Objective prior distribution of climate sensitivity

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The problems posed by the choice of prior distribution constitute one of the most fundamental obstacles to assign probabilities to the possible values of climate sensitivity S. The prior is the probability distribution that we assume before introducing data. In the literature about climate sensitivity, the most frequently used prior is the uniform. On first inspection, this distribution would seem to represent absence of information, but, as is well known, this assumption leads to paradoxes. This observation has led to the widespread belief that priors are inherently subjective and should be decided by expert elicitation, even though this amounts to questioning the objective value of scientific results. In general, the climate science community is unaware of the "objective Bayesian" literature, which seeks objective criteria to determine non-informative prior distributions (or reference priors).

In a recent paper (Pueyo 2011) I applied an objective Bayesian approach to climate sensitivity. I described three lines of evidence indicating that the distribution that really represents absence of information about S is log-uniform, i.e. it consists of a uniform distribution of log(S) instead of S:

• In the case of S, only the log-uniform distribution satisfies Jaynes' invariant groups criterion, i.e. this distribution does not change when modifying assumptions that are not explicitly included in the enunciate of the problem (I only included the definition of S).

• In terms of information theory, information about S can be identified with mutual information between changes in radiative forcing and in temperature. Absence of mutual information between these variables implies a log-uniform distribution of S.

• The frequency distribution of sets of parameters formally comparable to climate sensitivity is approximately log-uniform for a broad range of values.

A log-uniform distribution of S is intermediate between a uniform distribution of S and a uniform distribution of the climate feedback parameter, which has also been used as a prior in some studies. The log-uniform behaves better than the uniform in the upper tail.

These results do not necessarily imply that the log-uniform should be used directly when treating data. The log-uniform represents absence of information, but we do have information preceding the use of any given dataset, for example about the physical processes involved. Ignoring this information could lead to severe biases. The construction of an optimum prior should start from the non-informative prior (of S or of other parameters of which S is a function), and pieces of information should be introduced in the form of partial, explicit and well-justified modifications of this distribution. It would be interesting to initiate a collective process to construct this prior, and, thereafter, to use it by combining several heterogeneous, representative datasets.

Reference

Pueyo, S. 2011. "Solution to the paradox of climate sensitivity". Clim. Change, doi: 10.1007/s10584-011-0328-x