



A Philosophical Defense of the IPCC's AR4 Bayesian Methodology

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1. Introduction

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) Bayesian method of uncertainty analysis and expression is justifiable on pragmatic grounds: it overcomes problems associated with vagueness, thereby facilitating communication between scientists and policy makers such that the latter can formulate decision analyses in response to the views of the former. I argue that the most pronounced criticisms against the AR4's Bayesian approach are misguided.

2. Salient Sources of Uncertainty in Climatological Analysis

- Chaotic nature of system.
- Feedbacks (positive/negative; natural/anthropogenic).
- Stochastic aspects of system (e.g., fluctuations in solar intensity).
- Potential defects of modelling approaches.
- Potential conflicting modelling results.
- Imperfect understanding of climatic processes (e.g., properties of cloud formation).
- Gaps in data sets pertaining to certain lines of inquiry (e.g., resolution of climate models and palaeoclimate proxies).

3. Dealing with Uncertainty in Probability Analysis (not mutually exclusive in practice)

Objectivist Sense of 'Probability'

- Classical sense: probability = proportion of favourable cases, given a partition into equiprobable cases.
- Frequentist sense: probability = the limit of frequency in the long run.
- Propensity sense: probability = a physical tendency.

Subjectivist Sense of 'Probability'

- Subjective Bayesianism sense: probability = a personal degree of belief.

4. Subjective Bayesian Probability Analysis Applied to Climatological Assessment

| | | |
|-------------------------------------|--|---------------------------------|
| Level of agreement (or consensus) → | Qualitatively defined levels of understanding | |
| | High Agreement Limited evidence | High agreement Much evidence |
| | Low agreement Limited evidence | Low agreement Much evidence |
| | Amount of evidence (theory observations, models) → | |

(Reproduced from IPCC 2007, Guidance Notes)

The Uncertainty Lexicon

| Confidence Terminology | Degree of confidence in being correct |
|-----------------------------|---------------------------------------|
| <i>Very high confidence</i> | At least 9 out of 10 chance |
| <i>High confidence</i> | About 8 out of 10 chance |
| <i>Medium confidence</i> | About 5 out of 10 chance |
| <i>Low confidence</i> | About 2 out of 10 chance |
| <i>Very low confidence</i> | Less than 1 out of 10 chance |

| Likelihood Terminology | Likelihood of the occurrence/ outcome |
|-------------------------------|---------------------------------------|
| <i>Virtually certain</i> | > 99% probability |
| <i>Extremely likely</i> | > 95% probability |
| <i>Very likely</i> | > 90% probability |
| <i>Likely</i> | > 66% probability |
| <i>More likely than not</i> | > 50% probability |
| <i>About as likely as not</i> | 33 to 66% probability |
| <i>Unlikely</i> | < 33% probability |
| <i>Very unlikely</i> | < 10% probability |
| <i>Extremely unlikely</i> | < 5% probability |
| <i>Exceptionally unlikely</i> | < 1% probability |

(Reproduced from IPCC 2007, pp. 120-1)

Confidence vs. Likelihood

Degree Confidence ≠ Likelihood of occurrence

- The degree of understanding and/or consensus among experts.
- Constitutes a statement about expert judgment.
- The probability that a defined outcome will occur in the physical world.
- Constitutes an estimate using expert opinion

(Adapted with permission from Manning 2007)

e.g., "[I]t is *extremely likely* [i.e., >95% sure] that humans have exerted a substantial warming influence on the climate" (IPCC 2007, 131).

5. Two Criticisms of AR4 Bayesianism (typically voiced by 'skeptics')

- (A) Probability assignments are 'too subjective'.
- (B) Quantified personal probabilities are misleading as they suggest a strictly 'objective' probability analysis (see box 3).

6. Response to Criticisms

- (A)
- Climatological analysis of the AR4 requires subjective assessment.
 - The subjectivity of the analysis should not be equated with notions of capriciousness.
 - The IPCC's subjective analysis is guided by objective constraints (as is typical of Bayesian philosophy of science).
 - Even 'objective' statistical analysis requires some elements of subjectivity.
 - Elements of subjectivity do not render the entire research program 'subjective' in the way described by critics.
- (B)
- The IPCC is explicit about its subjectivity.
 - Government officials are typically trained to deal with technical material and as such are unlikely to be misled by the IPCC's Bayesian approach.
 - Unlike ordinary scientific analysis, the IPCC's mandate is to produce an assessment of scientific research tailored to an audience of policy makers who want to make informed decisions. In order to fulfill this mandate, a statement of expert opinion is required; and quantifying this opinion facilitates clear communication.

7. Key Advantages of the AR4 Bayesian Method

- Avoids problems associated with vagueness.
- Facilitates communication among scientists in Working Groups that employ the uncertainty lexicon.
- Facilitates communication between scientific and public/political communities
- Makes subjective degrees of belief explicit.
- Provides numerical figures for policy (or other) analysts to incorporate in decision models, which circumvents their having to assign interpolated probabilities when assessing relevant qualitative statements.

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