Comments on "Understanding User Decision Making and the Value of Improved Precipitation Forecasts: Lessons from a Case Study"

—Bob Glahn
NOAA, National Weather Service,
Meteorological Development Laboratory,
Silver Spring, Maryland

DOI:10.1175/BAMS-86-10-1484

The article "Understanding user decision making and the value of improved precipitation forecasts" (Stewart et al. 2004, hereafeter SPN) is an interesting study of a particular decision-making activity that is critically dependent on weather and weather forecasts. The specific purpose of the study is not clearly defined, but it appears to be just what the title implies—an effort to understand, through a case study, how improved weather forecasts might be translated into economic and other societal benefits.

I glean the following three main conclusions, none of which is really surprising:

1) even what might be considered at first blush a reasonably self-contained and short-term decision-

making problem can be very complicated;
2) it was very hard to acquire user data on the operation, relevant costs, and decision-making process; and
3) it was very difficult to acquire good weather data, especially forecasts and their accuracy for the study.

From the several statements in SPN about the lack of data to support the study, one must conclude that the study was of limited success. For instance, one passage reads,

> Due to the lack of relevant and useful weather information, the complexity of the decision process, and uncertainty about potential outcomes and their value, there is a substantial gap between the available data and improvement in QPF. An estimate of value would therefore have to be based in large part on untested assumptions and judgments, and would have an extremely wide confidence interval if, indeed, a confidence interval could be obtained. Such assumptions could easily be modulated within the bounds of credulity to result in an extremely wide range of outcomes. These factors led us eventually to abandon the goal of estimating in any meaningful way the dollar value of improved QPF.

In regard to the difficulty of acquiring good weather data,[1] the National Weather Service (NWS) zone forecasts, mentioned by SPN as an available source, are being augmented with digital forecasts. Specifically, the NWS has just implemented a National Digital Forecast Database (NDFD). This is explained in detail by Glahn and Ruth (2003). Basically, it is a mosaic of gridded forecasts produced by forecasters at NWS Weather Forecast Offices (WFO), and as such comprises official NWS forecasts (as opposed to machine-produced guidance). The grids (values of specific weather elements at a regular array of grid points, each related to a specific point in the United States or immediate coastal waters) are produced though the Interactive Forecast Preparation System (IFPS) (Ruth 2002) that became operational for the conterminous United States (CONUS) on 30 September 2003; implementation in the Alaskan and Pacific areas will follow in a few months.

These grids represent up-to-date forecasts of the weather elements of the sort needed in studies of the kind presented by SPN and are free and accessible to anyone with Internet access.[2] WFO forecasters modify or produce new gridded forecasts whenever new data become available that indicate a better forecast can be made. They can be updated at any time; the NDFD mosaic is updated hourly. Generally, forecasts are available at 3-h increments (projections) and at a resolution of 5 km. That is, for example, a forecast of temperature and of probability of precipitation are available every 3 h out to 3 days, and at 6-h intervals from 3 to 7 days for each point in the United States every 5 km. It is likely that the resolution will be increased to 2.5 km in the future.

In response to SPN's recommendation—"We strongly recommend a review of weather data archiving procedures and verification studies for supporting future studies of the use and value of forecasts,"—the NDFD forecasts are being archived and will be available for researchers and operational entities. An interim capability currently managed by the Meteorological Development Laboratory (MDL) will be transferred to the National Climatic Data Center in the near future. The forecasts are verified and the results will be made available. Such NWS forecasts should, in large measure, solve the forecast access problem for weather elements that are routinely forecast; very specific forecasts, such as roadway temperatures or hours needed to dry hay, must be determined from secondary relationships or from private sources. Observations can only be archived at locations where they are made; however, analyses (gridpoint values) can be made on the scale of the observations, and, in connection with the verification of the NDFD, such analyses will be made and archived at some time in the future.

With regard to the difficulty of the decision process and the availability of data concerning it, it is likely that a realization of the potential of (improved) weather forecasts can come only through a long-term view and attack on the problem by a specific business or activity. This requires a budget of sufficient size to support at least two full-time

[1] SPN may not have explored the full range of available forecasts. For instance, the Meteorological Development Laboratory (MDL) produces interpretative guidance forecasts [Model Output Statistics (MOS)] from the numerical models being run operationally at the National Centers of Environmental Prediction for most sensible (surface based) weather elements. These forecasts are available in a variety of formats, and a full archive exists for the past several years. Although these forecasts apply only to several hundred specific points, and may not be appropriate in any specific study, Teisberg et al. (2005) used them successfully in a study in scheduling electricity generation.

[2] At the time of writing, the national grids are being provided experimentally. Full operation will be declared when adequate quality is assured.

persons of sufficient training and long-term interest to analyze the weather-related portion of the business and to derive and recommend alternative decision-making processes. More than one person would be required to provide continuity when there is personnel turnover. These persons should have computer skills and have capabilities in meteorology, statistics, and systems analysis. Little can be accomplished in this highly complex world without the ability to manipulate quantities of data in meaningful ways, and this requires computer skills. The SPN authors evidently write from an academic and research perspective. While a real-life situation was studied, it was studied retrospectively from a research perspective and not from the perspective of actually producing a decision-making paradigm. Even the recommendations are largely couched in terms of providing data for research, not for determining decision paradigms.

Studies such as SPN can sensitize businesses and meteorologists alike to the difficulty of systematically applying weather data to a complex decision-making situation. This *could* lead to improvement; however, 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.

I find it curious that probabilistic forecasts were not mentioned,[3] although that form of forecast is the most useful in decision making; providing categorical forecasts is, in effect, making the weather-related portion of the decision for the user (see AMS 2002). SPN's table is an example of the classic, and most simple, cost–loss decision matrix, and its use cries out for probabilistic forecasts. In this context, the best that SPN were able to do was relate machine-made forecasts in two categories (no precipitation/any precipitation) to toll booth operators' observations in two categories (clear/rain or snow).[4]

MDL has been producing probability of precipitation occurrence and probability of quantitative precipitation (as well as other variables) in several categories out to 72 h as postprocessed numerical model guidance, and making such forecasts available to NWS and other users for a number of years. These forecasts have been verified, and should be a better source of data than the forecasts used in this study, even though they are currently for only 1,400, or so, points in the United States.[5] It is a goal of the NWS to introduce probabilistic information in the NDFD in order to quantify the uncertainty and support better weather-information-sensitive decisions [see SPN, p. 223 (b)].

Systematically using weather forecasts in enhancing the economy of the nation has an exceptionally bright future, but it will require a long-term view by specific decision-making activities, and it will require highly trained persons with the skills necessary to accomplish the work. It is unlikely that the composite skills are being adequately taught today in our colleges and universities.

[3] The closest SPN came (p. 229) to probability forecasting is in defining what is needed, " a detailed model of current and future forecast skill that specifies both the distribution of forecasts and the conditional probability of specific weather events, given specific forecasts . . ." Even here it is implied that the forecasts are categorical, and then conditional probabilities (really, relative frequencies) are derived.

[4] It is not clear how SPN computed a Brier skill score [the Brier score is used for verifying probability forecasts (Brier 1950)] from categorical forecasts. Yes, a categorical forecast of the occurrence of an event can be considered a 100% probability and the forecast of the nonoccurrence of the event can be considered a 0% probability, but computing a Brier score from a set of such forecasts is not a good practice. The stark number of a "Brier skill score of 0.403," as reported by SPN, especially without knowing what "standard" was used as the basis of "skill," is of no use.

[5] The MOS interpretative forecasts will soon be provided in gridded form, with phased implementation to occur over the next couple years. In addition, hourly updated MOS forecasts made every 3 h are available and will be improved and the frequency of production increased to hourly in a couple of years (see Glahn and Ghirardelli 2004).

ACKNOWLEDGMENTS. The views expressed in these comments are those of the author and do not necessarily represent the views of any element of the U.S. Government.

REFERENCES

AMS, 2002: Enhancing weather information with probability forecasts. *Bull. Amer. Meteor. Soc.*, **83,** 450–452.

Brier, G. W., 1950: Verification of forecasts expressed in terms of probability. *Mon. Wea. Rev.*, **78,** 1–3.

Glahn, H. R., and D. P. Ruth, 2003: The new digital forecast database of the National Weather Service. *Bull. Amer. Meteor. Soc.*, **84,** 195–201.

——, and J. E. Ghirardelli, 2004: The new and improved Localized Aviation MOS Program (LAMP) analysis and prediction system. Preprints, 17th *Conf. of Probability and Statistics*, Seattle, WA, Amer. Meteor. Soc., CD-ROM, J12.3.

Ruth, D. P., 2002: Interactive forecast preparation—The future has come. *Preprints, Interactive Symp. on the*

Advanced Weather Interactive Processing System (AWIPS), Orlando, FL, Amer. Meteor. Soc., 20–22.

Stewart, T. R., R. F. Pielke Jr., and R. Nath, 2004: Understanding user decision making and the value of improved precipitation forecasts: Lessons from a case study. *Bull. Amer. Meteor. Soc.*, **85,** 223–235.

Teisberg, T. J., R. F. Weiher, and A. Khotanzad, 2005: The value of National Weather Service forecasts in scheduling electricity generation. *Bull. Amer. Meteor. Soc.*, in press.