



IPCC Findings and Confidence-Based Decision Making

Managing Severe Uncertainty meeting, February 2015



Outline

1. IPCC treatment of uncertainties
2. Alternative decision models
3. Deciding with Confidence
4. Future research directions

IPCC Treatment of Uncertainties

A rapidly evolving framework



IPCC Language of Uncertainty

Quote from AR5 Uncertainty Guidance Note:

The AR5 will rely on two metrics for communicating the degree of certainty in key findings:

Confidence in the validity of a finding, based on the type, amount, quality, and consistency of evidence (e.g., mechanistic understanding, theory, data, models, expert judgment) and the degree of agreement. Confidence is expressed qualitatively.

Quantified measures of uncertainty in a finding expressed probabilistically (based on statistical analysis of observations or model results, or expert judgment).

Examples

In the Northern Hemisphere, 1983–2012 was likely the warmest 30-year period of the last 1400 years (medium confidence).

Multiple lines of evidence provide high confidence that an [Equilibrium Climate Sensitivity] value less than 1°C is extremely unlikely.

Decisions: The Standard Framework

- Actions/policies are functions from states to consequences
- Uncertainty measured by a unique probability Pr on states
- Rational choice is expected utility maximising, where:

$$EU(f) = \sum_i U(f(s_i)) \cdot \text{Pr}(s_i)$$

| Actions | States | |
|---------|----------|----------|
| | s_1 | s_2 |
| f | $f(s_1)$ | $f(s_2)$ |
| g | $g(s_1)$ | $g(s_2)$ |



IPCC findings don't fit the standard framework

- IPCC findings communicate both less information (imprecision in probabilities) and more information (confidence) than is required for application of the EU criterion.
- Our question: What decision rule is best fitted to this information?

Alternative Decision Models

Imprecise Probability and Confidence

DM under ambiguity or disagreement

- Models of decision making under ambiguity motivated by both practical and theoretical problems (Ellsberg and Popper paradoxes).
 - Imprecise information modelled by a set of probability functions, $C = \{Pr_1, \dots, Pr_2\}$
 - Allows for decision rules based on a range of expected utilities for each act.



Maximin EU

Pick action with greatest minimum EU relative to set of probabilities C:

$$\text{Min } EU(f) = \text{Min}_{Pr \in C} \left[\sum_s [EU(f(s))] \cdot \text{Pr}(s) \right]$$

- Hurwicz (1951); Levi (1974, 1980); Gärdenfors and Sahlin (1982); Gilboa & Schmeidler (1989)
- How is C determined?
- Doesn't use all available information



Alternatives to Maximin EU

- Maximise the Mean ('the Principle of Indifference').
- Maximise the α -weighted average of the minimum and maximum EU ('the Hurwicz criterion')
- Maximise the α -weighted average of the minimum and expected EU ('the Ellsberg criterion')

Confidence

- Confidence / reliability modelled by 2nd-order weights w on first-order probabilities.
- Confidence-weighted EU:

$$CWEU(f) = \sum_{Pr \in C} [EU_{Pr}(f)] \cdot w(Pr)$$

- Linear averaging models e.g. Harsanyi, 2nd-order Bayesianism
- With ambiguity aversion: Klibanoff, Marinacci and Mukerji
- Where do the weights come from?
- Problem of proposition-invariant weights

Deciding with Confidence

Hill (2013)

Example: Nuclear Power Plant

| | Accident [0.001 – 0.01] | No accident [0.99 – 0.999] |
|-------------|--|-------------------------------|
| Build Plant | Interrupted power supply Major damage [-1000] | Reliable power supply [10] |
| Don't build | Reliant on coal [0] | Reliant on coal [0] |

- Caution might favour not building in this case. But ...
- Compare with a situation in which utilities are fractions of these, but the probabilities are the same.



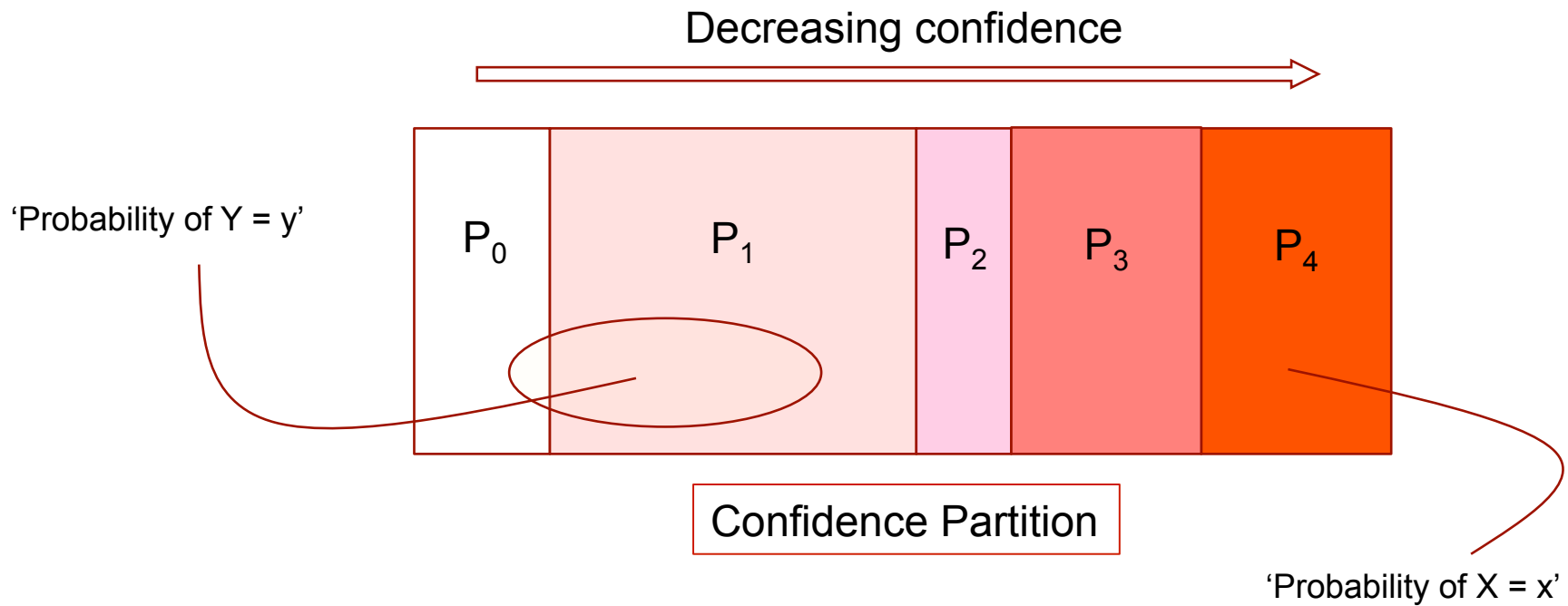
Choosing with Sufficient Confidence

- Assign each set of opinions a grade that reflects the confidence you have in it.
- Determine a stake-sensitive confidence threshold.
- Base your decision on the smallest set of opinions that achieves the confidence threshold
- If it's a singleton, maximise EU relative to it. If not either:
 - Defer
 - Apply one of the alternative decision rules.



Confidence Relations

- Π is a set of probability measures on the event space; intuitively the probabilities yielded by different models or expert judgements
- $\Delta(\Pi)$ is the set of subsets of Π ; elements are the (imprecise) probability propositions.
- Model confidence as a weak pre-order on $\Delta(\Pi)$, i.e. as reflexive and transitive, but not complete.
- Assume the existence of a **finest confidence partition**:
 - A confidence partition is a partition that is linearly ordered by the confidence relation.
 - Intuitively, the most specific propositions for which the DM has confidence judgements



- Confidence partition can be:
 - Binary, multi-valued, infinite
 - Centred on a singleton
- Confidence relation induces a nested set of probability measures based on P_0



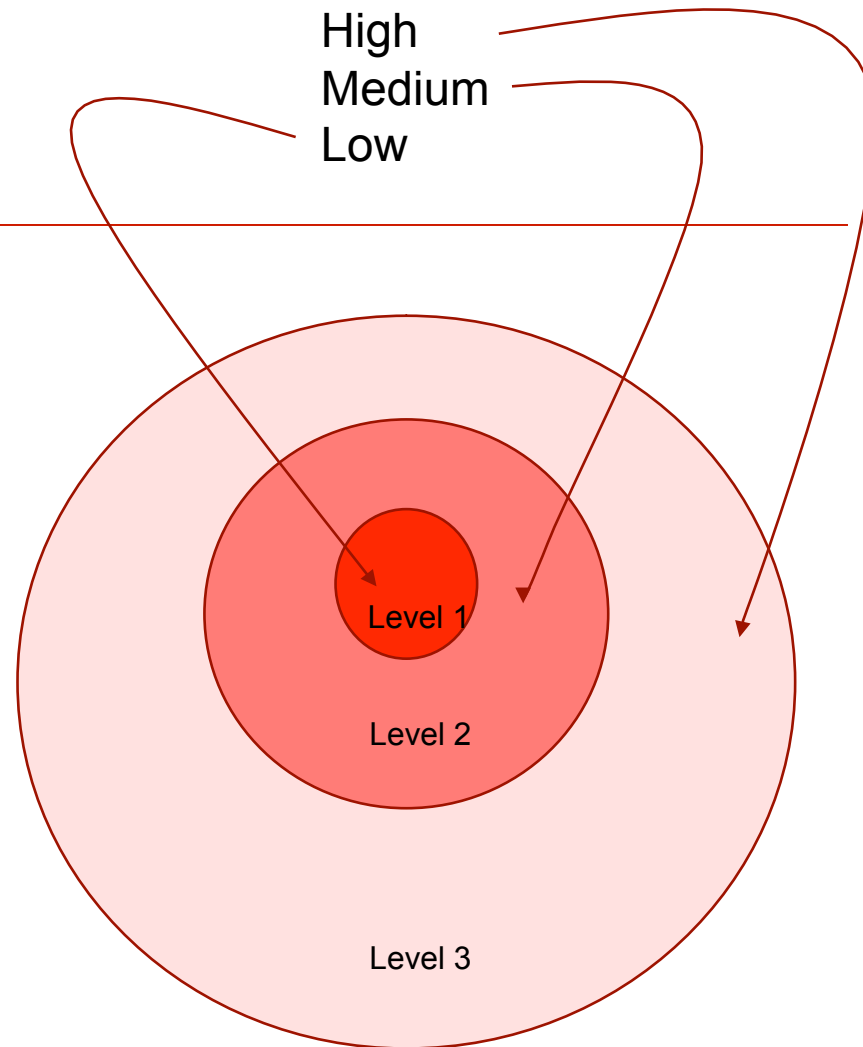
Stakes

- The **stakes** are determined by decision problem e.g.
 - Magnitude of worst consequence.
 - Difference between best and worst outcomes.
- A **cautiousness coefficient** is a mapping from stakes to a confidence level
 - Low stakes decisions based on central confidence set
 - High stakes decisions based on wider set

If stakes are:

High
Medium
Low

Then base decision
on this confidence
level





Evaluation

- Informational conditions roughly match IPPC reporting
 - Represents two levels of uncertainty: probability and confidence
 - Probabilities can be imprecise
 - Allows for a purely ordinal confidence grading
- Model has great generality.
 - Other uncertainty representations are derivable as special cases
 - Allows for application of different decision rules in different contexts (e.g. MaxMin EU relative to probabilities in which one has sufficient confidence).



Research Questions

- Is this an adequate model of the role confidence should play in decision making?
- How should confidence be calibrated across individuals?
- How should the stakes and cautiousness coefficient be determined?
- Can the model provide guidance on which particular decision criterion to adopt?
- Does this picture help further develop the IPCC uncertainty framework?