Climate Science and the Uncertainty Monster

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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
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.
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
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 lies 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
Global Average Temperature

- Observations
- (Natural) volc+solar
- (Anthropogenic + Natural) volc+solar+ghg+so4

Anomalies from 1890-1919 (°C)

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.”
JC speaks out:

- Need for public availability of data, greater transparency of methods
- Need for greater acknowledgement of uncertainties
- Emphasized 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

“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.”

By Michael D. Lemonick

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%
expert judgment in the context of a subjective Bayesian analysis

<table>
<thead>
<tr>
<th>Level of Agreement/Consensus</th>
<th>Established but Incomplete</th>
<th>Well Established</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speculative</td>
<td>Competing Explanations</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Amount of Evidence (Observations, model output, theory, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW</td>
</tr>
<tr>
<td>Terminology</td>
</tr>
<tr>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Virtually certain</td>
</tr>
<tr>
<td>Very likely</td>
</tr>
<tr>
<td>Likely</td>
</tr>
<tr>
<td>About as likely as not</td>
</tr>
<tr>
<td>Unlikely</td>
</tr>
<tr>
<td>Very unlikely</td>
</tr>
<tr>
<td>Exceptionally unlikely</td>
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**IPCC Characterization of Uncertainty**

Moss & Schneider 2000
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.
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 uncertainty monster . . .

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


Unknown limitations of knowledge

Spiegelhalter and Reisch (2011)
Levels of uncertainty / ignorance

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

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

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Walker et al. 2003
Quality of Evidence
Guyatt et al. 2008

<table>
<thead>
<tr>
<th>Quality of Evidence</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High quality</td>
<td>Further research is very unlikely to change our confidence in the estimate of effect</td>
</tr>
<tr>
<td>Moderate quality</td>
<td>Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate</td>
</tr>
<tr>
<td>Low quality</td>
<td>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</td>
</tr>
<tr>
<td>Very low quality</td>
<td>Any estimate of effect is very uncertain</td>
</tr>
</tbody>
</table>
Reasoning about Uncertainty

Italian Flag: TESLA

Classical probabilistic 2-value logic

<table>
<thead>
<tr>
<th>Probability hypothesis is true</th>
<th>Probability hypothesis is false</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>0.7</td>
</tr>
</tbody>
</table>

- Unknowns undifferentiated
- May lead to false assertions

Evidence based 3-value logic

<table>
<thead>
<tr>
<th>Evidence for belief in hypothesis</th>
<th>Ignorance</th>
<th>Evidence against belief in hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>0.5</td>
<td>0.2</td>
</tr>
</tbody>
</table>

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

Belief For + Belief Against + Uncertainty = 1
Reasoning about Uncertainty
Propagating Information: TESLA

Influence diagrams
Tree logic
Interval probability methods

Breaking down and formalizing expert reasoning
Key finding of the IPCC AR4:

“Most of the observed increase in global average temperatures since the mid-20th century is very likely [\textit{\textgreater}90\%] due to the observed increase in anthropogenic greenhouse gas concentrations.”

97\% of 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

**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.”

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

**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
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$^{-2}$)

• 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

Equilibrium Climate Sensitivity (°C)

Probability Density

IPCC likely >66%
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)
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.

Source: P. D. Jones, T. J. Osborn, and K. R. Briffa
University of East Anglia, Norwich, UK
D. E. Parker, Met. Office, Bracknell, Berkshire, UK
Uncertainty: Natural Internal Variability

Atlantic Multidecadal Oscillation (AMO)

Pacific Decadal Oscillation (PDO)

warm phase

cool phase
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
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 20\textsuperscript{th} century observations
- Bootstrapped plausibility of the models, forcing data, and observations
- High precision and confidence [\textit{very likely}] in a non quantitative and imprecise statement [\textit{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 finding 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 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 (includes strong funding)
• Personal and political sympathies for environmental movement
• UNFCCC/IPCC ideology

* Reasons for JC’s belief ca. 2006-2008
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 Skepticism and Deniers

- “Big industry”
- Mainstream media
- Libertarian think tanks
- Scientific skepticism by academic researchers
- Conservative/evangelical skepticism: 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:

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

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

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
- Greater emphasis on understanding 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
• Skeptics