17.3 IDENTIFYING HEAVY RAIN EVENTS ALONG NEW ZEALAND'S WEST COAST USING THE NCEP ENSEMBLE PREDICTION SYSTEM

Tony Simmers
Meteorological Service of New Zealand Ltd

1. INTRODUCTION

This study investigates the ability of NCEP's ensemble prediction system (EPS) to identify heavy rain events along the South Island of New Zealand's West Coast. Rainfall along the West Coast is strongly orographically forced, and accumulations of more than 100 mm/day, the criteria required for a heavy rain warning, are not uncommon.

At short lead times of 1-2 days, MetService forecasters do well at identifying West Coast heavy rain events (probability of detection (POD) 91%, false alarm ratio (FAR) 19%, and critical success index (CSI) 0.75). Their forecasts are largely based on output from a number of deterministic NWP models.

Mullen and Buizza (2001) looked at the European Centre for Medium Range Forecasting's (ECMWF's) ensemble system and found there was skill in detecting amounts over 1 mm/day to beyond a week, but that at a threshold of 50 mm/day forecasts were not significantly skilful even at day 1.

However, the extent to which any model can forecast large amounts is in part a function of the resolution of the model. Olsson et al. (1999) demonstrated the dependence on averaging area of precipitation maxima in a study of 11 years data from 161 rainfall stations in southern Sweden (see Fig 1).

The mesoscale nature typical of many high rainfall producing systems may not be resolved by a coarse resolution model, particularly when heavy rainfall is driven by convective events. However the link between forecast and observed rainfall is likely to be stronger where the driving mechanism is enhancement of synoptic scale rainfall by orography, as is the case along the South Island West Coast (Palmer et al., 2001). Because of this, the West Coast was considered the most likely region of NZ to find a heavy rain signal within the NCEP EPS forecasts.

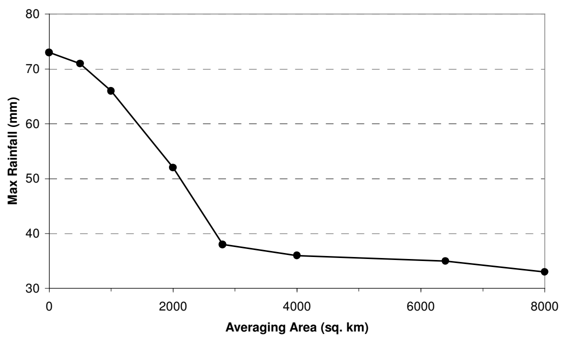

Fig 1. Extreme rainfall as a function of spatial averaging (Olsson et al., 1999). Mean rainfall did not show the change evident at scales of around 2800 km^2.

2. DATA AND ANALYSIS

Eleven months of probability forecasts of 24 hour rainfall accumulations from NCEP's ensemble system were compared with observations used to verify MetService's Severe Weather Warnings (SWWs). The EPS data had been regridded to a resolution of 2.5 degrees at NCEP, with data only from the single grid point closest to Hokitika on the West Coast (42.5S, 170.0E) being used. The rainfall probabilities were simply calculated as the number of members forecasting more than each threshold from a combination of the 00Z and previous 12Z EPS runs.

A preliminary inspection of the data at the Hokitika grid point showed the data set exhibited two useful properties. Firstly, there was no apparent dependence with lead time on the amount of rainfall present. For example, the number of occasions that 5 mm/day or greater was forecast was approximately constant at 27% from day 1 through to day 14. The second feature of the data was that for events that were identifiable early, there was little drift in the expected time of arrival of the event, with only a slight tendency to forecast events later than they actually occurred.

Signal detection theory (e.g., Mason, 1982 cited in Buizza et al., 1999) was used to determine whether a recognisable signal corresponding to the occurrence of 100 mm/day could be extracted from the noisy probability forecasts.

The approach extends the familiar concept of a contingency table for a single deterministic forecast to encompass a set of contingency tables. In effect, each probability category (0%, 10%, 20%…) is treated as a deterministic 'yes' forecast. Typically the hit and false alarm rates for each category are plotted to obtain the relative operating characteristic (ROC) curve. The area to the right of the curve can be taken as a measure of how useful a forecast is. Areas of greater than 0.8 are usually taken to represent 'good' forecast systems, while the limit of a useful system is usually taken to be 0.7[1].

3. RESULTS

Forecast probabilities of precipitation (PoP) exceeding 5, 10, 13 and 25 mm in a day were extracted for the EPS grid point closest to Hokitika. These (noisy) probabilities were set against the yes/no signal of events with more than 100 mm/day

[1] See Wilson (2000) for a discussion of some of the finer points relating to the calculation of area under a ROC curve. In this study SYSTAT was used to perform the ROC analysis. No assumptions were made about the underlying distributions, and the area under the ROC curve was calculated using straight lines to join the points.

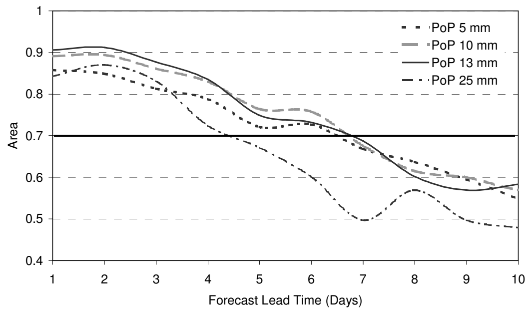

Fig 2. Area under the ROC curves for the detection of 100mm/day along the South Island West Coast for a range of PoPs from the NCEP EPS.

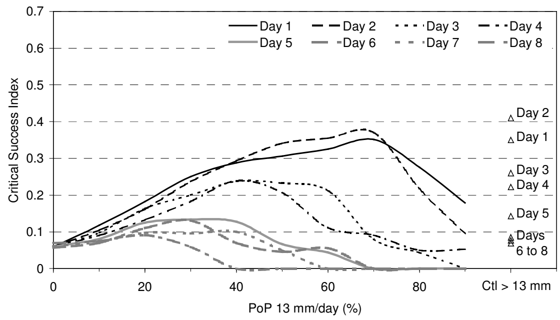

Fig 3. CSI scores for West Coast heavy rain based on PoP 13 mm/day forecasts from the NCEP EPS. Inset on the right are the CSI scores from the EPS control.

as determined from the SWW verifications. The area under the ROC curve was calculated for the probabilities of each precipitation threshold for periods out to 14 days, which is plotted as Fig 2.

The strongest signal at short lead times is shown by the PoP 13 mm trace. This is as might be expected, since the climatological frequency of an individual forecast exceeding this threshold during the period (10%), was closest to the observed frequency of SWW events (7%). The signal could be considered 'good' as far out as day 4, dropping below the level of usefulness at day 7.

Two trials using combinations of variables were tried to see if they aided performance. In the first, lagged forecasts from three runs were combined in order to evaluate the usefulness of looking at previous runs when making a forecast. The second trial looked at combining more than one rainfall threshold from the same model run. In each case the results were worse than from the 'regular' ensemble.

Having determined that there was a useful signal from the ensemble data the next step was to briefly investigate the nature of that relationship.

The hit and false alarm rates used to construct the ROC curves for detection of SWW events by the PoP 13 mm forecasts were used to calculate critical success indices for each probability band. The results (Fig 3) show that in the early part of the period a PoP 13 mm of about 70% attained the highest CSI at around 0.37.

For comparison, the CSI score for the operational SWWs for the period, which typically had a lead time of 24-48 hours, was 0.75. The reason behind the clearly greater value of the human forecasts is likely to be the forecaster's ability to recognise when and how much convection will occur.

Inset on the right hand side of Fig 3 are the CSI scores from the control run forecasts for amounts exceeding 13 mm/day. These scores are equal or even slightly better than those of the combined ensemble. This result may initially suggest there is no added value in using the full EPS. This is true if the only result sought is a yes/no forecast. However, there is additional value in the *range* of values that a probabilistic forecast system can return. There was not time to conduct such an analysis for this study.

4. CONCLUSIONS

The NCEP EPS forecasts of heavy rainfall for the South Island West Coast are stable in the sense that average rainfall amounts from the underlying model are approximately constant at all forecast periods, and there is little apparent drift in the arrival time of events.

The strongest signal for rainfall events of over 100 mm/day is in the PoP 13 mm field. Beyond day 7 there is no useful signal.

Human forecasters show a lot more skill than the NCEP EPS for yes/no forecasts of heavy rain events at lead times of 1-2 days. This skill is thought to be based on their recognition of events where convection plays an important role.

5. REFERENCES

Buizza, R., A Hollingsworth, F. Lalaurette, and A. Ghelli, 1999: Probabilistic predictions of precipitation using the ECMWF EPS. *Wea. Forecasting*, **14**, 168-189.

Mullen, S. L., and R. Buizza, 2001: Quantitative precipitation forecasts over the United States by the ECMWF EPS. *Mon. Wea. Rev.*, **129**, 638-663.

Olsson, J., V., P. Singh and K. Jinno, 1999: Effect of spatial averaging on temporal statistical and scaling properties of rainfall. *J. Geophys. Res.*, **104**, 119-126.

Palmer, T., F. Lalaurette, J. Barkmeijer, A. Beljaars, R. Buizza, C. Jacob, T. Paccagnella, D. Richardson, S. Tibaldi, and E Zsoter, 2001: Report on the operational use of EPS to forecast severe weather and extreme events. CBS Meeting of Expert Team on EPS, Tokyo Japan, 15-19 October 2001 (CBS/ET/EPS/Doc.3, Item 3).

Toth, Z. and E. Kalnay, 1997: Ensemble forecasting at NCEP and the breeding method. *Mon. Wea. Rev.,* **125**, 3297-3319.

Wilson, L. J., 2000: Comments on "Probabilistic predictions of precipitation using the ECMWF EPS". *Wea. Forecasting*, **15**, 361-364.