Integrating Ensemble Information into Calibrated Probabilistic Weather Forecasts

Workshop on Information Integration
Position Paper

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Weather forecasting has historically been a deterministic enterprise, in which a single forecast is given without uncertainty information. The one exception has been the "probability of precipitation", but no uncertainty information is typically provided about other weather quantities such as temperature, humidity, wind, snow or amount of rain. Probability information is important for decision-makers who are affected by weather, in industries such as farming, tourism, transportation and the military, as well as ordinary people planning events and activities. In response to this need, a recent National Research Council report recommends a massive reorientation of national weather forecasting efforts toward probabilistic forecasting (National Research Council 2006).

Operationally, probabilistic weather prediction is based on ensemble methods (Gneiting and Raftery 2005). An ensemble forecast comprises multiple (typically between 5 and 100) runs of numerical weather prediction models, which differ in the initial conditions being used and/or the parameterized representation of the atmosphere, thereby addressing the major sources of forecast uncertainty.

Realizing the full potential of an ensemble forecast requires postprocessing of the model output, in that model biases, dispersion errors, and the differing spatial scales of model gridboxes and observations need to be addressed, and information from the various models be integrated. To this end, Raftery et al. (2005) developed a principled statistical method for postprocessing forecast ensembles based on Bayesian model averaging (BMA), which is both well calibrated and precise enough to be useful. The BMA predictive probability density function (PDF) of any quantity of interest is a weighted average of PDFs centered around the individual (possibly bias-corrected) forecasts, where the weights are equal to posterior probabilities of the models generating the forecasts, and reflect the models' skill over the training period.

Cognitive experiments have been run by psychologists Susan Joslyn and Earl Hunt showing how best to display uncertainty information, and a real-time website displaying probabilistic weather information for the public has been set up. This is for the Pacific Northwest, and based on a state-of-the-art regional short-range ensemble system (Eckel and Mass 2005), at lead times up to two and a half days, but also serves as a demonstration project that is being used as a model all over the world. An example screenshot is shown in Figure 1.

The Navy and the Air Force are collaborating on a new probabilistic weather forecasting system called the Joint Ensemble Forecast System (JEFS) that will make use of these methods. The Meteorological Service of Canada is implementing BMA and plans to issue public forecasts based on them within a year. And the national weather services of Germany, Spain and the Netherlands are implementing these methods with the intention of evaluating them for routine use.

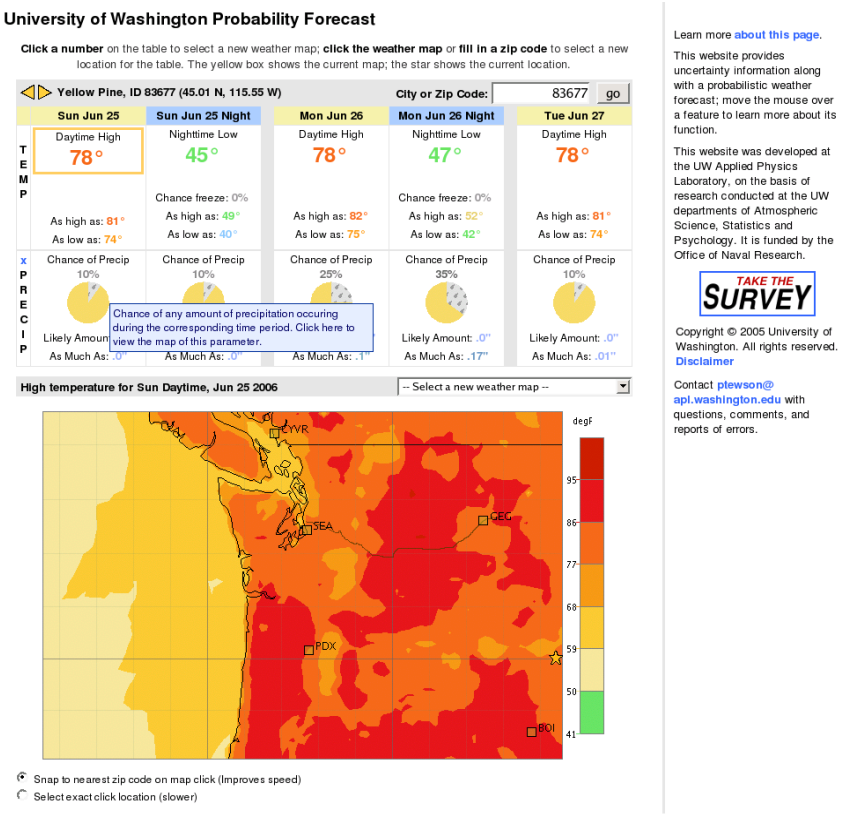

Figure 1: An example screenshot from the Probcast system (www.probcast.washington.edu)

Much remains to be done. We have developed operational methods for integrating ensemble information for temperature and precipitation, and need to do so for wind, snow, humidity, visibility, turbulence, cloud cover and other weather quantities. We also need to develop methods for quantities defined over a spatial region rather than at a single place, such as the probability that there will be freezing at some point on a mountain highway. Additional, highly interdisciplinary effort is required in the communication, visualization and evaluation of probablistic weather forecasts. Applications to severe storm prediction and climate forecasts at seasonal to interannual and decadal time scales provide new challenges, in view of a dearth of training data, and remain to be addressed.

References

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