Verification of precipitation forecasts

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Abstract

Of all the weather elements that are forecast on a regular basis, the one of greatest interest to the public is rainfall. Increasingly, there is demand not only for forecasts of occurence of rain, but also for estimates of expected rain amounts. Guidance for producing quantitative precipitation forecasts (QPFs) beyond the immediate next few hours generally comes from output of numerical weather prediction (NWP) models. Forecasters often have access to QPFs from several global and regional models and use their experience of these models, along with evaluation of the models' performance during the most recent day or two, to judge which model(s) will be most likely to produce a good QPF.

The skill of NWP models in predicting rainfall has improved over the course of time (Olsen et al., 1995). Nevertheless, QPFs are still prone to large errors. Factors contributing to QPF errors include incorrect initial conditions, inaccurate prediction of atmospheric flow (dynamics), inappropriate rainfall parameterisation, and inadequate representation of topography. The resulting QPF errors may take many forms. They may be in the position of the rain system, the shape and size of the rain pattern, and the magnitude or intensity of the rain, and most QPFs contain some of each type of error. If the errors are systematic then it may be possible to determine their causes.

Verification of model QPFs is useful both for helping forecatsers understand the strengths and weaknesses of the QPFs and for pointing out to modellers where improvements need to be made in the model physics. Most routine verification is done on a national scale and is based on a number of objective scores such as Equitable Threat Score, Hansssen and Kuipers score, bias etc. This type of verification provides a useful picture of the overall performance. However for large countries like the USA or Australia it can also make the performance for individual weather events difficult to evaluate when multiple events are present. For example, good values of certain verification measures could be achieved in a situation where rainfall was grossly overpredicted in one part of the country but grossly underpredicted in another part of the country. Thus it is desirable to verify rainfall at the scale of the rainfall events themselves. An advantage of verifying individual events is that systematic errors are made more apparent.

Knowledge of the spatial distribution of rainfall in real time or near real time is necessary for flood warnings, water management, initialisation and verification of NWP models and other applications. Historically rainfall distribution has been estimated using measurements made from networks of rain gauges. The point rainfall observations are generally averaged within subdomains, or analysed into a grid using objective analysis procedures such as kriging, successive corrections, spline interpolation or optimal interpolation. The resulting analyses give an accurate picture of rainfall distribution in regions where the density of rain gauges is great relative to the scale of the rainfall processes themselves. Accuracy is also improved with increased temporal and spatial averaging. In regions where rain gauge density is low, the gauge analysis will be of lower accuracy. Rain cells may occur between gauges and thus go undetected. Conversly, an isolated rain measurement may be

incorrectly taken to represent the mean rainfall over the surrounding region. One way to provide additional rainfall data in real time is to include remote sensed rainfall estimates from radar and satellite. Radar is generally considered to provide more accurate instantaneous rainfall estimates than are available from satellite. Unfortunately, most radars are strategically located so as to observe significant weather near airports and metropolitan centres, and these regions are usually well sampled by rain gauge networks. This leaves satellite data as the next best source of rainfall estimates in gauge-sparse regions, although there are considerable problems in the accuracy of this source of data.

In recognition of the importance of precipitation forecasts, the CAS/JSC Working Group on Numerical Experimentation (WGNE) has an ongoing project on verification and comparison of precipitation forecasts from operational global models. Several centres have been pursuing activities in this area. At DWD precipitation from CMC, DWD, ECMWF, Meteo-France, NCEP and UKMO have now been assessed over Germany for over three years. At NCEP, quantitative precipitation forecasts over the USA from CMC (global and regional models), DWD, ECMWF and NCEP (medium-range forecast, Eta, and nested grid models) are being examined. At BMRC verification of QPF over Australia from Australian Bureau of Meteorology (global and regional models), DWD, ECMWF, JMA, NCEP and UKMO are being carried out. In addition to quantitative scores, a start has been made at looking at case studies for some heavy rainfall events and work has started on verifying ensemble forecasts based on ensembles formed from different models available in real-time.

This paper will concentrate mainly on verification of QPFs being carried out at BMRC. Some details on the operational rainfall analysis together with problems in analysing rainfall data will be presented. This will be followed by a brief description of various objective scores being used and presentation of results from the inter-comparison of forecasts from various operational models. Some examples of model performance for heavy rainfall events will be shown. Finally an indication will be given of future directions such as attempts to include satellite data to augment the data base, extension of verification methods to synoptic types and weather systems, and ensemble prediction of precipitation.