Using Specific Language to Describe Risk and Probability

Anthony G. Patt
Boston University
and
Potsdam Institute for Climate Impact Research
Telegrafenberg A31
14473 Potsdam, Germany
tel: (49) 331 288 2500
email: apatt@bu.edu

Daniel P. Schrag
Laboratory for Geochemical Oceanography
Department of Earth and Planetary Sciences
Harvard University
Cambridge, MA 02138 USA

8 May 2002

Abstract

Good assessment of environmental issues, such as climate change, requires effective communication of the degree of uncertainty associated with numerous possible outcomes. One strategy that accomplishes this, while responding to people's difficulty understanding numeric probability estimates, is the use of specific language to describe probability ranges. This is the strategy adopted by the Intergovernmental Panel on Climate Change in their Third Assessment Report. There is a problem with this strategy, however, in that it uses words differently from the way lay readers of the assessment typically do. An experiment conducted with undergraduate science students confirms this. The IPCC strategy could result in miscommunication, leading readers to under-estimate the probability of high-magnitude possible outcomes.

Introduction

The potential impacts of climate change vary not only according to their timing and magnitude, but also according to the probability with which they will occur. Some of the most consequential potential impacts—such as rapid seas level rise due to the disintegration of the West Antarctic Ice Sheet—thankfully will probably not occur. Effective assessment of climate change allows policy-makers to take into account scientific knowledge about not only the most likely outcomes of environmental change, but also these less likely, but more consequential possibilities. A significant challenge confronting the Intergovernmental Panel on Climate Change (IPCC) and

Probability Interpretation

Both psychologists and behavioral economists have shown that people's descriptions and understanding of probabilities depend on contextual factors such as objective probability, base-rate, and event magnitude (Weber, 1994). In terms of objective probability, Kahneman and Tversky (1979) identify a weighting function people use to interpret evidence of probabilities, shown in Figure 1. People tend to overestimate the probability of relatively infrequent events (such as dying from botulism) and underestimate the probability of relatively frequent events (such as dying from heart disease. The change in people's reactions when an event's assessed probability goes from 0% to 1% is much greater than when it goes from 36% to 37% (Patt and Zeckhauser, 2002). For very small probabilities, people's responses are more binary than continuous (Kammen et al., 1997; Covello, 1990). Below a certain threshold of concern people view the event as impossible; above the threshold, they take measures to prevent it, measures that may not be justified by the event's small probability. People are relatively insensitive to changes in assessed probability in the middle of the scale, treating all such probabilities as roughly fifty-fifty.

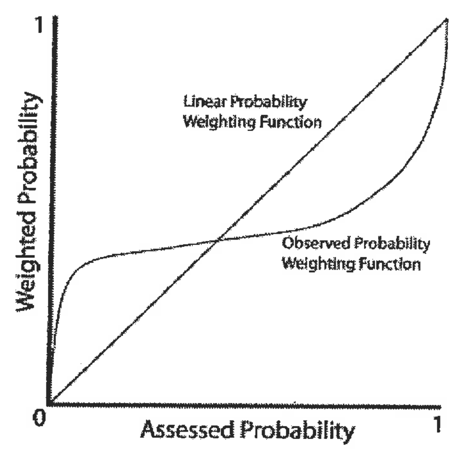

Figure 1—Probability Weighting

In terms of base rates, Wallsten et al.(1986) observe that people's interpretation of probability descriptors depends on the background frequency of an event. Hence, people interpret a "slight chance" of rain in London as meaning a higher numeric probability than a "slight chance" of rain in Madrid. Windschitl and Weber (1999) observe a similar phenomenon even when people are

Uncertainty Assessment

Fortunately, scientific assessors have increasingly appeared sensitive to audience perceptions, revealed in a variety of ways they have communicated uncertainty. Some assessments fail to report highly uncertain information, or else avoid quantification of uncertainty by giving ranges of expected outcomes without clarifying the probability bounds for that range. This approach offers information that is easy to understand, yet at the same time incomplete. Patt (1999) examines the assessment of a highly unlikely yet highly consequential result of climate change—the rapid collapse of the West Antarctic Ice Sheet—across different types of assessment. He finds that the large, consensus-oriented assessments, such as the IPCC, were less likely to provide information on the event. Smaller assessments, both those conducted by advocacy groups and those responding to specific questions of their intended audience, tended to provide greater detail on the issue. There are several explanations. First, consensus within the assessment team might be difficult to achieve for high-consequence low-probability events. For example, Morgan and Keith (1995) obtained subjective probability judgments from a number of climate change scientists, using a variety of expert elicitation techniques. What they observed was disagreement, often between disciplines, with many experts' ranges failing to overlap. As events become more and more speculative, it is likely that expert opinion will diverge even more. Patt also concluded that for these extreme events, it is possible that assessment authors would be tempted to view any treatment as counterproductive. Because people's responses to low-probability events are likely to be binary and polarized, discussion of such events may in fact lead to greater conflict within the policy community. If assessment authors see their task as building consensus, not only among themselves but also among decision-makers, then they will limit their discussion to events that are either certain or of middle-probability.

Van der Sluijs (1997), likewise, examines how the IPCC has described the range of future temperature changes associated with climate change. He observes that the range has remained fairly constant, even as new evidence has become available. Assessors were reluctant to depart from a previously stated position, and "anchored" on the old estimate absent a compelling reason to change it. To maintain intellectual honesty, they failed to quantify the probabilities associated with that temperature range. As long as it remained unclear what a given temperature range actually meant, they could continue to use it. Like the strategy of omitting treatment of extreme events altogether, the anchoring phenomenon is a way of avoiding the rigorous treatment of uncertainty, when being rigorous could make consensus difficult, or could confuse the audience.

Other assessments—assessments of health and technological risks in particular—present quantified probability estimates. This approach offers more information but may be difficult to

Table 1—IPCC Qualitative Descriptors

Probability Range	Descriptive Term
< 1%	Extremely Unlikely
1–10%	Very Unlikely
10–33%	Unlikely
33–66%	Medium Likelihood
66–90%	Likely
90–99%	Very Likely
> 99%	Virtually Certain

There may be good reasons for this approach. First, using language such as *very likely* or *virtually certain* to describe an uncertain outcome avoids the problem of experts having to reach consensus on a particular probability estimate or range. Since it may well be impossible for experts to reach consensus, the alternative to the use of such language may well be complete omission of the uncertain outcome. Obviously, it is better to describe an event than to omit it, even if the probability range is wide and not completely precise. Second, many people understand, or feel they understand, the meanings of such words better than they do accurate numbers or ranges (Wallsten et al., 1986). This is especially true for forecasts of one-time events (e.g., the chances of one meter sea level rise), as opposed to forecasts of frequent outcomes (e.g., the chances of any one person contracting malaria during a visit to Honolulu) (Pinker, 1997). To a lay audience, a numeric probability for the frequent event makes sense; the typical person stands an X% chance of contracting malaria, since X people in 100 actually do contract the disease. But for the one time event, for which there is no past data, the meaning of the X% is somewhat different. The probability estimate conveys a degree of confidence in the outcome occurring, rather than a description of past data. The use of probability language to describe degrees of confidence, rather than numeric estimates, makes more sense to most people (Moss and Schneider, 2000). Additional information, the accurate numerical data, may simply upset this simple approach toward communicating uncertainty.

is whether there exists a basic behavioral tendency for people in general to interpret probability language describing weather events in a way that responds to event magnitude, as others have observed in the literature. It may well be that highly-trained individuals will demonstrate less of a bias. But by using college students as subjects, we can draw conclusions about people's underlying decision-making biases.

Table 2—Survey Versions

Communicators		Audience	
High Magnitude Outcome	Low Magnitude Outcome	High Magnitude Outcome	Low Magnitude Outcome
Imagine that you are the weather person for a Boston television station. The date is September 8, 2001.		Imagine that the date is September 8, 2001, and you are watching the weather report on television.	
You are somewhat concerned about a very powerful hurricane currently near Bermuda. Usually these hurricanes hit land in the Carolinas, or else track out to sea, but in this case conditions make it possible that the hurricane could hit land near Boston, devastating the region with sustained winds of over 100 mph and extensive flooding.	You are somewhat concerned about a cold front currently over western New York State. Usually at this time of the year these fronts bring isolated thunderstorms and chilly temperatures (40s to 50s) to the region, but in this case conditions make it possible that Boston will see some snow flurries and temperatures dipping into the high 30s.	The weather person is talking about a very powerful hurricane currently near Bermuda. Usually these hurricanes hit land in the Carolinas, or else track out to sea, but in this case conditions make it possible that the hurricane could hit land near Boston, devastating the region with sustained winds of over 100 mph and extensive flooding.	The weather person is talking about a cold front currently over western New York State. Usually at this time of the year these fronts bring isolated thunderstorms and chilly temperatures (40s to 50s) to the region, but in this case conditions make it possible that Boston will see some snow flurries and temperatures dipping into the high 30s.
The National Weather Service is currently predicting the chances of this happening at 10%, and you believe this to be a good estimate. Which of the following language would you use to describe to your viewers the chances of this happening?		The weather person, whom you trust, is saying that it is unlikely, perhaps very unlikely, that this will actually happen. Based on this forecast, what do you think the chances of this event happening actually are?	
a. Extremely Unlikely b. Very Unlikely c. Unlikely d. Medium Likelihood e. Likely f. Very Likely g. Virtually Certain		a. < 1% b. 1–10% c. 10–33% d. 33–66% e. 66–90% f. 90–99% g. > 99%	

probability descriptors (e.g., *likely* instead of *unlikely*) to discuss more serious consequence events. But people are also sensitive to this practice in others, expecting a certain amount of exaggeration about the likelihood of high magnitude events.

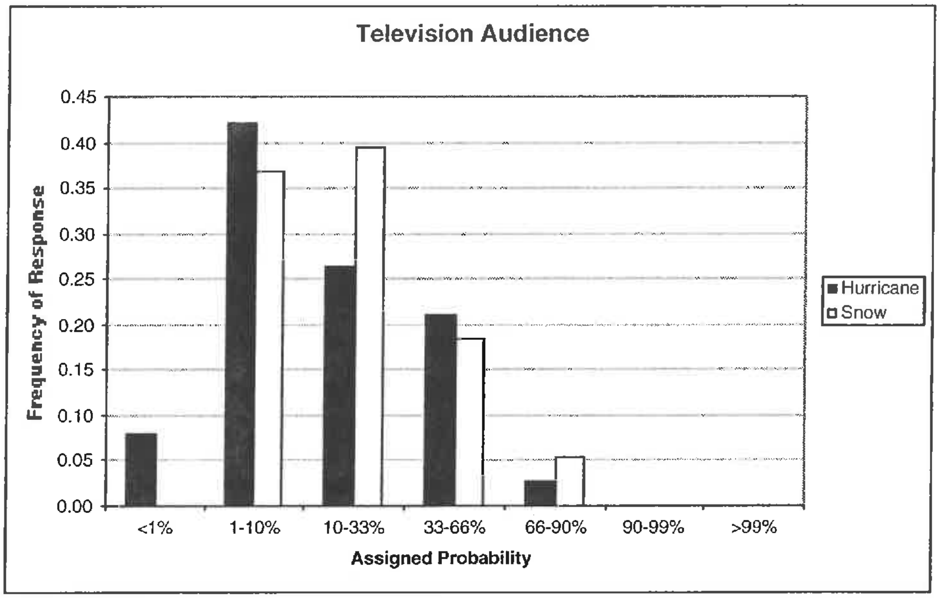

Figure 3—Audience' Probability Estimates

A weather forecaster might describe a 10% probable snow flurry as *very unlikely*, which the television viewer would accurately interpret to mean about 10%. Likewise, a weather forecaster might describe a 10% probable hurricane as *medium likelihood*, which the television viewer would again accurately interpret to mean about 10%. The symmetry of the two groups allows for effective communication. Figure 4a illustrates this pattern. Assigning a fixed probability scale to describe uncertain event with significantly different magnitudes of impact could disrupt that symmetry, as seen in Figure 4b. What would happen if forecasters were to use a single phrase, such as *unlikely*, to describe both the hurricane and snowfall? Attempting to correct for the assumed exaggeration, the viewers would understand the single word *unlikely* as implying a smaller chance for the hurricane than for the snow flurries.

Biased Mitigation Efforts

In response to the fixed probability scale, people will have a tendency to over-estimate the likelihood of low-magnitude events, and under-estimate the likelihood of high-magnitude events. Importantly, the two errors do not balance each other out, but introduce a bias in people's aggregate responses to the two events. Imagine, for example, that the hurricane, if it hits Boston, will cause damages of $10 million. The probability of this outcome is 10%, yielding an expected loss of $1 million, but people underestimate this probability to be 5%, yielding an expected loss of $0.5 million. The snow-flurries will cause very small damages, perhaps one additional road accidents costing $10,000. The probability is 10%, yielding an expected loss of $1000, but people overestimate the probability to be 15%, yielding an expected loss of $1500. The underestimate of damages for the high-magnitude event completely overshadows the overestimate from the low-magnitude event. People's expectation of damages from the two combined events will be biased downward.

The efficiency of people's efforts to mitigate damages, through advance preparation, will also be biased downward, with a net loss in welfare. To see how this is so, consider one possible mitigation strategy an individual or local area might pursue: the purchasing of insurance. First, imagine that it is possible to insure against each event at an actuarially fair rate, i.e., 10% of the possible loss from each event. Rational risk-averse actors would gain the greatest expected benefit from fully insuring against each event, purchasing $1 million of coverage for the hurricane, and $10,000 of coverage for the snow flurries, reducing to zero the variance of possible outcomes while leaving the expected outcome unchanged. But if people believed the probability of the hurricane were 5%, the insurance at a 10% rate would appear overpriced, and they would underinsure, i.e., purchasing insurance to cover < $1 million. Likewise, estimating the likelihood of snow-flurries at 15%, people would over-insure. In each case, they would have purchased the wrong amount of insurance, resulting in positive variance, and a lowering of expected utility, for each event. Second, imagine that it is possible to purchase a single insurance policy for cover both events. At an actuarially fair rate of 10%, this policy would cost slightly more than $1 million. With the two errors in probability understanding, people would estimate losses at slightly more than $0.5 million. The policy would appear too expensive, and people would purchase less than full coverage.

the risks associated with low-probability high-magnitude events may be the most important elements of a rational decision-making framework addressing climate change. However, unless scientists encourage quantitative rigor on the part of policy-makers, it is likely the policy-makers will not give enough attention to these risks, and will take inadequate steps either to avoid or to prepare for these risks.

Conclusion

The strategy of using specifically defined language to describe the probabilities of climate change risks achieves important objectives, but may also introduce bias into policy-makers responses. Intuitively, people use such language to describe both the probability and magnitude of risks, and they expect communicators to do the same. Assessors need to emphasize that the IPPC's use of this language departs from people's expectations. Unless policy-makers appreciate this fact, their response to the assessment is likely to be biased downward, leading to insufficient efforts to mitigate and adapt to climate change.

References

Brun, W. and Teigen, K.H.: 1988, 'Verbal probabilities: ambiguous, context-dependent, or both?' *Organizational Behavior and Human Decision Processes* **41**, 390.

Breyer, S. (1993). *Breaking the vicious circle: Toward effective risk regulation.* Cambridge, Harvard University Press.

Covello, V.: 1990, 'Risk comparisons and risk communication: issues and problems in comparing health and environmental risks', in Kasperson and Stallen (eds.) *Communicating Risks to the Public: International Perspectives*, Dordrecht, Kluwer Academic Publishers: 79-124.

Fischhoff, B.: 1996, 'Public values in risk research', *Annals of the American Academy of Political and Social Science* **545**, 75.

Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, and D. Xiaosu (eds.): 2002, *Climate Change 2001: The Scientific Basis*, Cambridge UK, Cambridge University Press.

Irwin, A. and B. Wynne (eds.): 1996, *Misunderstanding Science?* Cambridge UK, Cambridge University Press.

Kahneman, D. and Tversky, A.: 1979, 'Prospect theory: an analysis of decision under risk', *Econometrica* **47**, 263.

Kammen, D., A. Shlyakhter, and R. Wilson: 1994, 'What is the risk of the impossible?' *Journal of the Franklin Institute* **331A**, 97.

Leiss, W.: 1996, 'Three phases in the evolution of risk communication practice', *Annals of the American Academy of Political and Social Science* **545**, 85.

STORMWATER QUALITY STANDARDS TASK FORCE

"Ballot" for Stormwater Sites

SITE	REC-1	REC-1 LIMITED	NOT REC-1
Temescal Creek above Corona			7 votes
Temescal Creek at Main Street, Corona		4 votes	4 votes
Storm Drain on River Road		5 votes	3 votes
Santa Ana River at River Road near 2nd Street	7 votes	1 vote	
Chino Creek at Pine Avenue			
Cucamonga Creek at Hellman Avenue		5 votes	3 votes
Day Creek Channel at Limonite		5 votes	3 votes
Santa Ana River at Etiwanda Avenue	8 votes		
Storm Drain at 60th Street and Bain Street			
Santa Ana River at Van Buren Blvd	6 votes	1 vote	
City of Riverside's Effluent Channel	7 votes	1 vote	
Tequesquite Arroyo at Santa Ana River		6 votes	2 votes
Santa Ana River at Mission Bridge	7 votes		1 vote
Tequesquite Arroyo at Victoria Avenue		1 vote	
Storm Channel at SAWPA		1 vote	3 votes