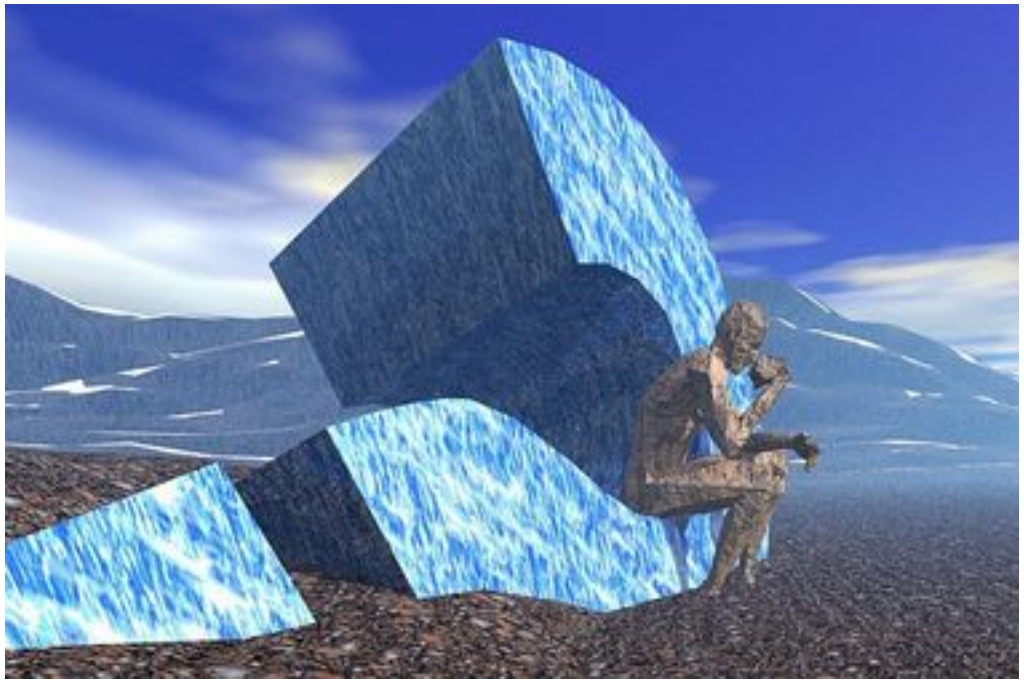
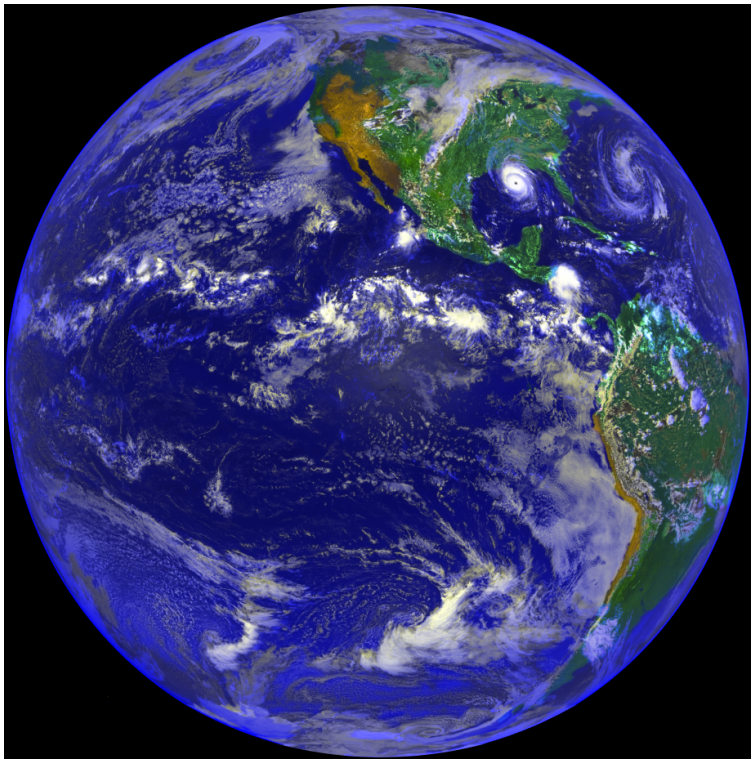
Climate Science and the Uncertainty Monster

Judith Curry

Georgia Institute of Technology





Genealogy of the Uncertainty Monster

Monster theory: monster as symbolic expressions of cultural unease that pervade a society and shape its collective behavior

Monster metaphor of Dutch philosopher Martijntje Smits: co-existence of public fascination and discomfort with new technologies

Uncertainty monster of Dutch social scientist Jeroen van der Sluijs: ways in which the scientific community responds to the monstrous uncertainties associated with environmental problems

Climate Uncertainty Monster

The "monster" is a metaphor used in analysis of the response of the scientific community to uncertainties at the climate science-policy interface.

Confusion and ambiguity associated with:

- knowledge versus ignorance
- objectivity versus subjectivity
- facts versus values
- prediction versus speculation
- science versus policy

Uncertainty monster coping strategies

after van der Sluijs

Monster hiding. Never admit error strategy motivated by a political agenda or fear of being judged as poor science.

Monster exorcism. Reducing uncertainty through more research.

Monster simplification. Subjectively quantifying and simplifying the assessment of uncertainty.

Monster detection. Scientists, auditors, "merchants of doubt".

Monster assimilation. Giving uncertainty an explicit place in the contemplation and management of environmental risks.

JC's history with the climate uncertainty monster: I

Oct 2003 presentation to the NRC CRC:

Some Thoughts on Uncertainty: Applying Lessons to the CCSP Synthesis and Assessment Products

- Is the assessment process and "science for policy" (as interpreted by climate scientists) torquing climate science in a direction that is fundamentally less useful for both science and policy?
- The answer to this question is probably "yes", and both the root of the problem and its eventual solution solution lie in how scientists and decision makers deal with the issue of **uncertainty**.

JC's history with the climate uncertainty monster: II

Spring 2005 presentation to Physicians for Social Responsibility:

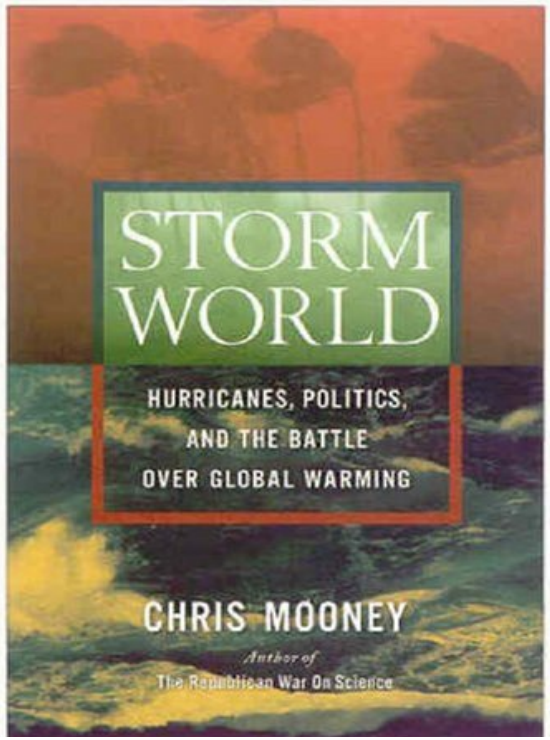
"There is no question that the climate is warming; the issue is what is causing the warming."

"It is very difficult to separate natural variability from that caused by humans."

Hurricane Wars

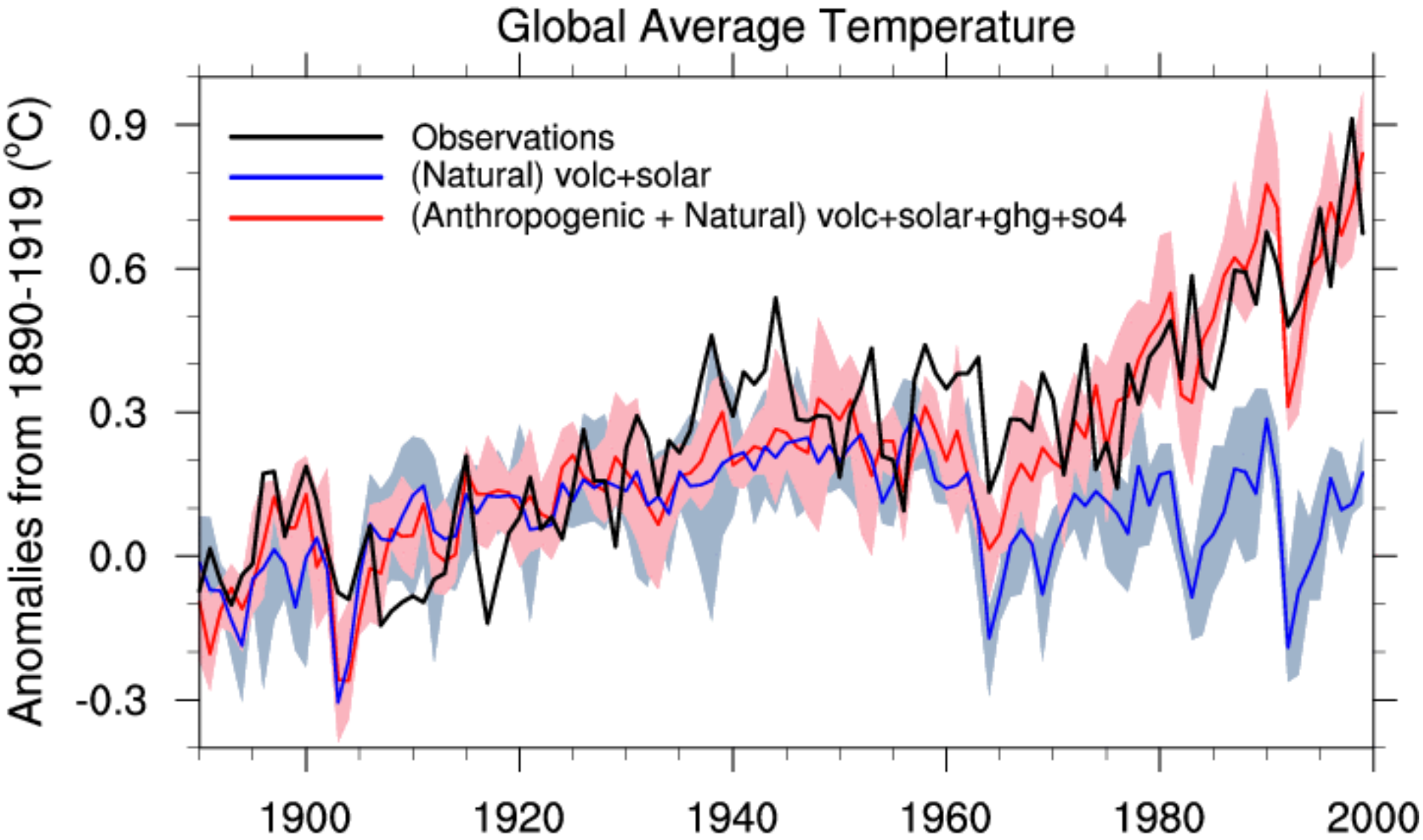
Mixing Politics and Science in Testing the Hypothesis That Greenhouse Warming Is Causing a Global Increase in Hurricane Intensity

BY J. A. CURRY, P. J. WEBSTER, AND G. J. HOLLAND



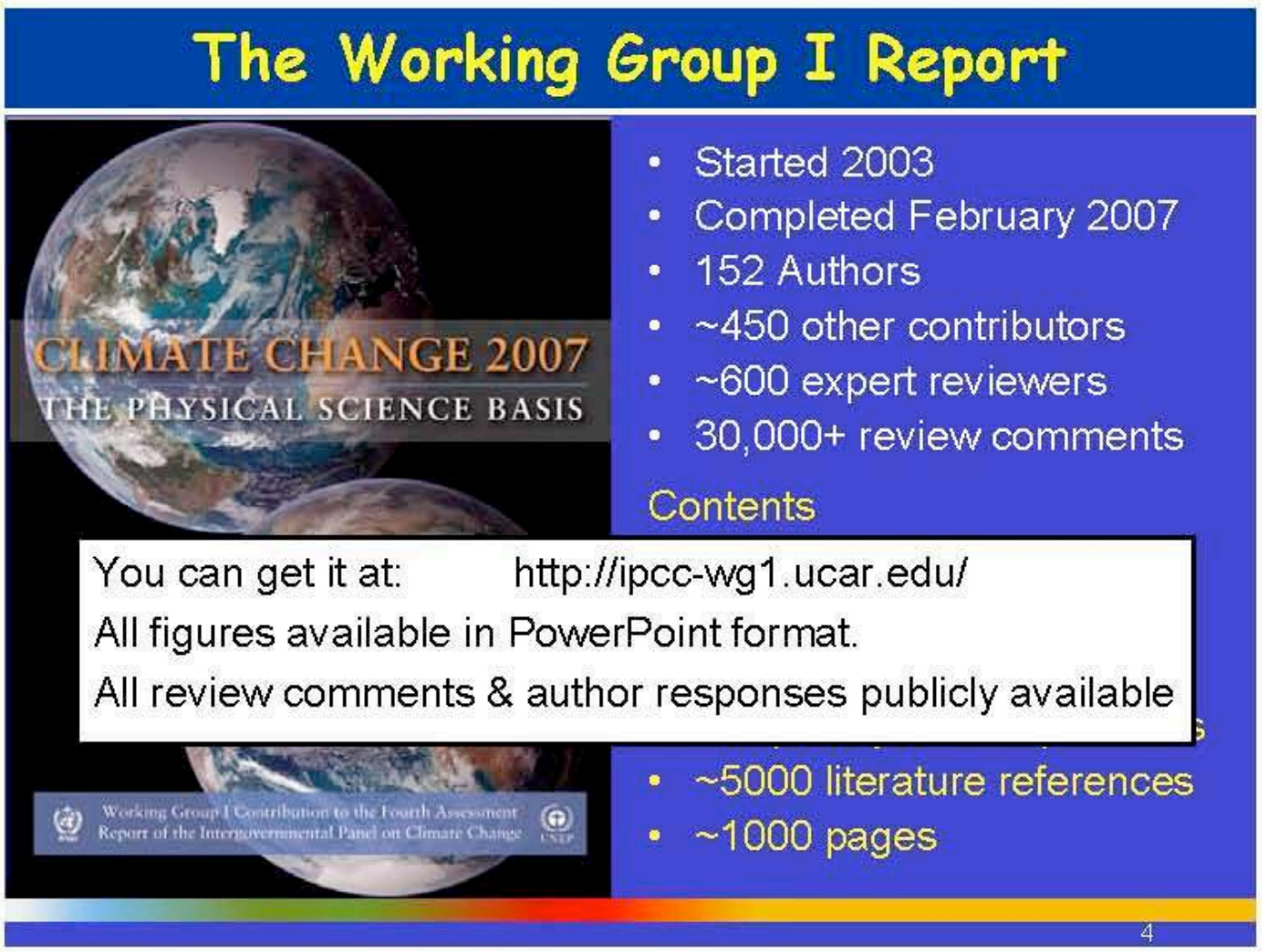
BAMS, 2006

NCAR Climate Model



Meehl et al 2004

Trying to ignore the monster

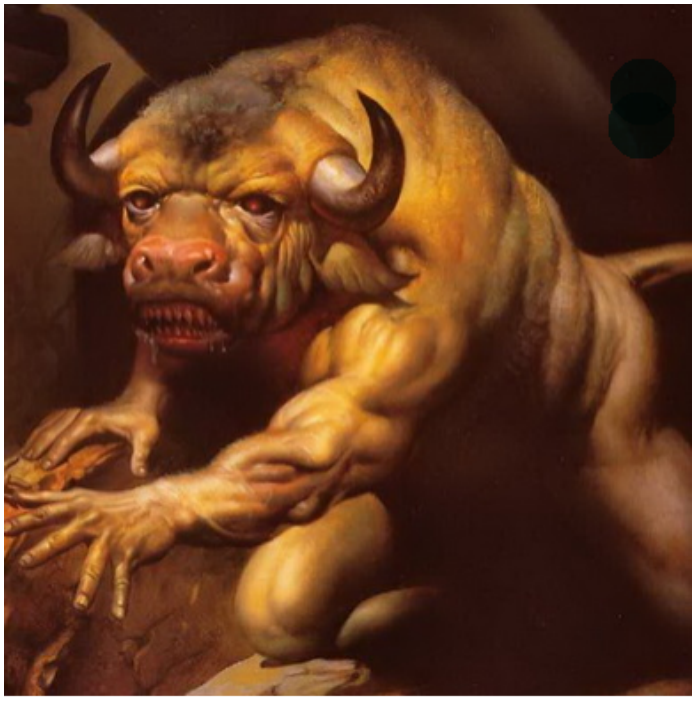


JC: "Don't listen to what one scientist says; listen to the consensus reached by over a thousand scientists."

Credit: Minnesotans for Global Warming

JC speaks out:

- Need for public availability of data, greater transparency of methods
- Need for greater acknowledgement of uncertainties
- Need to engage skeptics and consider multiple perspectives
- Importance of scientific integrity



Climate Heretic: Judith Curry Turns on Her Colleagues

Why can't we have a civil conversation about climate?

October 25, 2010

Why I Wrote About Judith Curry

By Michael D. Lemonick

"Simply by giving Judith Curry's views a respectful airing, I've already drawn accusations of being irresponsible — and it's valid to raise the question of whether giving her any sort of platform is a bad idea."

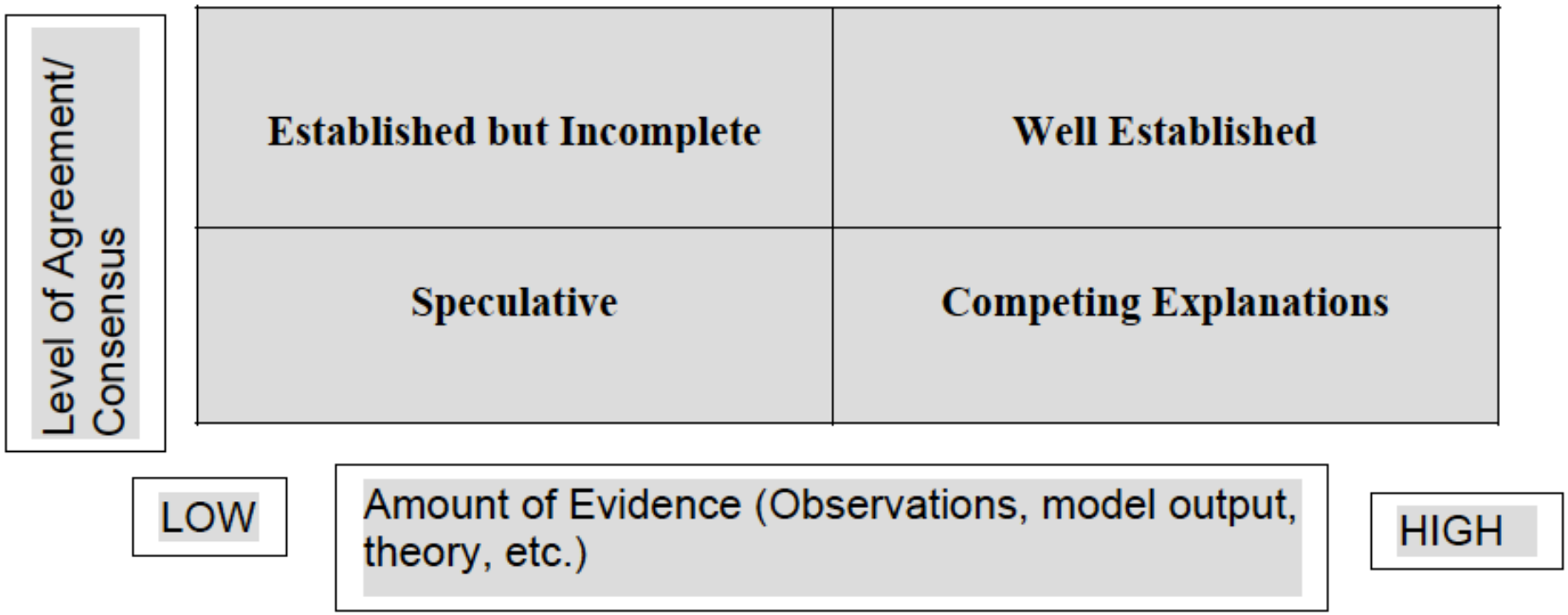
Scientific American Online Survey

2. Judith Curry is:	
a peacemaker.	**67.1%**
a dupe.	7.3%
both.	4.2%
I've never heard of her.	21.4%

IPCC Characterization of Uncertainty

Moss & Schneider 2000

expert judgment in the context of a subjective Bayesian analysis



IPCC Characterization of Uncertainty

Moss & Schneider 2000

Terminology	Degree of confidence in being correct
Virtually certain	> 99% probability of occurrence
Very likely	> 90% probability
Likely	> 66% probability
About as likely as not	33% to 66% probability
Unlikely	< 33% probability
Very unlikely	< 10% probability
Exceptionally unlikely	< 1% probability

IPCC Reasoning about Uncertainty

Given the complexity of the climate problem, expert judgments about uncertainty and confidence levels are made on issues that are dominated by unquantifiable uncertainties.

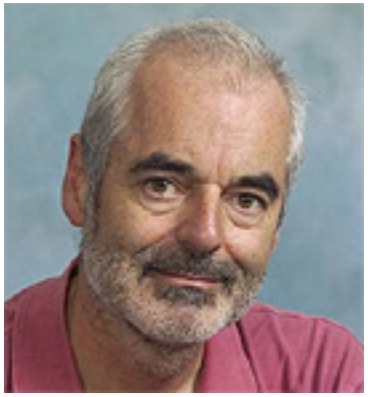
Consensus building process: exercise in collective judgment in areas of uncertain knowledge.

Consilience of evidence: combines a compilation of evidence with subjective Bayesian reasoning -- independent lines of evidence that are explained by the same theoretical account.

THE ROYAL SOCIETY

Handling Uncertainty in Science
March 22-23, 2010

- Weather/climate
- Quantum mechanics
- Cosmology
- Deterministic dynamics
- Public health
- Economics and finance



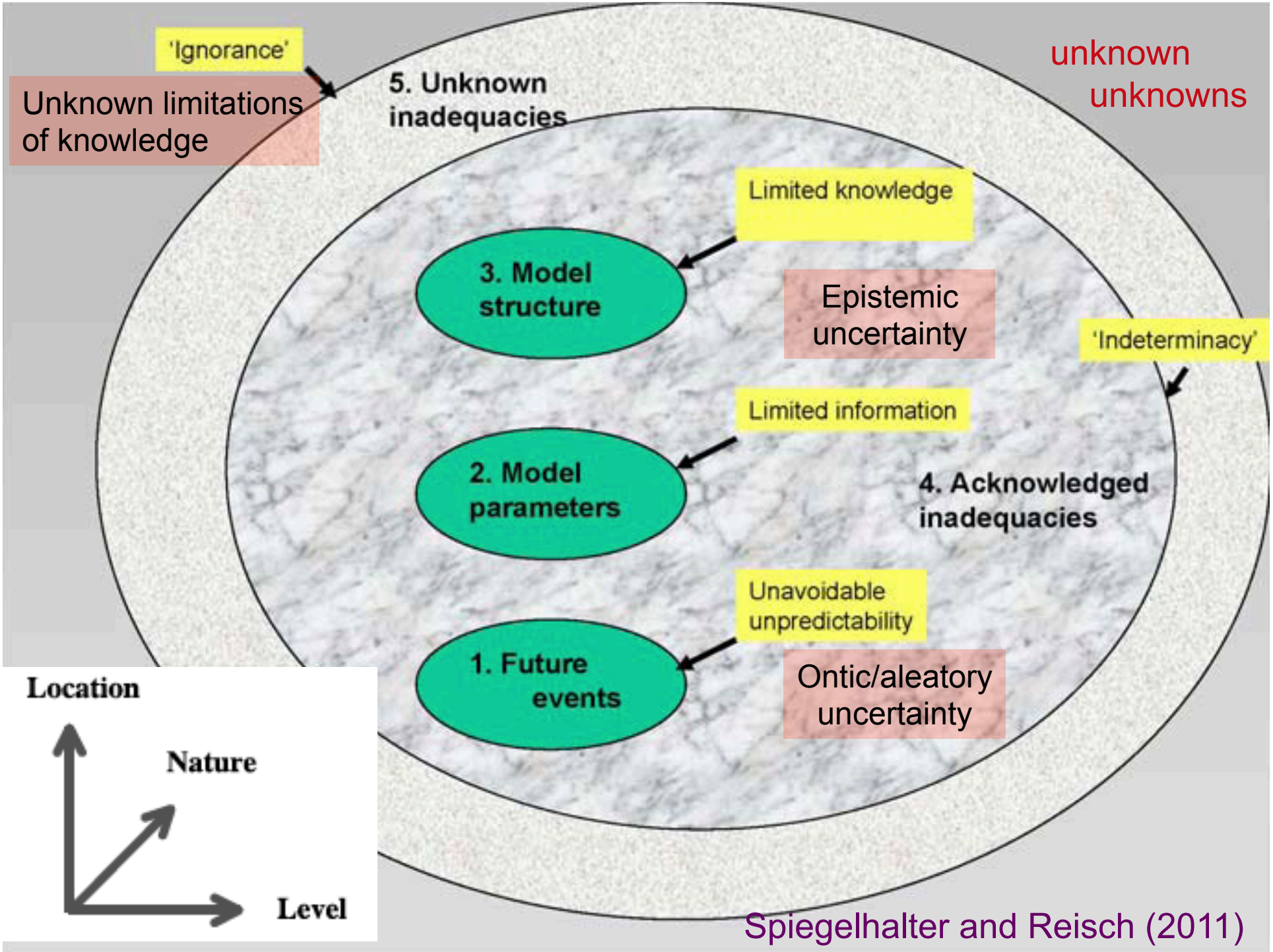
David Spiegelhalter
Biostatistics Unit
Institute of Public Health
University of Cambridge

Towards taming the climate uncertainty monster . . .

Curry JA. and PJ. Webster (2011) Climate Science and the Uncertainty Monster. *BAMS*, (pre-published online).

Curry, JA (2011) Reasoning About Climate Uncertainty. *Climatic Change*, in press (pre-published online).

Curry J. (2011) Nullifying the Climate Null Hypothesis. *WIRE's Climate Change*, in press

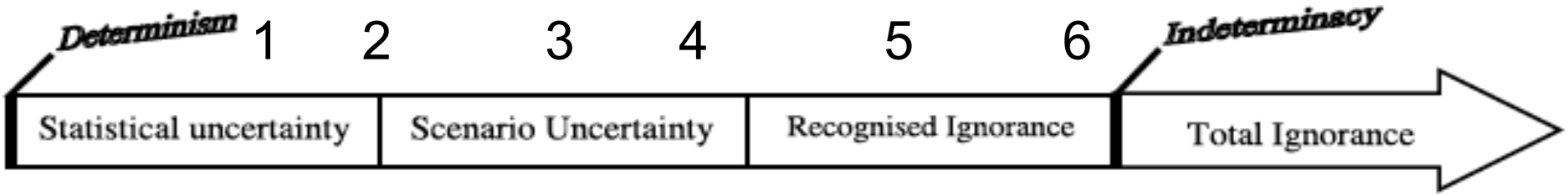

'Ignorance'
Unknown limitations of knowledge
5. Unknown inadequacies
unknown unknowns
Limited knowledge
3. Model structure
Epistemic uncertainty
'Indeterminacy'
Limited information
2. Model parameters
4. Acknowledged inadequacies
Unavoidable unpredictability
1. Future events
Ontic/aleatory uncertainty
Location
Nature
Level
Spiegelhalter and Reisch (2011)

Levels of uncertainty / ignorance

Measure of likelihood	Justification
1 Full PDF	Robust, well defended distribution
2 Bounds	Well defended percentile bounds
3 First order estimates	Some estimate of likelihood
4 Expected sign or trend	Well defended trend expectation
5 Ambiguous sign/trend	Equally plausible contrary trend expectations
6 Effective ignorance	Lacking or weakly plausible expectations

(Kandlikar and Risbey 2007)

"Uncertainty should be expressed using the most precise means that can be justified, but unjustified more precise means should not be used."



Walker et al. 2003

Quality of Evidence

Guyatt et al. 2008

High quality	Further research is very unlikely to change our confidence in the estimate of effect
Moderate quality	Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate
Low quality	Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate
Very low quality	Any estimate of effect is very uncertain

Reasoning about Uncertainty

Italian Flag: TESLA

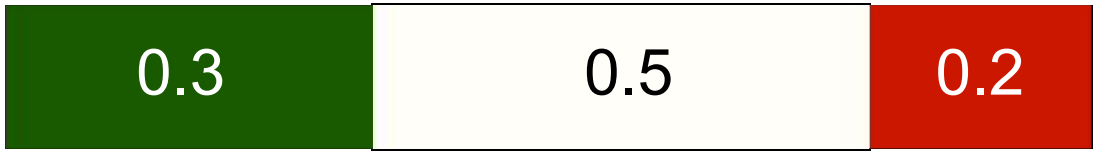
Classical probabilistic 2-value logic

Probability hypothesis is true

Probability hypothesis Is false

- Unknowns undifferentiated
- May lead to false assertions

Evidence based 3-value logic



Evidence for hypothesis

Ignorance Uncomitted belief

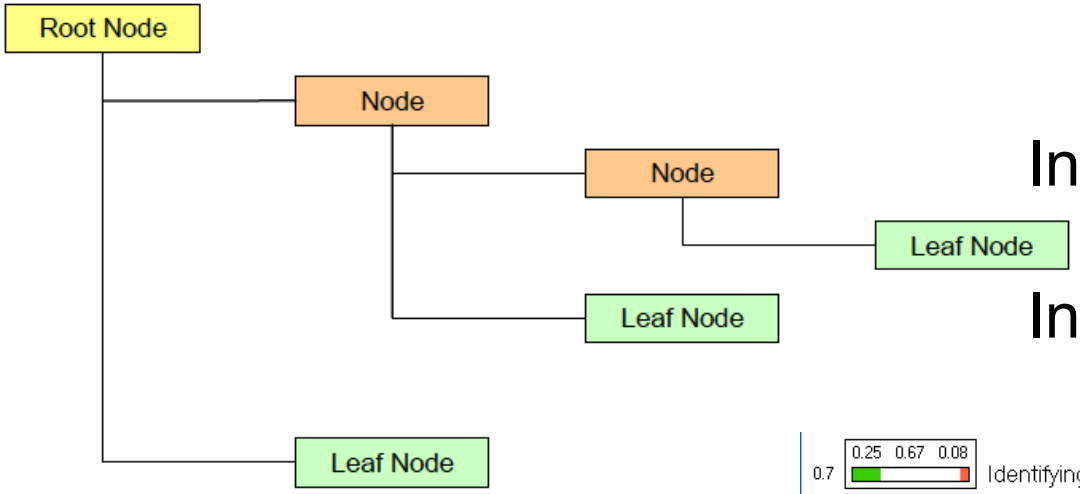
Evidence against Inhypothesis

- Honest about unknowns
- Allows better analysis of uncertainty
- Represents potential for improvement

Evidence For + Evidence Against + Uncertainty = 1

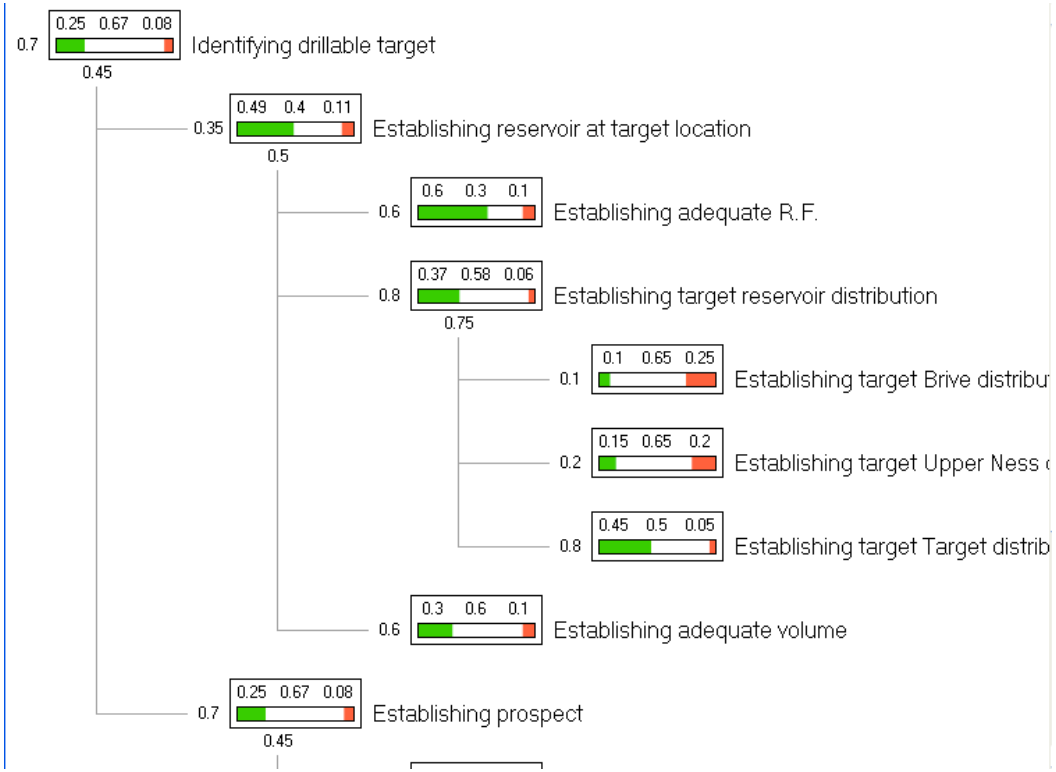
Reasoning about Uncertainty

Propagating Information: TESLA



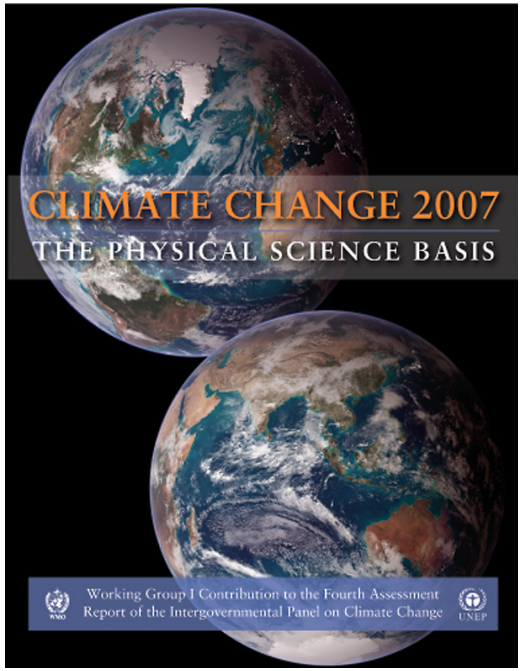
Influence diagrams
Tree logic
Interval probability methods

Break down and formalize expert reasoning



Key conclusion of the IPCC AR4:

"Most of the observed increase in global average temperatures since the mid-20th century is *very likely* [>90%] due to the observed increase in anthropogenic greenhouse gas concentrations."



97% of actively publishing climate experts agree with this statement (Anderegg et al. 2010)

Auditing the IPCC's attribution statement

Auditing focuses on accountability:

1) Treatment of scientific uncertainties
2) Traceability of the assessment
3) Logic of the argument

Evolution of the IPCC attribution statement

1988 Hansen's testimony

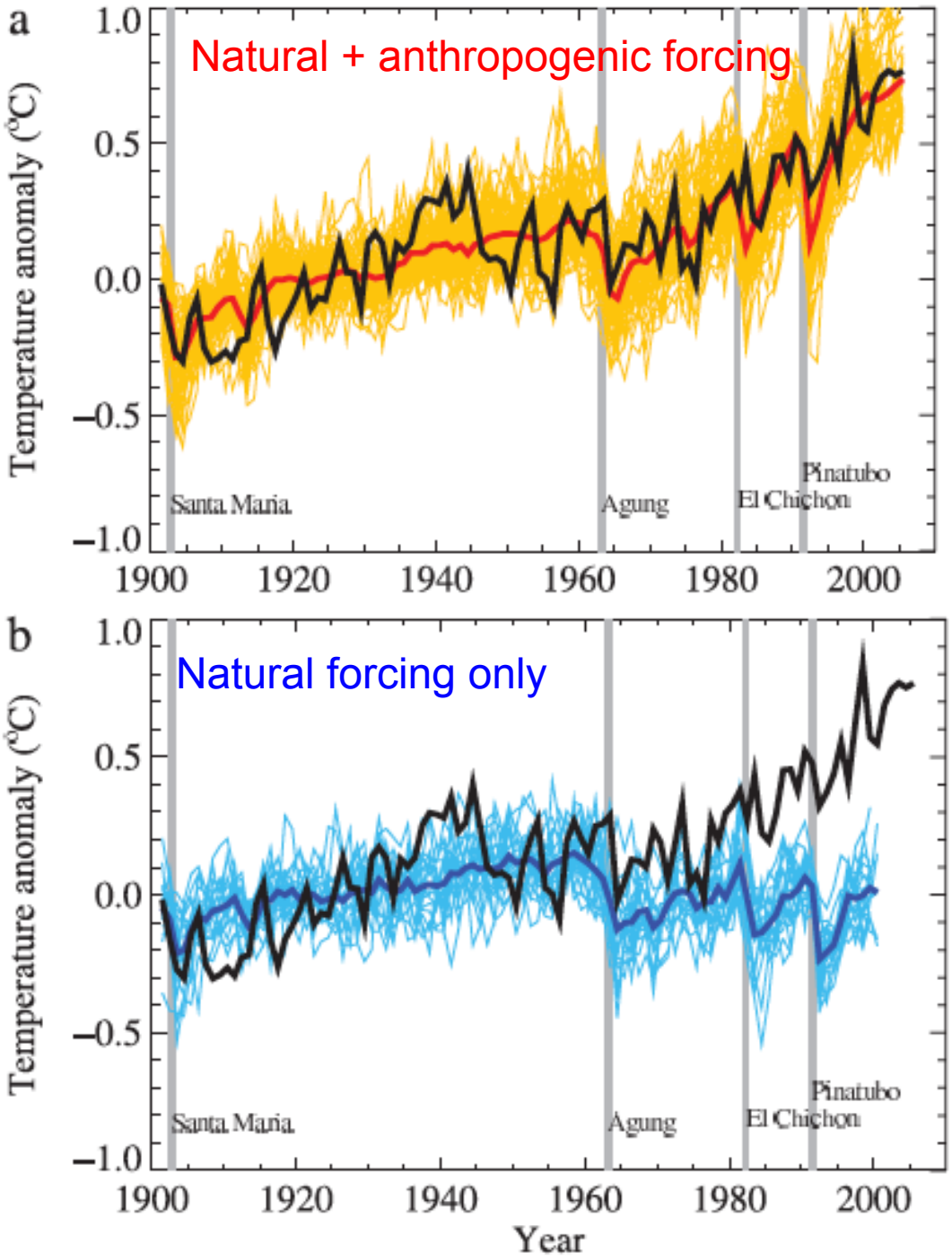
FAR (1990): "The size of this warming is broadly consistent with predictions of climate models, but it is also of the same magnitude as natural climate variability." 1992 UNFCC Treaty

SAR (1995): "The balance of evidence suggests a discernible human influence on global climate." 1997 Kyoto Protocol

TAR (2001): "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."

AR4 (2007): "Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations."

Is this "uncertainty monster exorcism" warranted?

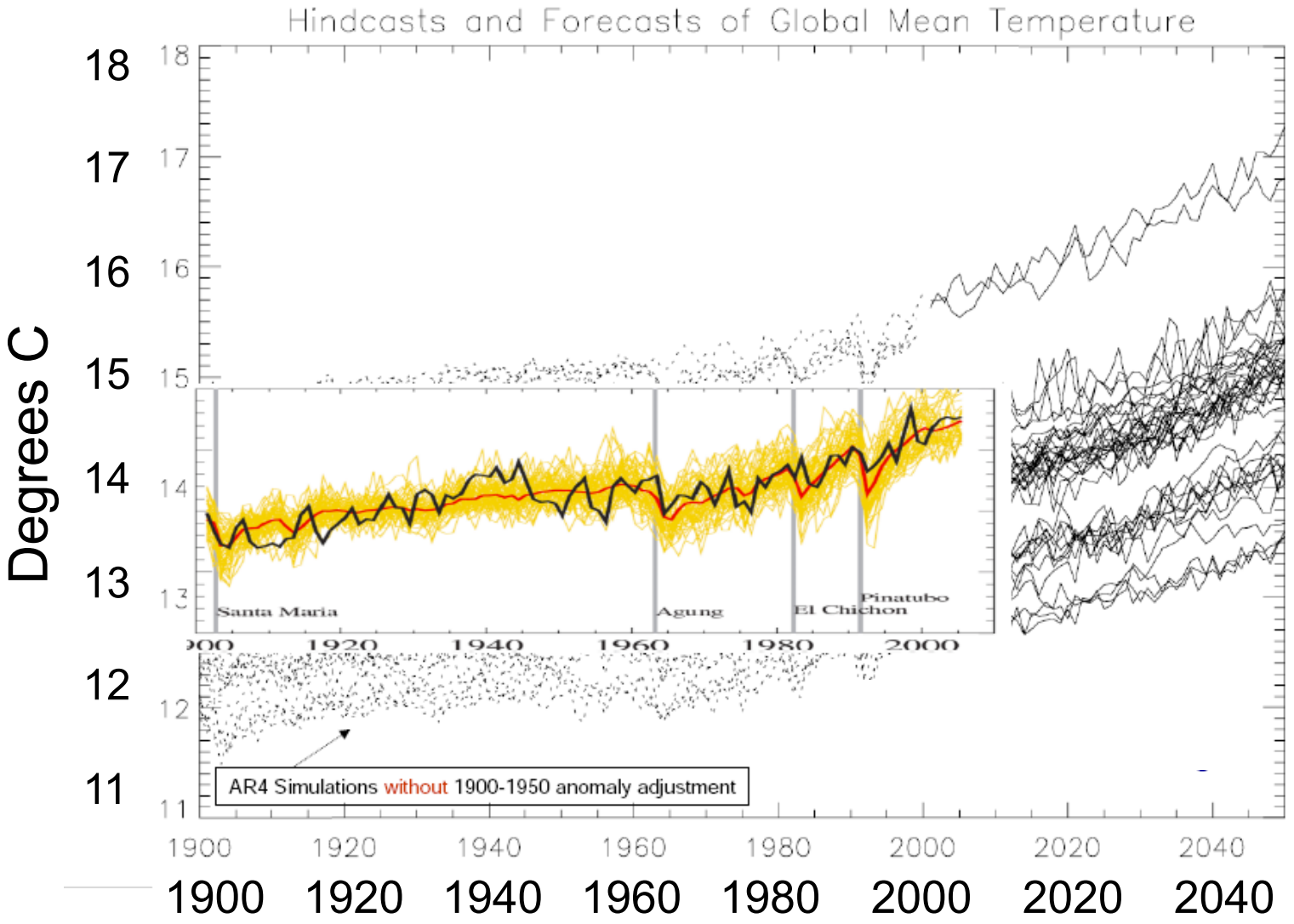


The strong agreement between observations and model simulations that combine both natural and anthropogenic forcing provide confidence that:

- observations are correct
- external forcing data is correct
- climate models are correct and agree with each other
- sensitivity of the climate models to increasing CO2 is correct

Figure 9.20, IPCC AR4 WG I

AR4 simulations without anomaly adjustment



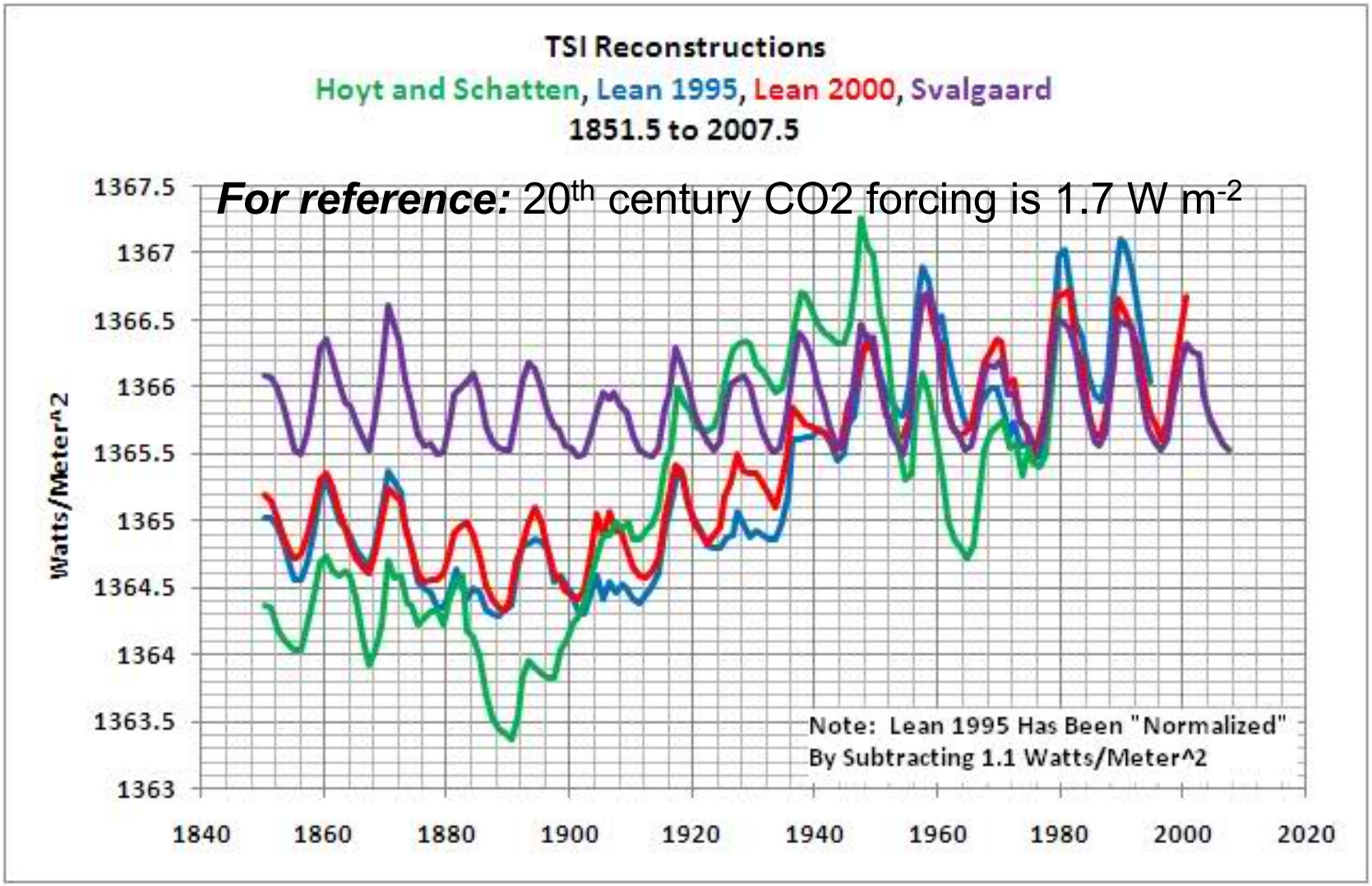
Slide courtesy of Leonard Smith

Sources of Uncertainty

- External forcing: solar and aerosols
- Climate sensitivity
- Assessment of natural internal variability

Uncertainty: Solar Forcing

level of understanding: low



Current understanding of the solar forcing is Svalgaard

The other curves were used as forcing in TAR, AR4

Uncertainty: Aerosol Forcing

level of understanding: low

- ***IPCC AR4:*** The net aerosol forcing over the 20th century likely ranges between –1.7 and –0.1 W m^{-2}

- ***Morgan et al. (2006) expert elicitation:*** –2.1 to –0.25 W m^{-2} with a much greater range of uncertainty (as high as 7 W m^{-2})

- ***Circular reasoning:*** Modeling groups selected their preferred forcing data sets using *inverse modeling*, whereby the magnitude of "uncertain parameters is varied in order to provide a best fit to the observational record."

Uncertainty: Model Sensitivity

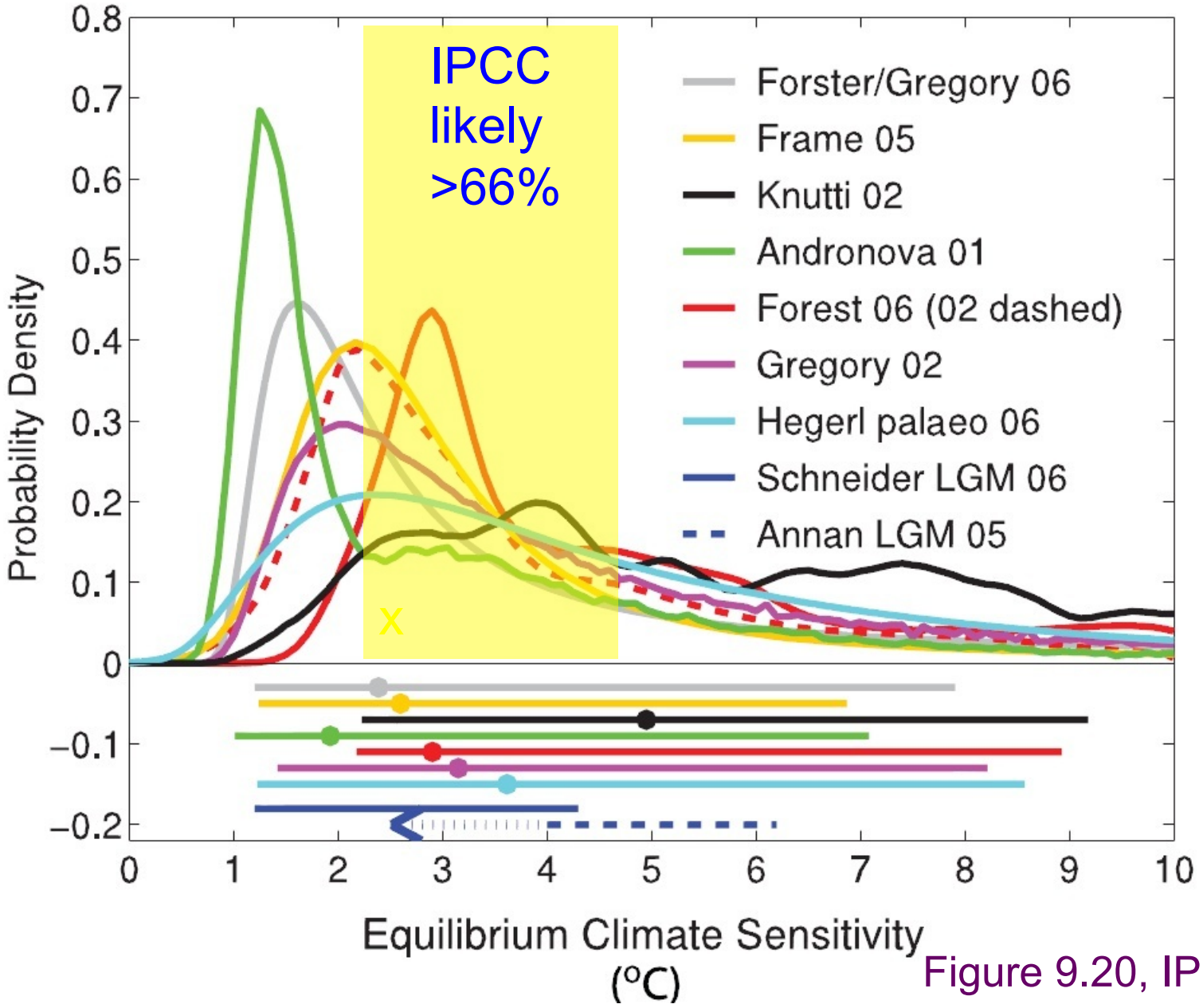
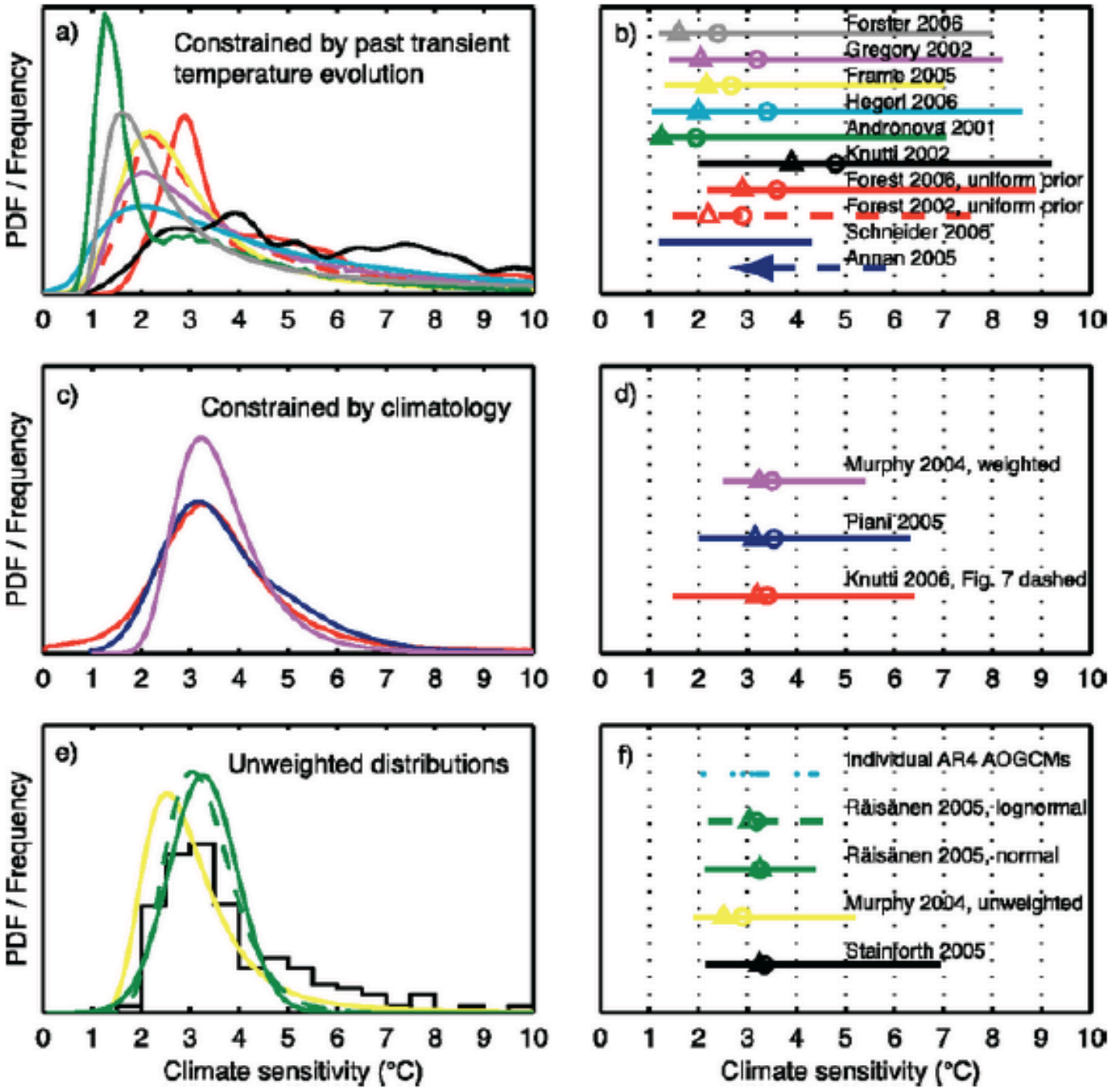
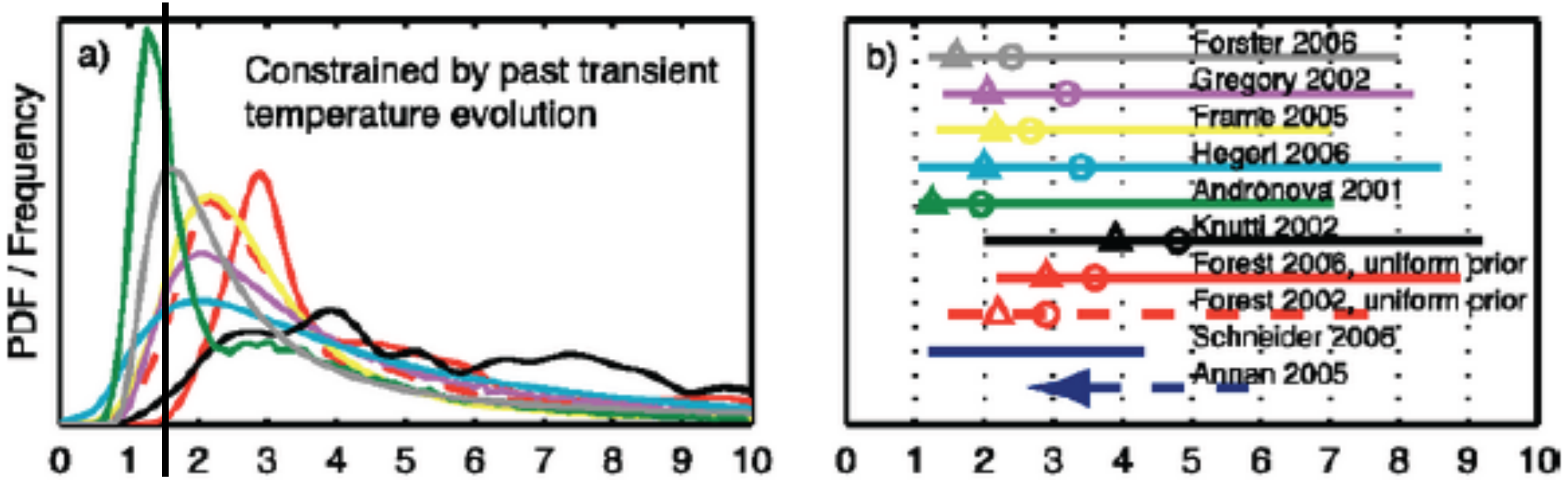


Figure 9.20, IPCC AR4 WG I



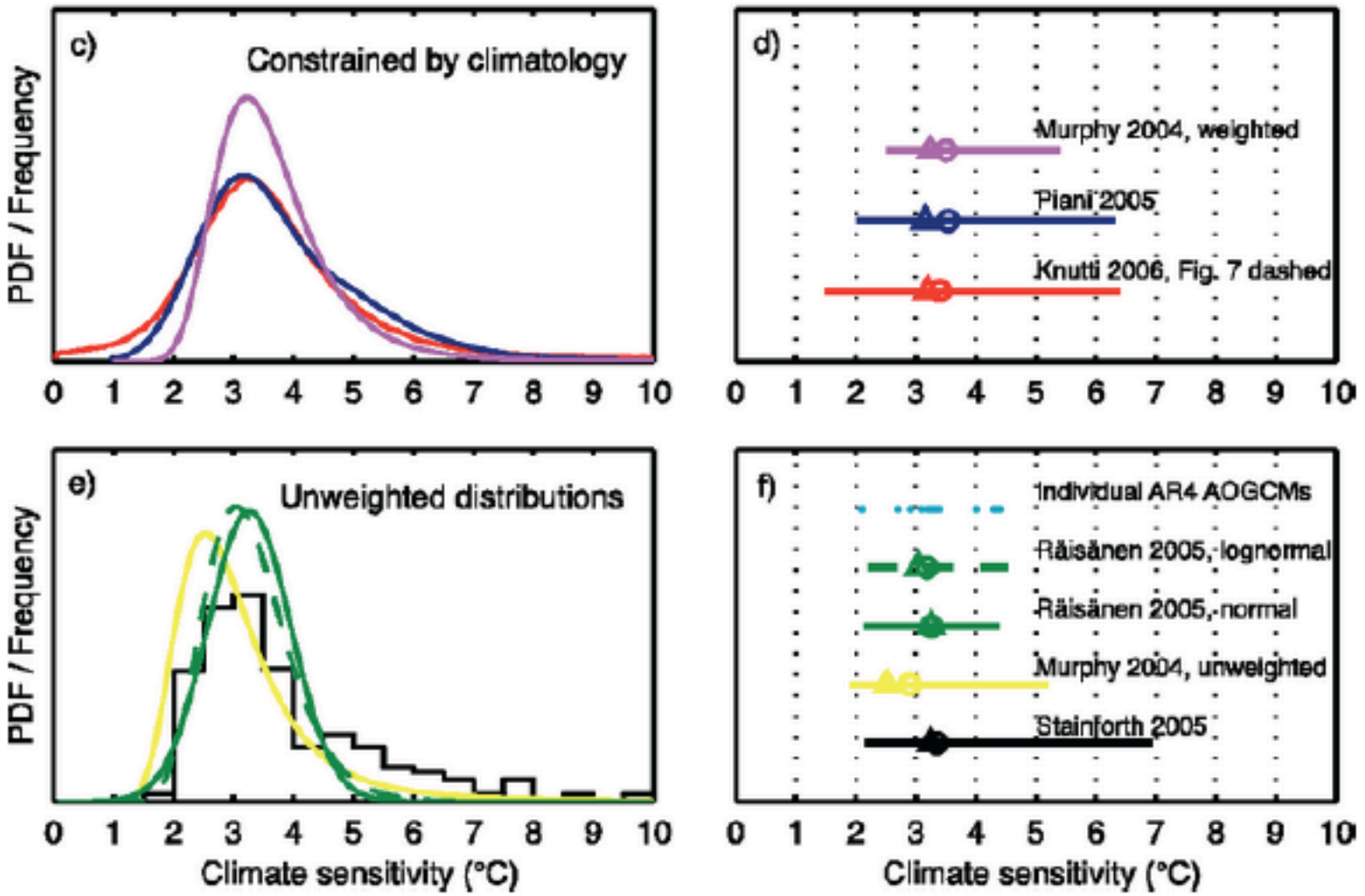
Where does the "likely" range 2-4.5°C come from?

Figure 10.2B, IPCC AR4 WG I



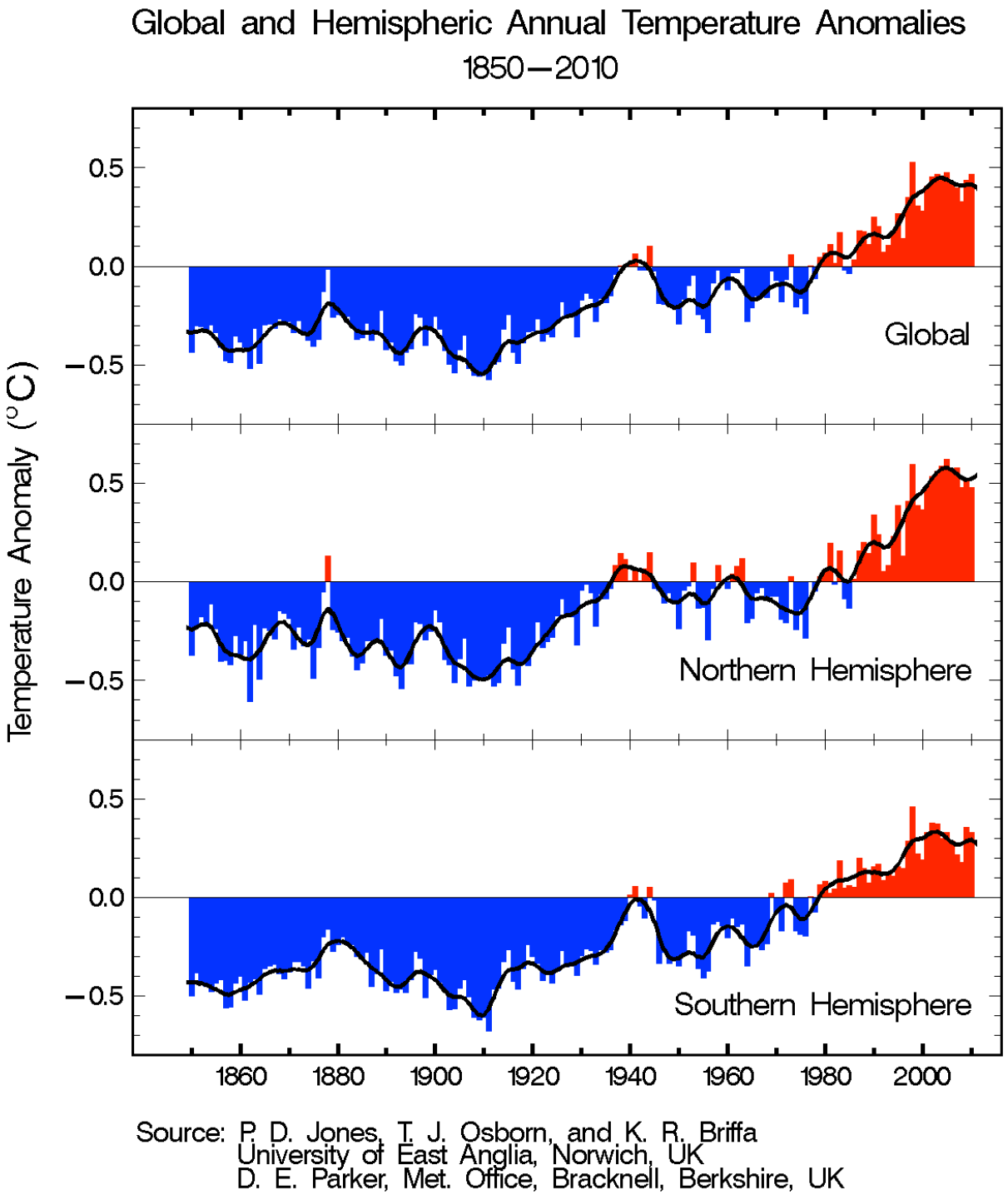
Median values, most likely values (modes) and 5-95% uncertainty ranges are shown in Box 10.2, Figure 1b for each PDF. ***Most of the results confirm that climate sensitivity is very unlikely below 1.5°C.***

Figure 10.2B,
IPCC AR4 WG I



c) and e) use atmosphere only GCMs.
Specifically, versions of HAD Atm
(except for 1 curve with AOGCMS)

Figure 10.2B, IPCC AR4 WG I



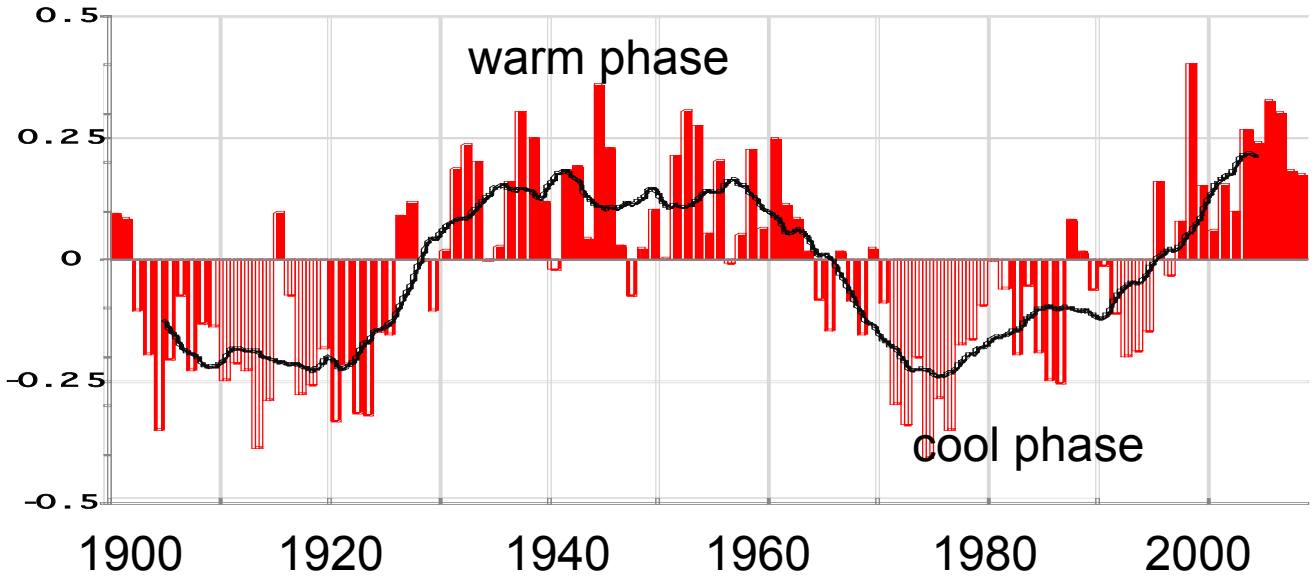
What caused the steep warming 1910-1940?

What caused the cooling 1940-1960?

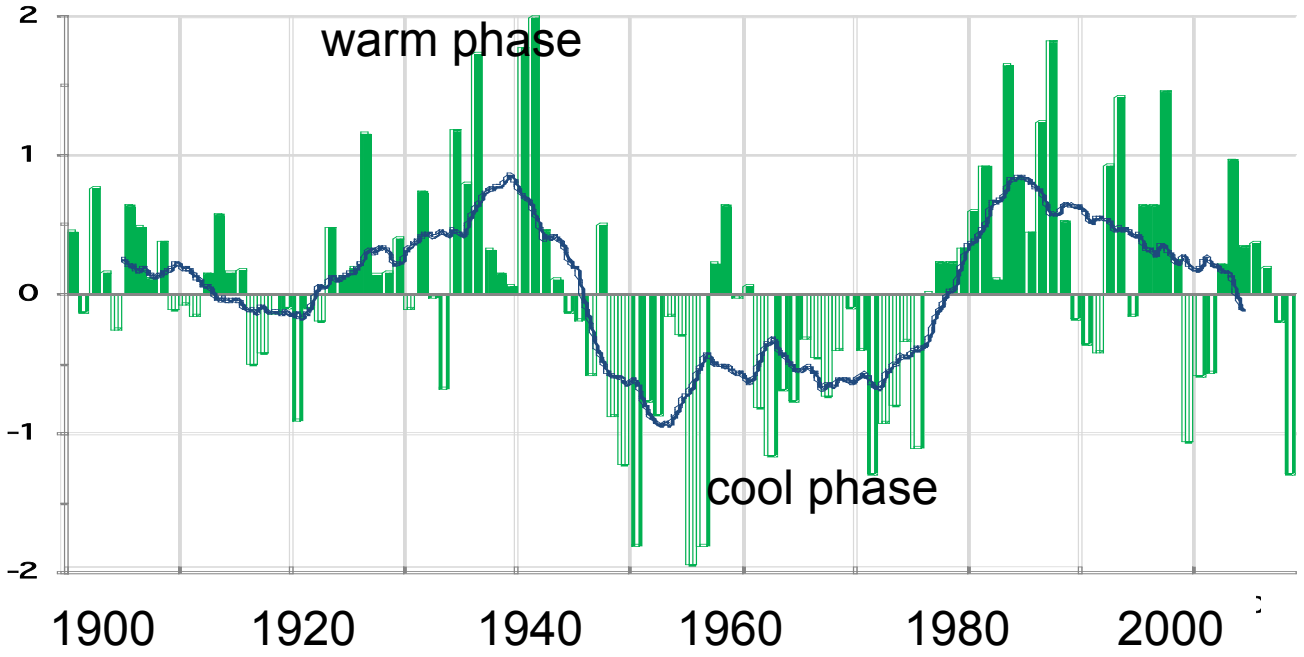
Solar variability does not work for the early warming

Aerosols do not explain mid-century cooling because the cooling is larger in the SH

Uncertainty: Natural Internal Variability



Atlantic Multidecadal Oscillation (AMO)



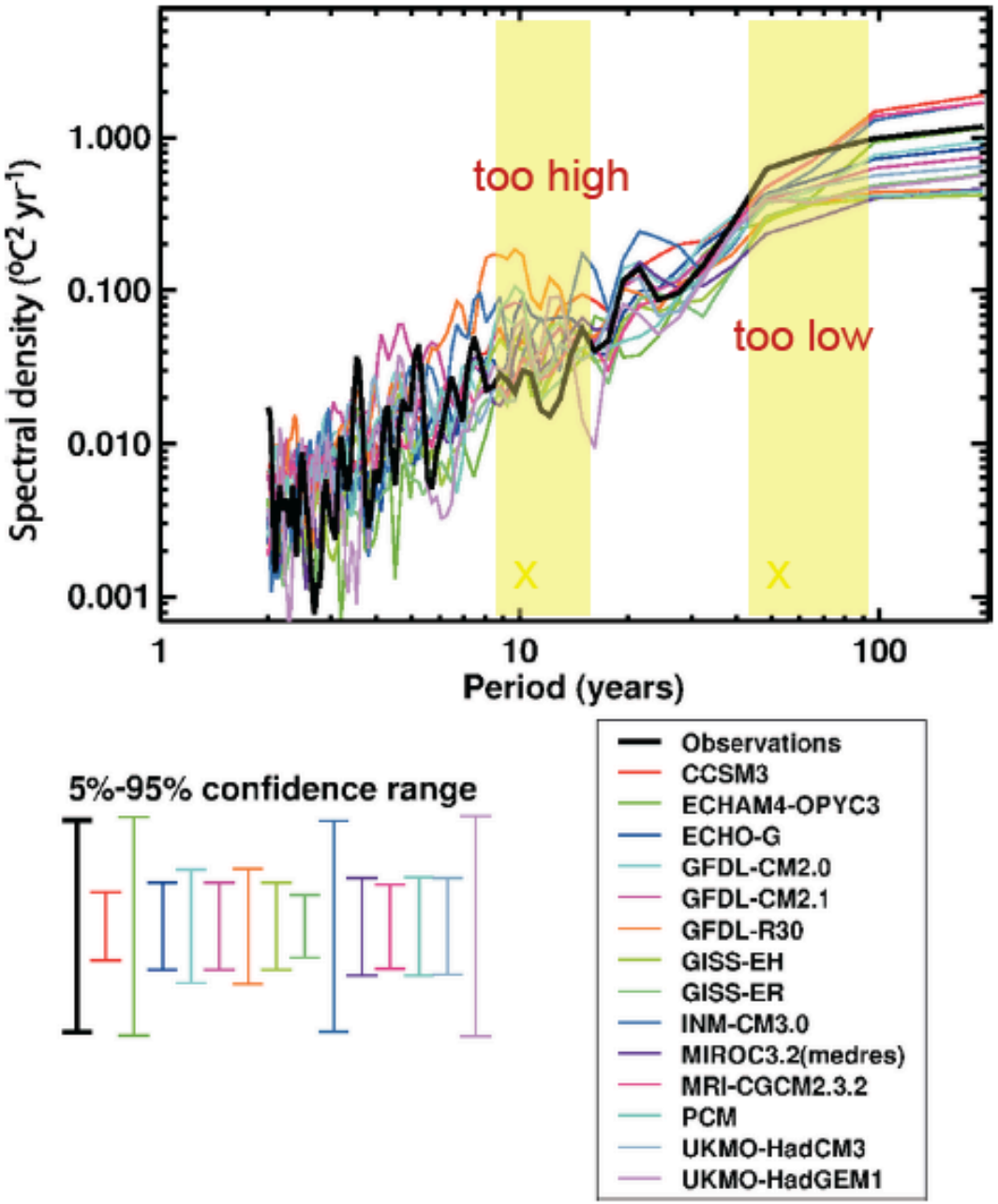
Pacific Decadal Oscillation (PDO)

Uncertainty: Natural Internal Variability

- ***Santer et al. (2011):*** *"Our results show that temperature records of at least 17 years in length are required for identifying human effects on global-mean tropospheric temperature"*

- ***Meehl et al. (2011):*** ***"****We will see global warming go through hiatus periods in the future, however, these periods would likely last only about a decade or so, and warming would then resume."*

Implication: the 30 year cool period 1940's to 1970's cannot be explained by natural internal variability



Power too high 8-17 yrs

Power too low 40-80 yrs

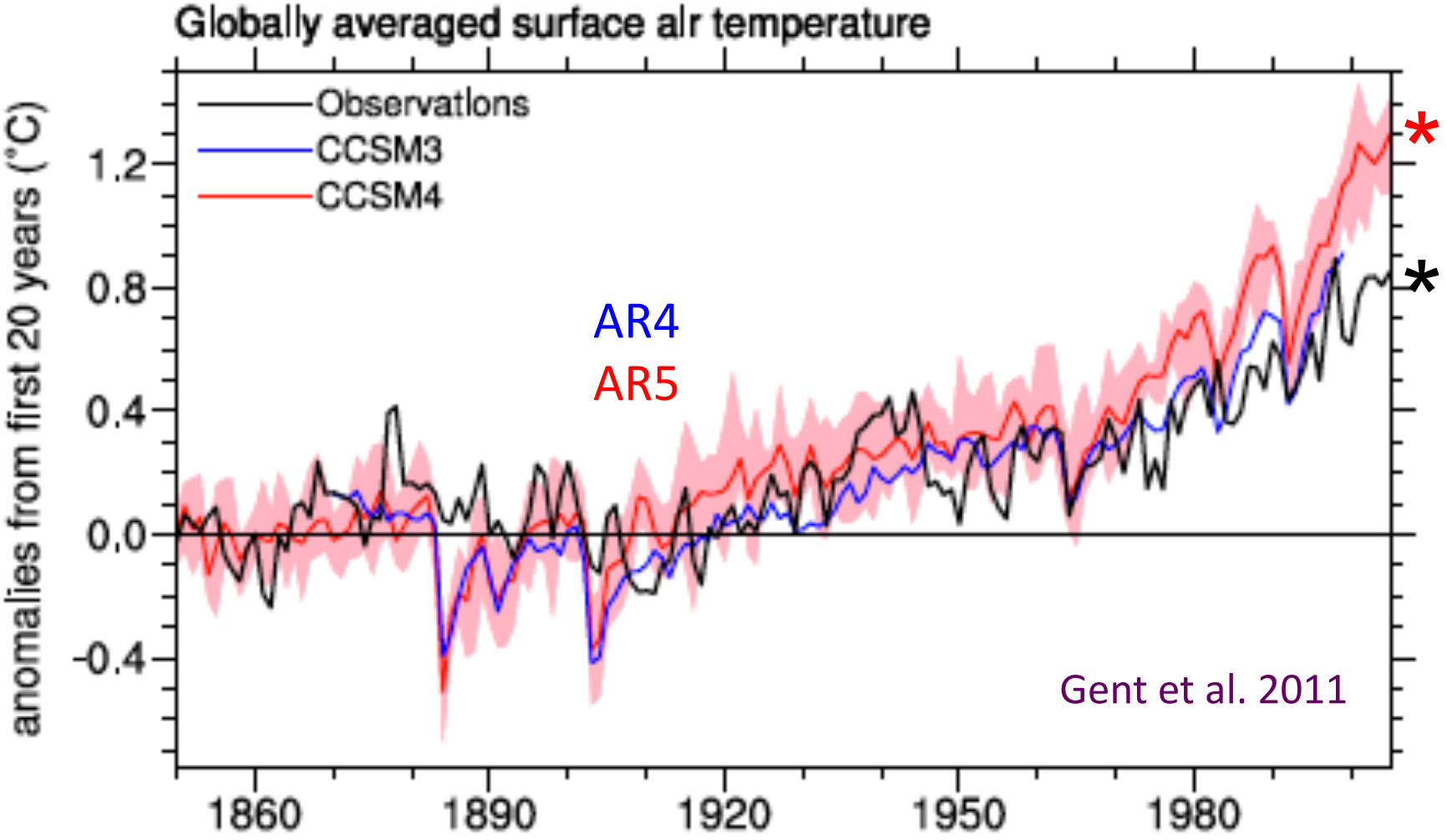
Power too low in AMO, PDO

All models simulate variability on decadal time scales and longer that is consistent with observations at the 10% significance level. Further details of the method of calculating the spectra are given in the Supplementary Material, Appendix 9.C.

JC NOTE: appendix 9.C does not exist

Figure 9.7, IPCC AR4 WG I

NCAR climate model simulations for the IPCC



AR4: Model parameters and forcing tuned to 20th century observations

AR5: Model parameters tuned to pre-industrial; best estimates of forcing

Why we should be skeptical of the IPCC AR4 attribution statement

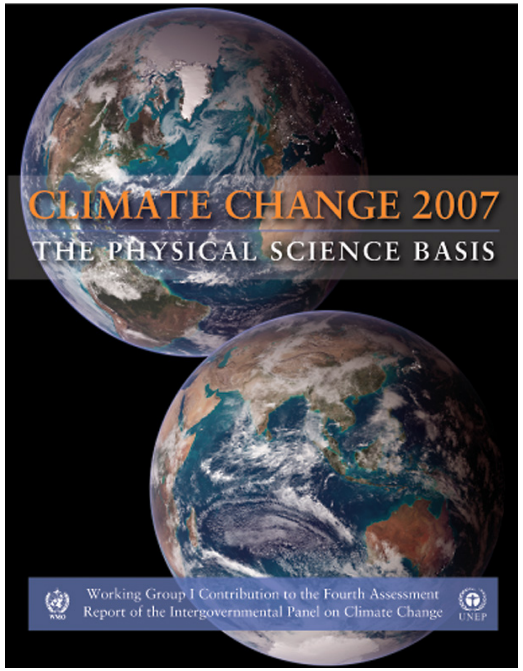
- Lack of traceability in the "expert judgment" assessment
- Circular reasoning associated with tuning model parameters and forcing to agree with 20th century observations
- Bootstrapped plausibility of the models, forcing data, and observations
- High precision and confidence [*very likely*] in a non quantitative and imprecise statement [*most*].

Scientific perils of overconfidence and uncertainty hiding/simplification

- Explicit consensus building processes can enforce overconfidence and belief polarization.
- Beliefs tend to serve as agents in their own confirmation
- Dismissal of skepticism is detrimental to scientific progress
- Disagreement provides a basis for focusing research in a certain area, and so moves the science forward.
- Overreliance on expert judgment motivates shortcuts in reasoning and hidden biases

Key conclusion of the IPCC AR4:

"Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations."



97% of actively publishing climate experts agree with this statement (Anderegg et al. 2010)

Why is there such strong belief among scientists in the IPCC attribution statement?

Some hypotheses:

- Overconfident interpretation of the scientific evidence
- Groupthink in context of a consensus building process
- Confidence in, and authority of, the IPCC
- High salience of the issue motivates individuals to take a stand
- **Solidarity among scientists against a perceived "war on science"**
- Defense of the status quo (strong funding feedback)
- Personal and political sympathies for environmental movement
- UNFCCC/IPCC ideology

* Reasons for JC's belief ca. 2006-2008

IPCC
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

WMO UNEP

IPCC/UNFCC Ideology

1. Anthropogenic climate change is real
2. Anthropogenic climate change is dangerous
3. Action is needed to prevent dangerous climate change
4. Deniers are attacking climate science and scientists
5. Deniers and fossil fuel industry are delaying UNFCCC CO2 stabilization policies.

Heresy implies dogma implies ideologues

Attributes of ideologues:

1. Absence of doubt
2. Intolerance of debate
3. Appeal to authority
4. A desire to convince others of the ideological truth
5. A willingness to punish those that don't concur

Climate scientists and polemics

Trenberth 2011 AMS Annual Meeting

- "The climate change deniers have very successfully caused major diversions from the much needed debate about what to do about climate change and how to implement it. It is important that climate scientists learn how to counter the distracting strategies of deniers."
- "The media have been complicit in the disinformation campaign of the deniers."
- "The corrupting influence of funding from all sources of vested interests prevents [politicians] from doing the right thing on behalf of the country and civilization as a whole."
- "Unfortunately, society is not ready to face up to these challenges and the needed changes in the way we create order and govern ourselves."

Denial literature

Climate change “denier” definition:

1. Global warming will never happen
2. Global warming is not primarily due to human activities
3. There is no scientific consensus about global warming
4. Global warming is generally exaggerated in the news
5. Not worried about global warming

McCright and Dunlap (2011)
Global Environmental Change

Climate Skeptics, “Deniers” & Auditors

- “Big industry”
- Mainstream media
- Libertarian think tanks
- Scientific skepticism by academic researchers
- Conservative/evangelical skeptics: amplified by talk radio, cable news, blogosphere

- -

- Climate auditors: technically educated people wanting greater accountability and transparency in climate research and assessments; enabled by blogosphere

Options for decision makers confronted with deep uncertainty:

"OK, all those in favour of delegating decision-making, shrug your shoulders"

- Wait and see
- Delay, gather more info
- Target critical uncertainties
- Enlarge the knowledge base for decisions
- Precautionary principle
- Adaptive management
- Build a resilient society

Understanding uncertainty and areas of ignorance is critical information for the decision making process

Getting climate science back on track

- Get rid of the consensus seeking approach to climate assessments
- Bring considerations of doubt, uncertainty, and ignorance to the forefront of the climate debate
- Seek to better understand natural climate variability
- Recognize that at the science-policy interface, understanding uncertainty and ignorance is of paramount importance
- Remind ourselves that debate and disagreement are the spice of academic life

http://judithcurry.com

Climate Etc.

- Climate science
- Uncertainty
- Communications
- Social psychology
- Philosophy of science
- Policy and politics
- Skepticism