ON THE WEB

Real-Time Calibrated Probabilistic Forecasting Web Site

The Bayesian Model Averaging (BMA) Web site (http://bma.apl.washington.edu, hosted at the University of Washington (UW), is a real-time forecasting tool that explores new displays of probabilistic weather forecasts. Ensemble forecasts tend to be too close to each other to encompass the outcome often enough, especially for surface parameters. However, statistical postprocessing of ensembles can correct this, yielding calibrated probabilistic forecasts. The UW BMA Web page ("BMA page") provides a calibrated summary of the UW Mesoscale Ensemble (UWME), a multianalysis ensemble that consists of eight different runs of the MM5 model, each with initial conditions from a different weather center. The statistical post processing is done by BMA.

BMA produces probabilistic forecasts that are verifiably more accurate than those produced by the raw ensemble or by climatology, and the Web site provides straightforward visualizations of the BMA forecasts. Model data displayed on the BMA page is produced over a 12-km grid for the

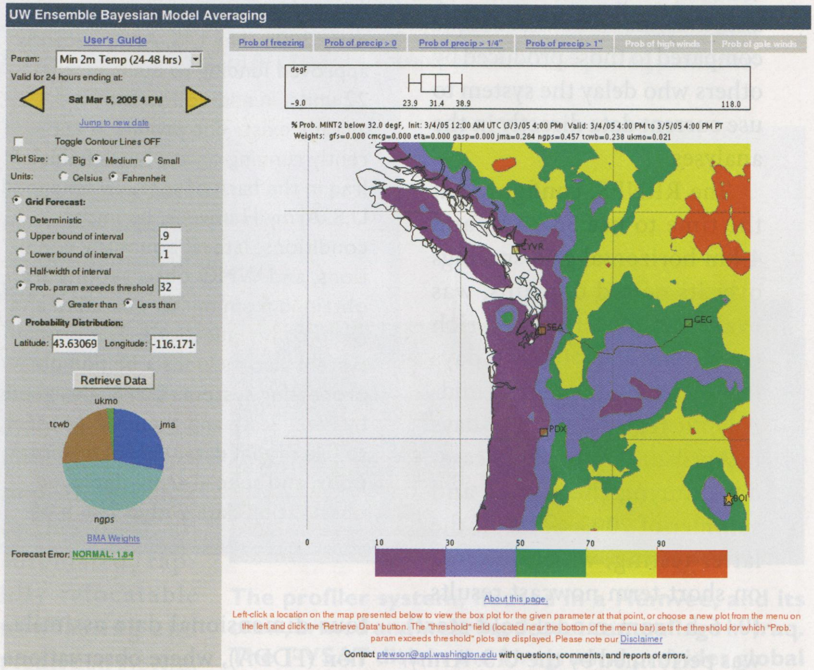

Fig. 1. The BMA page. Map shows the probability of surface temperature falling below freezing during the 24 hours before 4 p.m. LT on 5 March 2005. The box plot above the map shows the probability distribution of temperature at one location (downtown Seattle, WA). The pie chart shows the weights of the eight members of the forecast ensemble (some are zero).

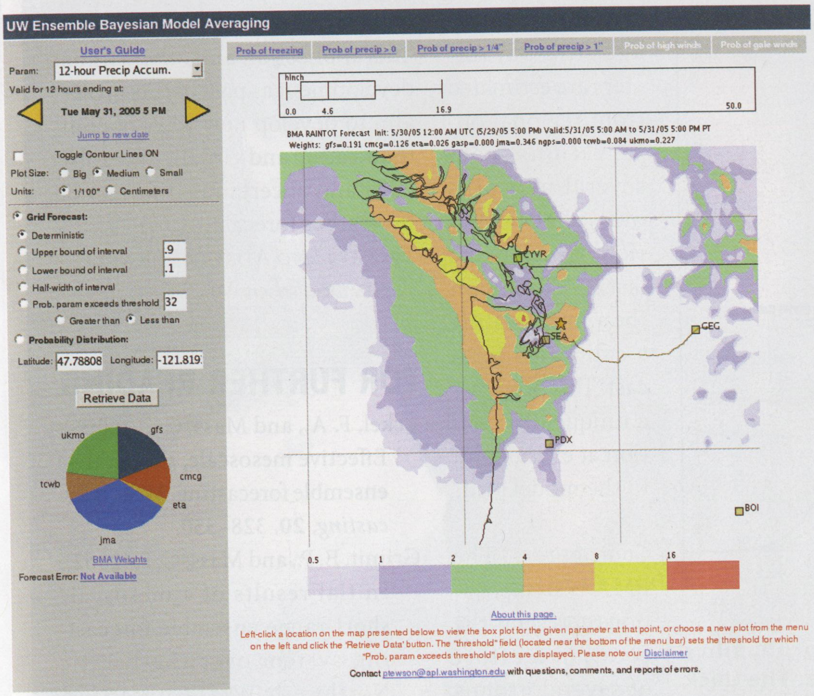

Fig. 2. BMA page showing upper-bound 90% forecast percentile of accumulated precipitation during the 12 hours before 5 P.M. LT on 31 May 2005.

Pacific Northwest; the techniques used here, however, should be applicable to any forecast ensemble. The forecasts aim to be calibrated, meaning that the reported probability of an event is equal to the proportion of the time that the event occurs. The displays are designed for users with specific questions, such as, "What is the chance it will freeze tonight?" or, "Will it rain, and if so, how much?" Verification information is provided as part of the system.

Features. Users arriving at the BMA site see a deterministic forecast of surface temperature, and can use the menu on the left-hand side to control the date, model parameter (surface temperature or precipitation), and forecast valid time on display. The user can also manipulate properties of the visualization with these controls, such as display of contour lines, plot size, and units. Available visualizations include both map- and point-based displays. Buttons across the top of the page link directly to maps of particular interest, circumventing the menu controls for quick access. These include probability of freezing surface temperature, as shown in Fig. 1, probability of measurable rain, probability of more than 0.25 inches of rain, and probability of more than 1 inch of rain (two others relating to high and dangerous winds will soon be available).

The user can select any one of five map plots from the left-hand menu: 1) the BMA forecast; 2) the upper bound of the predictive interval (90% of the area of the curve is below this point); 3) the lower bound of the predictive interval (90% of the curve's area is above this point); 4) the width of the predictive interval, which is an estimate of the uncertainty in the forecast; and 5) the probability of exceeding a threshold, such as surface temperature dropping below freezing. These values are derived from the distribution at each grid point and then displayed on the map. The user can control the levels of the upper and lower bound or threshold. An example of the upper bound for precipitation is shown in Fig. 2. These five quantities are shown for temperature at one location on the plot of the probability density function in Fig. 3.

Located directly above the map, the box plot gives information about a single map location, selected by clicking on the map display. In this visualization the box spans the middle half of the forecast distribution, with the middle vertical line indicating the median forecast. The "whiskers" extend from the box to the 10th and 90th forecast percentiles. The pie chart of model weights at the bottom of the left-hand menu shows the contribution of each of the core ensemble members to the forecast on display, followed by an indication of recent forecast error. Selecting "probability distribution" (instead of "grid forecast") brings up a forecast probability distribution function for the selected location instead of the map.

Algorithm. This Web application uses Bayesian model averaging to post-process an ensemble of forecasts, yielding a predictive probability distribution that is approximately calibrated. Ensembles tend to exhibit a relationship between model agreement and predictive ability known as the spread–skill relationship. However, ensemble predictions tend to be underdispersive, especially for surface parameters, and so are often un-

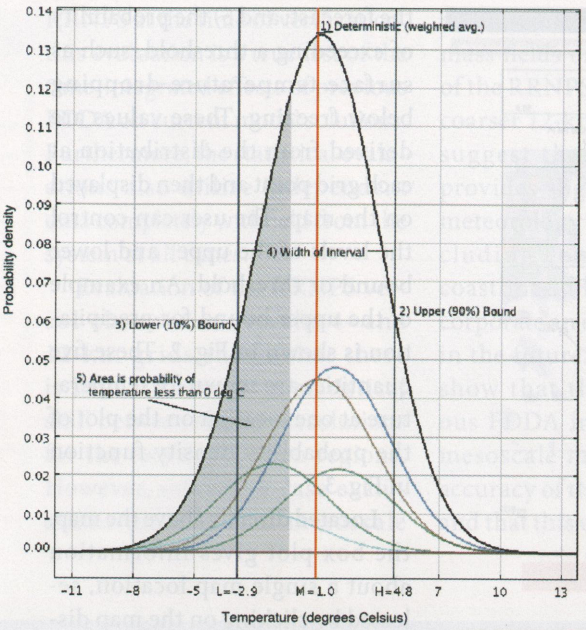

Fig. 3. A Bayesian model averaging probability density function (PDF) for temperature. The thick black line is the BMA PDF, and the thinner lines below it are the contributions from the individual ensemble members.

calibrated. BMA fits a probability distribution to each ensemble member and combines them using a weighted average; the parameters are estimated from regional observations from several networks over a recent period, typically the last 25 days, with the aim of creating a calibrated forecast. This produces a unique distribution at every point in the model grid.

Contributors. The BMA Web application represents the combined effort of several groups of scientists at the University of Washington, from atmospheric sciences, statistics, psychology, and the Applied Physics Laboratory, in an interdisciplinary project funded by the DOD MURI Program. This application and others under development as part of this project aim to develop new ways of communicating and visualizing probability and uncertainty information in weather forecasting.—Patrick Tewson and Adrian E. Raftery (University of Washington).

FOR FURTHER READING

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Grimit, E. P., and Mass, C. F. (2002): Initial results of a mesoscale short-range ensemble forecasting system over the Pacific Northwest. *Wea. Forecasting,* **17**, 192–205.

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HURRICANE HOUSING

In real estate, it's all about location. But when the location is an area of heavy hurricane activity, the effect on the market can be difficult to read. For example, the Florida Keys are seeing a mass exodus of residents, many of whom are no longer willing to put up with the burdens of the hurricane season. While most of the rest of Florida is experiencing a population boom, the population in the Keys dropped 2.16% from July 2004 to July 2005, and in the last five years the population dropped more than 4%. The McCoys, who recently moved away from the Keys, are typical of many of those who decided to get out. "We're gun-shy about going through another hurricane," says Dorothy McCoy. "We gave up on buying a home here in Key West." The irony is that there is plenty of incentive to leave even if a storm doesn't hit the area—multiple evacuations (six in the last two years) and the highest insurance premiums in the state. And when a storm does strike, the damage is impossible to avoid. When Hurricane Wilma hit last fall, it flooded about one-quarter of the homes in Key West with at least a foot of water.

Meanwhile, the opposite trend is occurring in New Orleans, where residents who evacuated during Hurricane Katrina are in many cases returning to destroyed homes, forcing them to find and buy new houses. The result has been a rare bright spot in the city's suffering economy: in the first quarter of 2006, sales of single-family homes were up 60% over the same period last year, with close to 4,000 residential units sold. Not surprisingly, most of the activity is in neighborhoods where Katrina caused little damage; areas that bore the brunt of the storm are still mostly desolate. (Source: Reuters)