Preface

The topic of this book brings to mind an oft-quoted adage: everyone talks about the weather, but no one does anything about it. Despite this adage, the focus of this volume is not the weather itself, or weather forecasting per se, or even the various economic impacts of weather, but rather the way in which weather forecasts can be utilized to mitigate these impacts. The viewpoint adopted here is that information about the weather has value only insofar as it affects human behavior. Despite their inherent imperfections, weather forecasts have the potential to influence behavior. To draw an analogy, even quite small but real shifts in the odds can produce attractive returns when playing games of chance.

It is indeed true that "talk" about the weather abounds. Relatively large expenditures are devoted to both observational systems and research programs intended to enhance weather forecasting capability, as well as to operational activities related to the production and distribution of forecasts to a variety of users. Moreover, many of the substantial economic impacts of various weather events are well documented. Somewhat surprisingly, however, relatively little attention has been devoted to determining the economic benefits of existing weather forecasting systems or the incremental benefits of improvements in such systems.

This lack of attention may partly reflect the fact that assessing the economic value of weather forecasts is a challenging problem; among other things, it is an inherently multidisciplinary endeavor. Besides the field of meteorology, the disciplines include economics (a monetary value is attached to a publicly available good), psychology (human behavior under uncertainty influences forecast use and value), and statistics as well as closely related fields of management science and operations research (the formal assessment process utilizes the principles of decision theory). All these disciplines are represented in the backgrounds of the contributors to the present volume.

The scope of the book encompasses forecasts over a wide range of temporal scales. Included are relatively long-range (e.g., monthly or seasonal) predictions, sometimes referred to as "climate forecasts." This term should not be confused with "climate change,"

a topic that is not covered here, in part because operational predictions of climate change are not yet produced on a regular basis. In view of the new long-lead climate outlooks produced by the U.S. National Weather Service, as well as the recently reinvigorated U.S. Weather Research Program, whose ultimate goal is to improve short-range weather forecasts, a book on the economic value of forecasts appears especially timely. It could even be argued that weather forecasts themselves constitute a resource of general interest to researchers concerned with decision making under uncertainty. After all, few other forecasting systems come to mind in which the predictions are routinely made available to a broad spectrum of potential users and in which it is possible to evaluate forecasting performance in a relatively straightforward and timely manner.

Chapter 1, "Weather Prediction," by Joseph J. Tribbia, describes the scientific basis of modern weather forecasting, with emphasis on the so-called numerical (i.e., physical–dynamical) component of the forecasting process. The highly nonlinear mathematical equations governing the time evolution of the state of atmosphere are presented. Moreover, the worldwide network of meteorological observations is such that this state is only incompletely observed at any given time. These two factors combine to produce the phenomenon of chaos, thereby limiting the predictability of day-to-day weather conditions. Brief reference is also made to the numerical-statistical procedures currently used to produce routine forecasts of surface weather conditions.

Chapter 2, "Forecast Verification," by Allan H. Murphy, describes an approach to forecast evaluation that recognizes the fundamental role of the joint distribution of forecasts and observations in the verification process, and focuses on a suite of methods designed to measure the various attributes of forecast quality. In addition, the concept of "sufficiency" is introduced as a means of screening two or more competing weather forecasting systems. Only when the sufficiency relation can be shown to hold between pairs of systems can it be unambiguously stated that one system dominates the other, in terms of being of at least as much value to all users.

Chapter 3, "The Value of Weather Information," by Stanley R. Johnson and Matthew T. Holt, presents the fundamental tenets of Bayesian decision theory, in which the criterion of selecting the ac-

tion that maximizes expected utility is adopted. Being normative in nature, this theory prescribes how individual decision makers ought to employ imperfect weather forecasts. Determining the economic value of an imperfect weather forecasting system entails a comparison of the expected utility with and without the system. In the absence of any forecasts, it is often reasonable to assume that the decision maker has access to historical probabilities of weather events, termed "climatological information." Also treated are other economic issues, including methods of determining the value of a forecasting system to society as a whole.

Chapter 4, "Forecast Value: Prescriptive Decision Studies," by Daniel S. Wilks, reviews case studies that have adopted the normative/prescriptive approach introduced in Chapter 3. The vast majority of such studies involve agriculture; other areas of application include forestry and transportation. Some of the more realistic case studies have required the modeling of sequential decision-making problems, that is, dynamic situations in which the action taken and the event that occurs at the present stage of the problem are related to actions and events at subsequent stages. At least in limited circumstances, these studies establish both that present forecasting systems can have substantial value and that nonnegligible incremental benefits could be realized with hypothetical improvements in such systems.

Chapter 5, "Forecast Value: Descriptive Decision Studies," by Thomas R. Stewart, reviews how individual users of weather forecasts actually behave in response to those forecasts. Research on judgment and decision making conducted by cognitive psychologists reveals that individuals do not necessarily behave in a manner consistent with the principle of maximizing expected utility, on which the prescriptive approach is predicated. Descriptive studies of the use of weather forecasts range from simple surveys to detailed monitoring of decision makers in action. Unfortunately, descriptive studies to date have lacked sufficient detail to produce actual estimates of the value of weather forecasts. Ultimately, the descriptive information provided serves to complement and inform prescriptive case studies such as those covered in Chapter 4.

Chapter 6, "Forecast Value: Prototype Decision-Making Models," by Richard W. Katz and Allan H. Murphy, utilizes the sufficiency concept introduced in Chapter 2 as well as the normative methodology described in Chapter 3. Prototype decision-making

models are treated, ranging from the simplest case of a static decision-making problem — such as whether or not to carry an umbrella in response to uncertainty about the occurrence of rain — to more complex, dynamic problems that mimic some of the essential features of real-world case studies reviewed in Chapter 4. For such prototype models, analytical results are derived concerning how economic value increases as a function of the quality of the forecasting system. These results include the existence of a threshold in forecast quality below which economic value is zero and above which value increases as a convex function (i.e., its slope is also an increasing function) of quality.

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