Interpreting Probability Claims in Climate Science

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Intro

The IPCC and probabilistic language

"ECS is positive, *likely* in the range 1.5°C to 4.5°C with *high confidence*, *extremely unlikely* less than 1°C (*high confidence*) and *very unlikely* greater than 6°C (*medium confidence*)."

– IPCC (2013, 81)

"the best estimate of ECS is 3°C, the *likely* range is 2.5°C to 4°C, and the *very likely* range is 2°C to 5°C. It is *virtually certain* that ECS is larger than 1.5°C. ... the 5°C upper end of the very likely range is assessed to have medium confidence and the other bounds have high confidence."

– IPCC (in press, chapter 7)

Some questions

(1) What does the IPCC mean by "confidence"?

(2) What does the IPCC mean by "likelihood"?

(3) What is the relationship between the two?

Some prior discussions: Helgeson et al. (2018), Mastrandrea et al. (2010), and Winsberg (2018)

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The talk

Negative claim: there is no traditional interpretation of probabilities that fits the actual practice (§1).

Positive claim: we should interpret the IPCC's use of "likelihood" in a *deflationist* (or perhaps *operationalist*) way (§2).

No traditional interpretation

What the IPCC says about "likelihoods"

Likelihood: "Quantified measures of uncertainty in a finding expressed probabilistically."

"Virtually certain"	$p = 0.99\text{-}1.00$
"Extremely likely"	$p = 0.95\text{-}1.00$
"Very likely"	$p = 0.90\text{-}1.00$
"Likely"	$p = 0.66\text{-}1.00$
"About as likely as not"	$p = 0.33\text{-}0.66$
"Unlikely"	$p = 0.00\text{-}0.33$
etc.	

See Mastrandrea et al. (2010)

Classical stats in IPCC reports 1

"GHGs [greenhouse gases] contributed a global mean surface warming *likely* to be between 0.5°C and 1.3°C over the period 1951–2010."

– IPCC (2013, 869)

Numbers here are based on Gillett et al. (2013) and Jones et al. (2013); see IPCC (2013, 883).

Classical stats in IPCC reports 2

"Attribution results are typically expressed in terms of conventional 'frequentist' confidence intervals or results of hypothesis tests: when it is reported that the response to anthropogenic GHG increase is *very likely* greater than half the total observed warming, it means that the null hypothesis that the GHG-induced warming is less than half the total can be rejected with the data available at the 10% significance level."

– IPCC (2013, 878)

Bayesian stats in IPCC reports 1

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– IPCC (2013, 81)

Bayesian stats in IPCC reports 2

"the probabilistic estimates available in the literature for climate system parameters, such as ECS and TCR have all been based, implicitly or explicitly, on adopting a Bayesian approach and therefore, even if it is not explicitly stated, involve using some kind of prior information. The shape of the prior has been derived from expert judgement in some studies, observational or experimental evidence in others or from the distribution of the sample of models available."

– (IPCC 2013, 922)

Why not both?

Estimates for anthropogentic warming by period in °C:

	1986-2005	1995-2014	2006-2015	2010-2019
Study 1	0.52-0.77	0.69-0.94	0.81-1.08	0.89-1.17
Study 2	0.32-0.94	0.63-1.06	0.74-1.22	0.92-1.30
Study 3	0.58-0.82	0.75-0.98	0.87-1.10	0.94-1.22
IPCC AR6	0.3-1.0	0.6-1.1	0.7-1.3	0.8-1.3

Reproduced from IPCC (in press, chapter 3).

Studies 1-3 are Ribes et al. (2021), Gillett et al. (2021), and Haustein et al. (2017) respectively.

A deflated interpretation

What is statistics?

Most basically: a method for scoring hypotheses based on compatibility with the evidence.

Some scoring methods yield probabilities. In particular:

- confidence level
- posterior probabilities

"Deflationist" probability on the evidence

The Kolmogorov-obeying "score" yielded by applying the best available statistical methods to the evidence.

Dos and don'ts

Dos:

- Compare intervals across methods.
- Identify the "best guess" according to a method.
- Method-relative estimates of the strength of the evidential support.

Don'ts:

- Interpret in terms of frequencies or credences.
- Plug into your decision matrix.

The IPCC's use of likelihoods

Claim: the IPCC's talk of likelihood should be interpreted in terms of these deflated probabilities.

More precisely: when the IPCC says that "the *likely* range [for ECS] is 2.5°C to 4°C," that means that they *estimate* that the score that would be assigned to that hypothesis by an ideal application of our best available method(s) to our available evidence is between 0.66 and 0.90.

Why an estimate?

The "best methods" won't always be perfectly applicable.

Statistical models are usually idealized; the ones in climate science are heavily so.

Hence the secondary talk of "confidence": can't be entirely sure that the ideal method would generate the same results as are actually recorded.

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