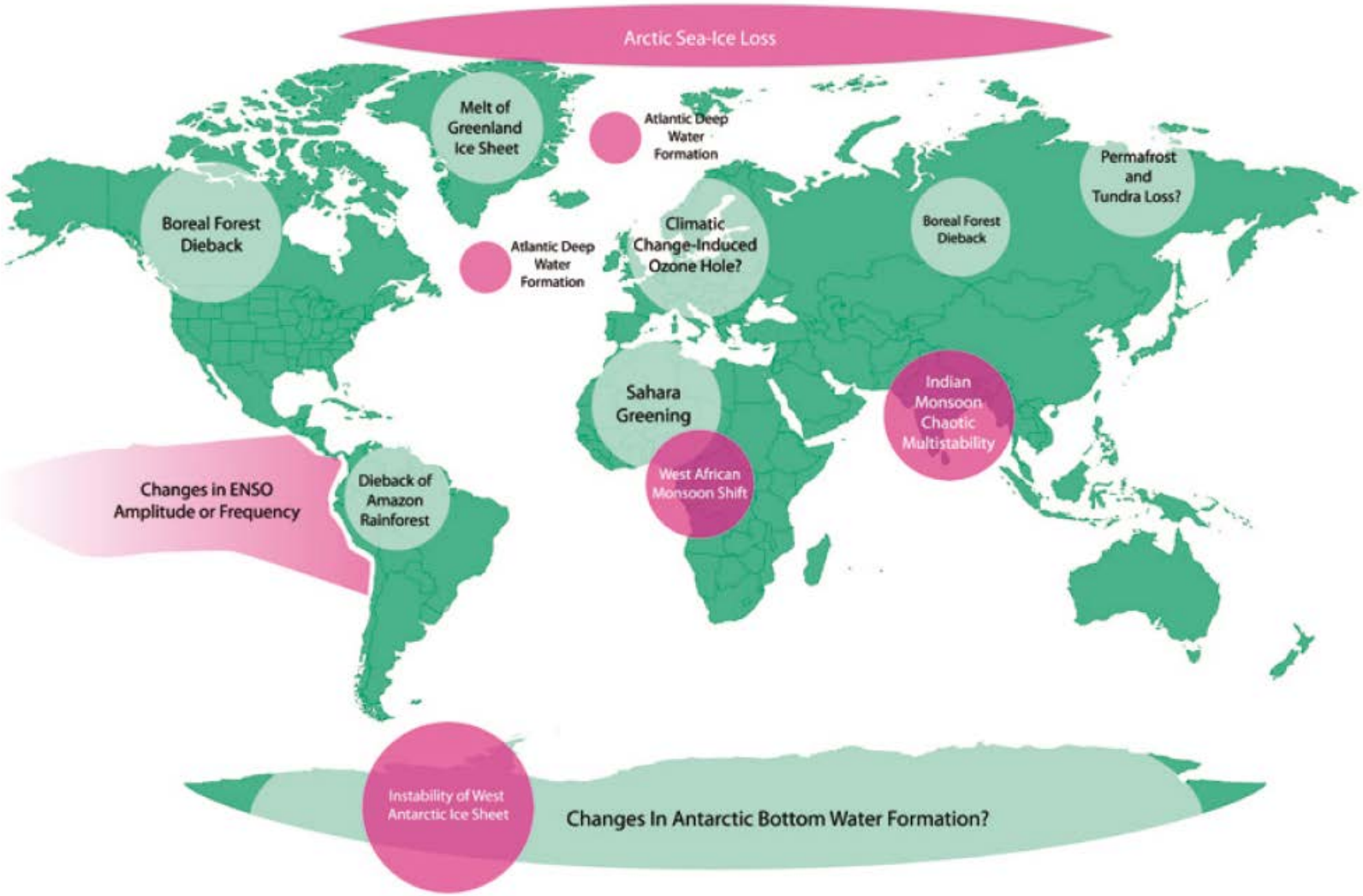


Box TS.5 Figure 1.

(IPCC 2014, AR5 WGII report)

http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-TS_FGDall.pdf

Potential tipping points

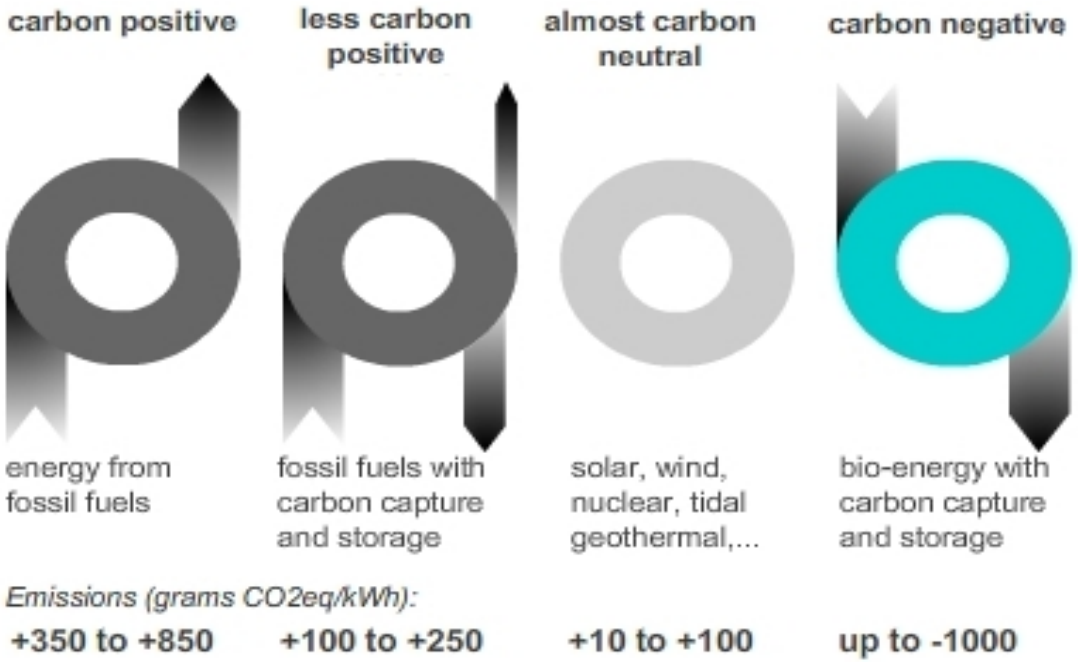


Tipping elements are regional-scale features of the climate that could exhibit threshold-type behaviour in response to human-driven climate change – that is, a small amount of climate change at a critical point could trigger an abrupt and/or irreversible shift in the tipping element. The consequences of such shifts in the tipping element for societies and ecosystems are likely to be severe. Question marks indicate systems whose status as tipping elements is particularly uncertain.
(Synthesis Report Climate Change Global Risks, Challenges & Decisions Copenhagen 2009 http://climatecongress.ku.dk/pdf/synthesisreport)

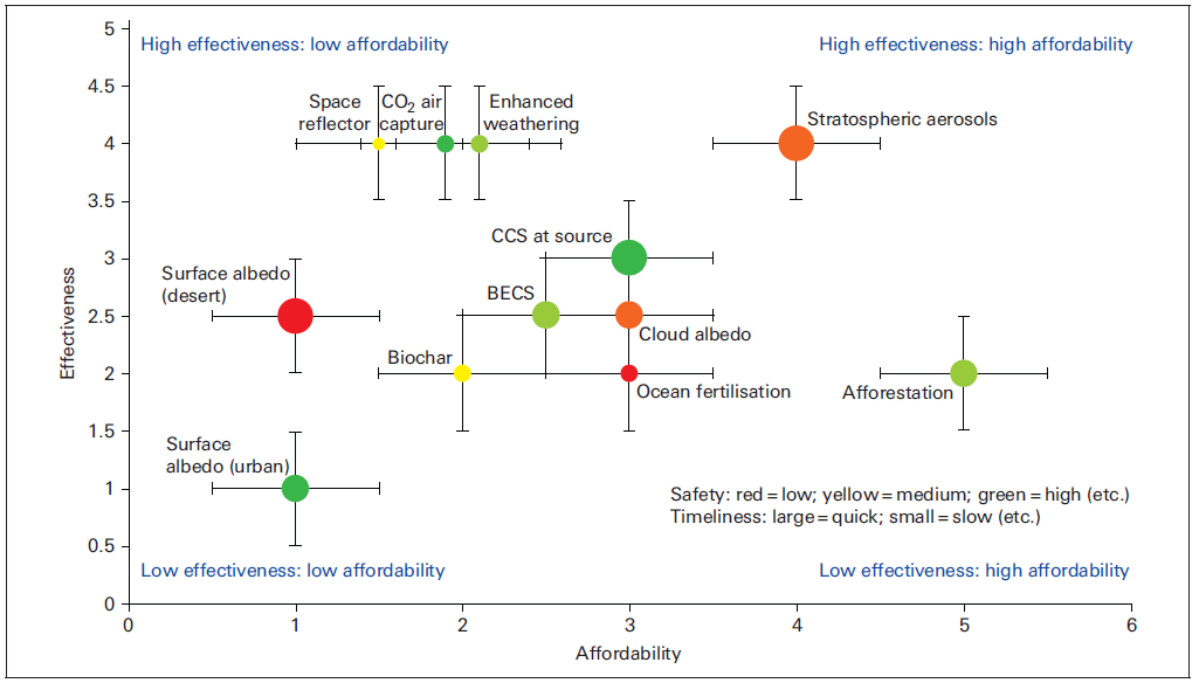
How to avoid tipping points?

Negative Emissions?

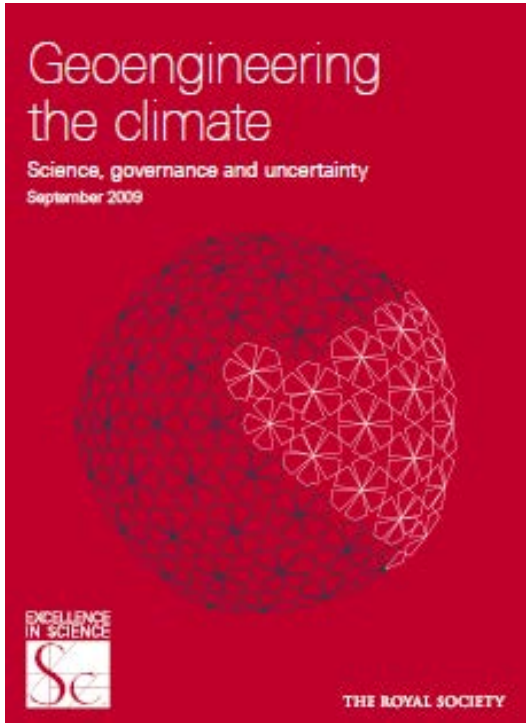
Geoengineering?



http://cdn.decarboni.se/publications/our-future-carbon-negative-ccs-roadmap-romania/50-bio-ccs-carbon-negative



http://royalsociety.org/Geoengineering-the-climate/



Ethical issues

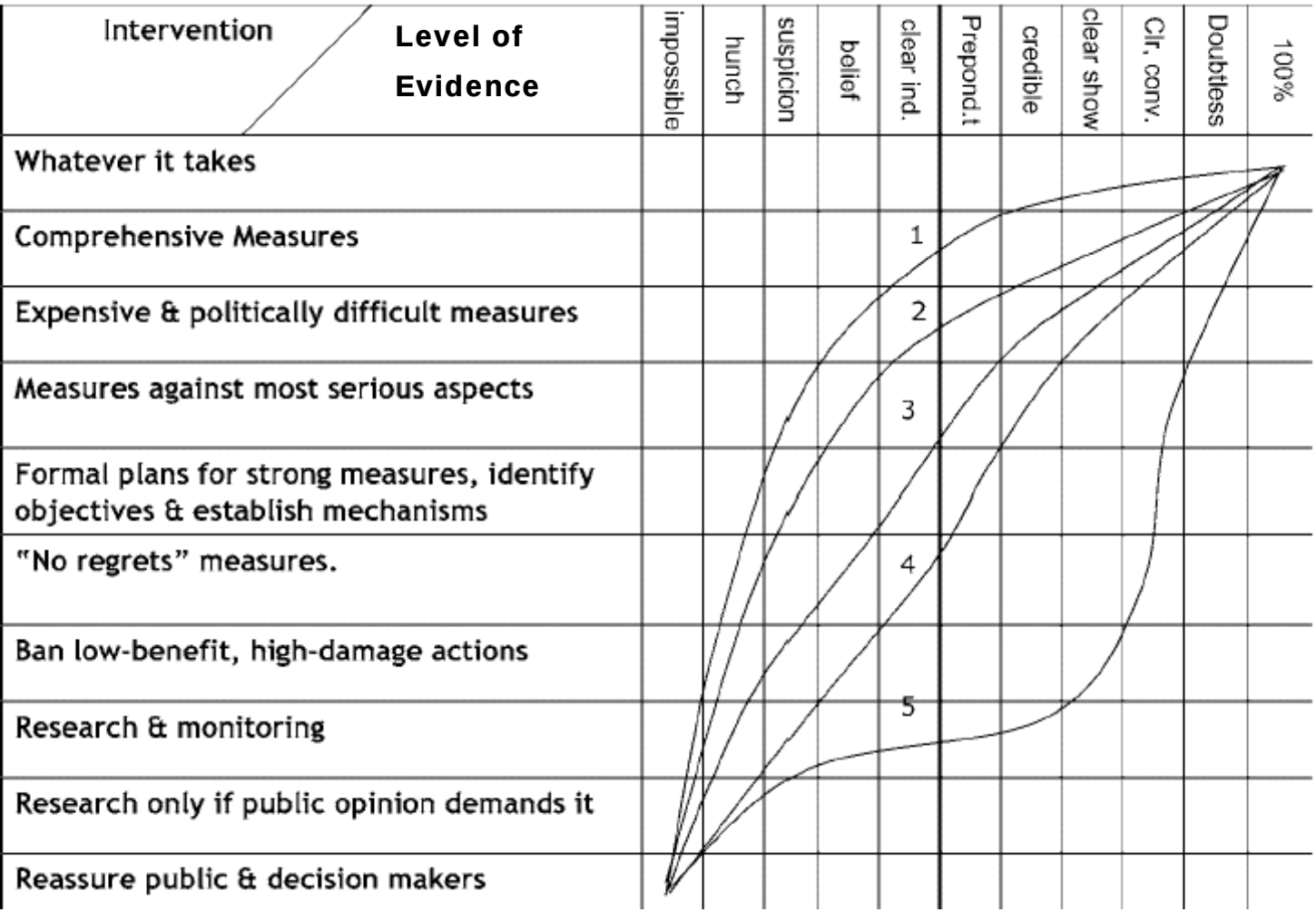
- How to act on weak signals of catastrophic tipping-points
- Highly unequal distribution of impacts
- Equitable burden-sharing North-South
- Societal controversy on how much intervention is justified at a given level of evidence of catastrophic risk

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

http://dx.doi.org/10.1023/A:1024847807590

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

http://dx.doi.org/10.1023/A:1024847807590

Further reading

- J.P. van der Sluijs (2012). **Uncertainty and dissent in climate risk assessment, a post-normal perspective**, *Nature and Culture* 7 (2) 174-195. http://dx.doi.org/10.3167/nc.2012.070204

- Jeroen P. van der Sluijs, Rinie van Est and Monique Riphagen (red.) (2010). **Room for Climate Debate, Perspectives on the interaction between climate politics, science and the media.** Den Haag, Rathenau Instituut. 98 pp http://www.nusap.net/downloads/reports/Room_for_climate_debate.pdf

- J.P. van der Sluijs, A.C. Petersen, P.H.M. Janssen, James S Risbey and Jerome R. Ravetz (2008) **Exploring the quality of evidence for complex and contested policy decisions**, *Environmental Research Letters*, 3 024008 (9pp) http://dx.doi.org/10.1088/1748-9326/3/2/024008

- J.P. van der Sluijs and J. Arjan Wardekker (2015) **Critical appraisal of assumptions in chains of model calculations used to project local climate impacts for adaptation decision support – the case of Baakse Beek**. *Environmental Research Letters* 10, 045005. http://dx.doi.org//10.1088/1748-9326/10/4/045005

- L. Maxim and Jeroen P. van der Sluijs (2011) **Quality in environmental science for policy: assessing uncertainty as a component of policy analysis**. *Environmental Science & Policy*, 14, (4) 482-492. http://dx.doi.org/10.1016/j.envsci.2011.01.003

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