Weather Forecasting

Weather forecasting is the process of predicting the future state of atmospheric conditions—typically precipitation, cloud cover, wind, and temperature—and is usually done for a specific time period and location. Weather forecasting can involve a variety of techniques, whose sophistication and accuracy have evolved greatly since humans first tried to predict the weather.

The earliest weather forecasts were based on local rules of thumb, natural clues (such as the behavior of animals), and folklore or proverbs. Compared to modern forecasting techniques, these early attempts at weather prediction lacked wide areas of coverage and extended timeframes, and they generally were not very accurate. Improvements in the scope and accuracy of weather forecasting relied on advances in technology and the science of meteorology, as well as the organization of large-scale (usually national) observation networks.

Although weather records and journals had been kept on the American continent since colonial times, it was not until the invention of the telegraph, in 1844, that the practical application of collected weather observations for forecasting became viable. In 1869, Cleveland Abbe, then director of the Cincinnati Observatory, began the first systematic, daily public weather forecasts in the United States, based on reports he received via telegraph from a small network of observers.

The establishment by an act of Congress in 1870 of a national weather service as part of the U.S. Army Signal Service (later a civilian agency known as the U.S. Weather Bureau and, eventually, the National Weather Service) led to the widespread collection, analysis, and dissemination of weather information. This made possible the synchronous observations across the country necessary for the accurate analysis and prediction of large-scale weather systems. In January 1871, Abbe began work supervising the forecasting efforts of the burgeoning weather service. His first published forecast for the service, or "probabilities," as it was known, was issued on February 19, 1871.

Despite the technological and bureaucratic developments that led to a national system of issuing forecasts, weather forecasting in the United State remained in many ways more of an art than a science through the first half of the twentieth century. Weather predictions were chiefly based on observation of the changes in barometric pressure and wind direction, and on comparisons of the current weather map with similar past situations—a process known as the analog method of forecasting. As a 1916 U.S. Weather Bureau publication, *Weather Forecasting in the United States,* stated in its preface, "The consensus of opinion seems to be that the only road to successful forecasting lies in the patient and consistent study of the daily weather maps."

Modern forecasting techniques grew out of the theoretical understandings of the atmosphere that were developed during the 1920s by a small group of scientists working at the Geophysical Institute in Bergen, Norway. Through the discovery of such principles as fronts and air masses, forecasters eventually gained a better understanding of the large-scale weather systems that produce much of the day-to-day weather experienced in the midlatitudes. It would take more than a decade before the techniques developed in Bergen were adopted by the U.S. Weather Bureau. In 1939, Francis Reichelderfer, who had recently been appointed chief of the Weather Bureau, hired meteorologist Carl-Gustaf Rossby—one of the scientists from Bergen—as his assistant chief. Under Reichelderfer and Rossby's direction, the Weather Bureau entered a new era, in which forecasts were based more on scientific principles and less on rules of thumb.

Official weather forecasts today are the result of numerical weather prediction, which uses powerful supercomputers to simulate future weather conditions by solving complex mathematical equations that govern the physics of the atmosphere. The first successful example of such computerized forecasting techniques was carried out in April 1950 by a small team at the Institute for Advanced Study at Princeton University and led by mathematician John von Neumann. Although crude by today's standards, the programs used to make the first numerical weather predictions were the forerunners to modern computer forecast models.

Numerical weather forecasting became operational with the creation of the Joint Numerical

Weather Prediction Unit (JNWPU), which began operation on July 1, 1954, in Suitland, Maryland. Staffed by members of the U.S. Weather Bureau, the U.S. Air Force, and the U.S. Navy, the JNWPU became the centralized location where numerical weather forecasting was performed. In 1958, the JNWPU merged with the National Weather Analysis Center (NAWAC) to become the National Meteorological Center (NMC). In 1995, the NMC was reorganized and became the National Centers for Environmental Prediction (NCEP), part of the National Weather Service. Forecasters today use the computer model output created by NCEP and other centers around the world as the basis of the forecasts they issue.

One limitation of computer forecast models is that they are highly dependent on the accuracy and number of data taken from observations of initial weather conditions (in other words, small variations in the initial weather observations can produce large changes in the computer model's output). For this reason, as well as the fact that the atmosphere behaves in a chaotic and nonlinear fashion, forecasts made using numerical weather prediction are accurate at the most for seven days.

To make more accurate predictions, forecasters often compare the results of several runs of the same model, using slightly different initial conditions for each run, or several different computer models that rely on the same initial conditions. Known as "ensemble forecasting," this method gives forecasters greater or lesser certainty about the model and forecast. If several runs of the same model or several different models produce a similar output, the meteorologist will have greater confidence in the forecast.

Another forecasting technique is persistence forecasting, which assumes that weather conditions for a given location will not change during the time period of the forecast. For example, a prediction that a location experiencing warm and sunny weather today will be warm and sunny tomorrow would be a persistence forecast. Forecasts are based on the statistical averages of weather conditions for a given location. This method works well for short time periods and for locations and times of the year that are not subject to frequent changes in weather.

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Sources

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