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A short-range ensemble prediction system for southern Africa

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INTRODUCTION

This research has been conducted in order to develop a short-range ensemble numerical weather prediction system over southern Africa using the Conformal-Cubic Atmospheric Model (CCAM). An ensemble prediction system (EPS) combines several individual weather model setups into an average forecast system where each member contributes to the final weather forecast (Atger, 1999). Four different EPSs were configured using lagged-average forecasting techniques (Kalnay, 2003) and two different cloud parameterisation schemes (McGregor, 2003; Rotstayn, 1997). Rainfall forecasts were simulated for seven days for the summer months of January and February, 2009 and 2010, for high (15 km) and low (50 km) resolution over the southern African domain. Statistical analyses were performed on the forecasts so as to determine which EPS was the most skilful at simulating rainfall. Measurements that were used to determine the skill of the EPSs were: reliability diagrams; relative operating characteristics; the Brier skill score; and the root mean square error. These scores will allow for a conclusion to be drawn as to which system performs the best, and what future research should be pursued.

ANALYSIS AND RESULTS

The Root Mean Square Error was calculated first. This is an analysis of deterministic forecasts – forecasts that are categorical and exact, with no statistical component. This indicates the ability of the model to predict exact values of precipitation events compared to observed data. From the results it can be seen that for a four-day lead time, the model performs well at high resolution, whereas at low resolution, the drop-off in accuracy is immediate after day one. The different ensemble configurations had very little or no effect on the accuracy of the model at either low or high resolution.

A probabilistic analysis was conducted, which is a stochastic analysis of the model to predict all future possible outcomes and whether these correspond with observed data. The Relative Operating Characteristic (ROC) was calculated and plotted for each ensemble at high and low resolution, indicating whether the model was able to discriminate between events and non-events. A perfect ROC score would have an area under the curve equal to 1, meaning that the model consistently predicted events and non-events corresponding to observations. The high resolution far outperformed the low resolution model, showing a much greater ability to discriminate the forecasts at all thresholds. For the forecasts made at high resolution, the largest ensemble was more skilful than the smallest ensemble. This result indicates that prediction systems with a large number of ensemble members are the most skilful. However, for the low resolution forecasts the size of the ensemble systems made little difference.

Reliability of the model was analysed using Reliability Diagrams that show how well the forecasts made with each prediction system correspond to the observations. These diagrams show that for February, the high resolution forecasts are more reliable than the low resolution forecasts. In January both resolutions performed well, with little difference between the four ensemble systems. This once again shows that high resolution systems perform better than low resolution. However, in both cases, the size of the ensemble does not have a great effect on the reliability of the forecasts.

Lastly, the skill of the different model configurations was calculated. The Brier Skill Score measures the skill of the model in terms of how accurate the probability forecasts are. For most cases the drop-off in skill with lead time is evident, which is expected since predicting conditions with a longer lead time is more difficult than for short lead times. It can be seen that there is very little difference between the high and low resolution forecasts. There is an immediate drop-off in skill after day one, with some cases having a sudden increase in skill after day four. These results show that the skill of the forecasts is similar for both the high and low resolution cases, and that ensemble size does not make a significant impact on the skill of the model.

Using the Conformal-Cubic Atmospheric Model (CCAM), the project shows that the largest ensemble at high resolution is the best system to predict rainfall over southern Africa. Future research will explore whether the CCAM at higher resolution and with an ensemble system larger than eight members could produce even better rainfall forecasts.

CONCLUSION

The results show that the higher resolution forecasts are consistently more skilful than the forecasts made at low resolution. For most cases, the largest ensemble is seen to perform better than smaller ensemble systems. These findings conclude that the largest ensemble at high resolution is the best system to predict rainfall over southern Africa using the CCAM. Future research should explore whether the CCAM at higher resolution and with an ensemble system larger than eight members could produce even better rainfall forecasts over southern Africa.

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