Reply

—Thomas R. Stewart
Center for Policy Research,
Nelson A. Rockefeller College of Public Affairs and Policy,
The University at Albany, State University of New York,
Albany, New York

—Roger Pielke Jr.
Center for Science and Technology Policy Research,
Cooperative Institute for Research in Environmental Sciences,
University of Colorado,
Boulder, Colorado

—Radhika Nath
Department of Primary Care and General Practice,
University of Birmingham,
Birmingham, United Kingdom

We thank Bob Glahn for his thoughtful comments on our paper. Here we offer several responses.

First, Glahn (2005, hereafter Glahn) is correct to point out that the National Weather Service (NWS) continues to innovate and expand its provision of forecast data products (he cites the example of the National Digital Forecast Database). But, because our paper was a descriptive study of the use of forecasts, we relied on the information that is used by the decision makers that we studied. We might also note that even having available forecasts at 3-h increments at 5-km resolution may not have made much difference for our study of the New York State Thruway for which decisions are made based on shorter time scales and smaller spatial scales.

Second, we agree that more detailed, longer-term studies of decision making than the limited study we were able to conduct are needed. In addition to computer skills and a capability in meteorology, statistics, and systems analysis, expertise in the psychology of judgment and decision making and in decision science would also be needed. Doswell's (2004) recent paper eloquently argues for the importance of the descriptive study of judgment and decision making in the production of forecasts. Such study is also important in understanding the use of forecasts.

Third, Glahn takes issue with our exploration and identification of numerous practical challenges facing the effective use of meteorological information. He writes, "one wonders whether showing how difficult the problem is will encourage users and potential users of weather data to be more reliant on such data." It is our hope that an accurate understanding of the real-world complexities associated with achieving the effective use of meteorological information will help prompt the meteorological research and operations community to respond with research, policies, and institutions that are reflective of the challenge. It is unlikely that mischaracterizing the complexities will lead to improved decision making by users. Glahn accurately heard a central theme of our paper—that the meteorological community has paid too little attention to such complexities, and, thus, should not be surprised that they limit the effective use of weather information in decision making. In this context, meteorologists know well that unraveling complex problems and turning such understanding into useful knowledge requires a commitment to research; processes of human decision making are no different. Thus, Glahn is certainly correct that our conclusions are of more immediate relevance for the research community than for the Thruway's decision makers.

Fourth, Glahn "find[s] it curious that probabilistic forecasts were not mentioned." Although we have always been strong supporters of the use of probabilistic forcasting in decision making, our study was a descriptive study of how decisions were being made by specific users of meteorological information. That these users were not aware of, or did not choose to use, other information that may have been available reinforces the difficulties that are associated with effectively connecting meteorological research and operational products with the information needs and wants of end users. As many scholars have observed, even perfect information has no actual value if it is

not effectively used to improve decision making. In this context, discussions of the theoretical or potential value of meteorological information can be little more than hand waving. Continued advances in research and operational products will meet a similar fate if they are not effectively connected with the decision processes of decision makers (and, in this context, we agree with Glahn that there are effective gains yet to be realized by improving the relationship of the public–private–academic sectors that are involved in the provision of weather services).

Glahn's technical comment (footnote 4) suggests that Brier skill scores are not appropriate for evaluating quantitative precipitation forecasts. Although Brier proposed his skill score for the evaluation of probability forecasts, probabilities are not required. Measures of accuracy based on mean squared error, such as the Brier skill score, have been used in many fields to evaluate both quantitative and probabilistic predictions. As Glahn correctly points out, we should have stated in the paper that we used a constant forecast of the mean observation as a standard for the skill score.

Finally, Glahn states that the requisite skills needed to "systematically use weather forecasts in enhancing the economy" are not presently being adequately taught in universities. It is unclear whether this is a comment about university educational standards generally or a comment about the scope of knowledge being taught. If he intends the latter, we would disagree. There are positive trends in several universities (e.g., Pennsylvania State University; University of Oklahoma; University of Colorado) that suggest that the value of expertise in economics, psychology, policy, and judgment and decision making is increasingly recognized by the atmospheric sciences community as being both important and necessary in the training of tomorrow's atmospheric scientists. Studies such as ours show that despite such positive steps, there is much more to be done.

REFERENCES

Doswell, C. A., 2004: Weather forecasting by humans— Heuristics and decision making. *Wea. Forecasting*, 19, 1115–1126.

Glahn, B., 2005: Comments on "Understanding user decision making and the value of improved precipitation forecasts." *Bull. Amer. Meteor. Soc.*, **86,** 1484–1487.