PART 2. THE IMPORTANCE OF QUANTIFYING UNCERTAINTY

There are a variety of words that are used to describe various degrees of uncertainty: "probable", "possible", "unlikely", "improbable", "almost impossible", *etc.* People often ask, why not simply use such words in describing uncertainty about climate change and its impacts?

Such qualitative uncertainty language is inadequate because: 1) the same words can mean very different things to different people; 2) the same words can mean very different things to the same person in different contexts; and 3) important differences in experts' judgments about mechanisms (functional relationships), and about how well key coefficients are known, can be easily masked in qualitative discussions.

Figure 2.1 illustrates the range of meaning that people attached to a set of probability words, when asked to do so in a study conducted by Wallsten *et al.* (1986), in the absence of any specific context. Mosteller and Youtz (1990) performed a review of 20 different studies of the probabilities that respondents attached to 52 different qualitative expressions. They argue that "in spite of the variety of populations, format of question, instructions, and context, the variation of the averages for most of the expressions was modest…" and they suggest that it might be possible to establish a general codification that maps words into probabilities. When this paper appeared in *Statistical Science* it was accompanied by eight invited comments (Clark, 1990; Cliff, 1990; Kadane, 1990; Kruskal, 1990; Tanur, 1990; Wallsten and Budescu, 1990; Winkler, 1990; Wolf, 1990). While several commenters who have economics or statistical backgrounds commented favorably on the feasibility of a general codification based on shared natural

language meaning, those with psychological backgrounds argued strongly that context and other factors make such an effort infeasible.

For example, Mosteller and Youtz argued that on the basis of their analysis of 20 studies "likely" appears to mean 0.69 and unlikely means 0.16. In a study they then did in which they asked science writers to map words to probabilities they obtained a median value for likely of 0.71 (interquartile range of 0.626 to 0.776) and a median value for unlikely of 0.172 (interquartile range of 0.098 to 0.227). In contrast, Figure 2.2 illustrates the range of numerical probabilities that individual members of the Executive Committee of the EPA Science Advisory Board attached to the words "likely" and "not likely" when those words were being used to describe the probability that a chemical agent is a human carcinogen (Morgan, 1998). Note that, even in this relatively small and expert group, the minimum probability associated with the word "likely" spans four orders of magnitude, the maximum probability associated with the word "not likely" spans more than five orders of magnitude, and there is an actual overlap of the probabilities the different experts associated with the two words! Clearly, in this setting the words do not mean roughly the same thing to all experts, and without at least some quantification, such qualitative descriptions of uncertainty convey little, if any, useful information.

While some fields, such as environmental health impact assessment have been relatively slow to learn that it is important to be explicit about how uncertainty words are mapped into probabilities, and have resisted the use of numerical descriptions of uncertainty (Presidential/Congressional Commission on Risk Assessment and Risk Management, 1997; Morgan, 1998) the climate assessment community has made relatively good, if uneven, progress

in recognizing and attempting to deal with this issue. Notable recent examples include the guidance document developed by Moss and Schneider (2000) for authors of the IPCC Third Assessment and the mapping of probability words into specific numerical values employed in the 2001 IPCC reports (IPCC WGI and II, 2001) (Table 2.1) and by the National Assessment Synthesis Team of the U.S. National Assessment (2000). The mapping used in the U.S. National Assessment, which the authors attempted to apply consistently throughout their two reports, is shown in Figure 2.3.

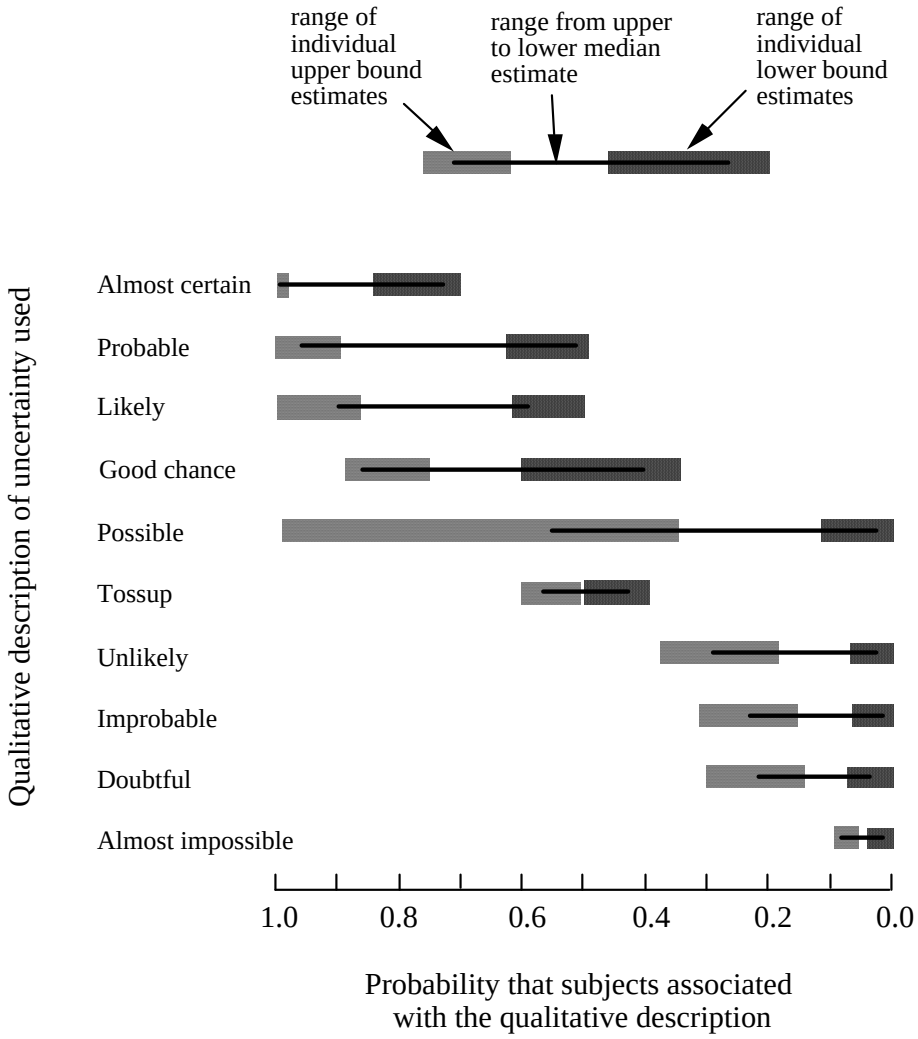

Figure 2.1 Range of numerical probabilities which respondents attached to qualitative probability words in the absence of any specific context. Figure redrawn from Wallsten *et al.* (1986).

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965 **Figure 2.2** Results obtained by Morgan (1998) when members of the Executive Committee of the EPA Science
966 Advisory Board were asked to assign numerical probabilities to words that have been proposed for use with the new
967 EPA cancer guidelines (U.S. EPA, 1996). Note that, even in this relatively small and expert group, the minimum
968 probability associated with the word "likely" spans four orders of magnitude, the maximum probability associated
969 with the word "not likely" spans more than five orders of magnitude, and there is an overlap of the probabilities the
970 different experts associated with the two words.

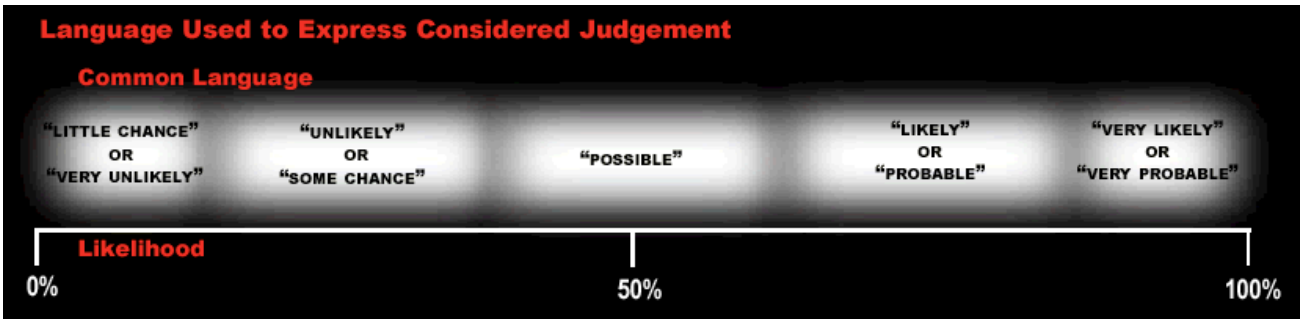

Figure 2.3 Mapping of probability words into quantitative subjective probability judgments, used in their two reports, by the members of the National Assessment Synthesis Team of the United States National Assessment (2000).

Table 2.1 Mapping of probability words into quantitative subjective probability judgments, used by WGI and II of the IPCC Third Assessment (IPCC WGI and II, 2001) based on recommendations developed by Moss and Schneider (2000).

word	probability range
Virtually certain	> 0.99
Very likely	0.9-0.99
Likely	0.66-0.9
Medium likelihood	0.33-0.66
Unlikely	0.1-0.33
Very unlikely	0.01-0.1
Exceptionally unlikely	< 0.01

Note: The report of the *IPCC Workshop on Describing Scientific Uncertainties in Climate Change to Support Analysis of Risk and of Options* (2004) observed: "Although WGIII TAR authors addressed uncertainties in the WG3-TAR, they did not adopt the Moss and Schneider uncertainty guidelines. The treatment of uncertainty in the WG3-AR4 can be improved over what was done in the TAR."

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