Storm forecasts in a convective-scale ensemble system at the Met Office

G. Leoncini *, N. Roberts
Joint Centre for Mesoscale Meteorology, Met Office

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1 Introduction

The UK Met Office is developing a convective-scale ensemble targeted at intense convective events with 12-36 hr lead time. The choice of type of events and lead time originates into floods, which are often caused by intense convection and many synoptic driven intense rain events have embedded convection (Bennett et al., 2006).

Convective storms over the United Kingdom are often characterised by low values of CAPE, low values of CIN and high moisture content. They are also commonly linked to upper level features, such as, for example, tropopause folds, PV filaments or anomalies. The sea-land contrast and the topography provide plenty of possible triggers which include convergence lines and sea breezes. An example of convective flood is the Boscastle Flood of August 16th 2008. The synoptic pattern provided conditions favourable to convection, while the sea-land contrast of the surface fluxes and the turning of the wind over land provided the convergence that triggered several localised storms that were advected over the same small river catchment.

2 Importance of the larger scale

Two main uncertainties affect forecasts of such convective storms: firstly, the uncertainty in the forecasts of synoptic systems and their mesoscale features. Secondly the uncertainties at the cloud scale. To highlight the importance of the larger scale features, the top row of Fig. 1 shows the wetbulb potential temperature at 950 hPa for three selected members of a second storm (the Ottery flood of September 6 2008). The position of the warm tongue and of the colder is such that the 6 hr total accumulations maxima (bottom row) fall in different places from where the actual flood happened, marked by the red "X".

* *Corresponding author address:* Giovanni Leoncini, JCMM, Met Office, Meteorology Building, University of Reading, PO Box 243 Earley Gate Reading, Berkshire, RG6 6BB, United Kingdom
E-mail: giovanni.leoncini@metoffice.gov.uk

3 A downscale ensemble

Two recent studies, Clark et al. (2010) and Gebhardt et al. (2010), have analised the effect on ensemble spread of different lateral boundary conditions (LBC's) and of different physics options for convective-scale ensembles. The former found that the LBC and physics ensemble have higher mean growth rates than physics only. The latter, instead shows that they take over after only 6 hr, over a much smaller domain. Since our domain size (roughly 1000 km), is closer the Gebhardt et al. (2010) study and because our lead time extends to 36 hr, we chose to generate the high-resolution forecast (1.5 km grid spacing) downscaling the larger scale ensemble members. This results in a set up which is simpler and easier to maintain, since no additional parameterisation change is required.

The model used for the operational forecasts is the Unified Model (Davies et al., 2005), which has semi-lagrangian dynamical core. For the high resolution forecast is ran on a variable resolution domain whose inner part has constant grid spacing of 1.5 km and covers the whole British Isles. Such model is currently ran quasi operationally, but because of its high costs the next supercomputer will accommodate up to 5 members. It is, therefore, necessary to select a small number of members out of the 24 available from the regional ensemble.

In the attempt of reducing the cost a sensitivity study with a inner grid spacing of 2.2 km has been carried out. However, the results were unsatisfactory since the lower resolution simulations developed a larger number storms, unrealistically strong, over the sea.

4 How to differentiate high resolution members?

The same clustering algorithm used for the regional scale ensemble was applied to a case study, to select 6 members representative of 6 clusters. Then both spread and cluster mean deviation from the ensemble mean were computed for a random choice of members with the ETKF cycle that generated the larger scale LBC and several random choices of members. The random selections in some instances showed better variances than the representative members. Therefore a novel way of differentiating members is introduced here.

The core idea is to develop a measure of distance such that members of the regional ensemble that are very far from each other are also very far when downscaled. Here we test two such measures, normally used for verification. The first (L_{match}) is obtained from the Fractional Skill Score of Roberts and Lean (2008) and is representative of the scale at which two simulations have the same mean of a particular field, above a specified threshold. The second is the L index of the SAL method of Wernli et al. (2008) and is indicative of the distance between the values above a threshold between two model runs. To avoid bias issues we used only percentiles as thresholds.

The rankings of the L_{match} for a specific case study are shown in Fig. 2. The x axis indicates the rankings of the 24 regional ensemble members for PV at 900 mb. The y axis instead, shows the rank, based on L_{match}, for the 3 hr accumulations of the convective scale members. The control run is used as a reference . At least for this specific case and time (24 hr into the forecast) the first and last 7 members are same in the two ensemble. The rank correlation coefficient is 0.79.

The SAL has been computed for the same case study and the L index gave the best correlations for the 90th percentile threshold of potential temperature at PV=2 for the regional ensemble and 6 hour accumulations for the convective scale. Figure 3 shows the scatter plot of the two L indexes 12 hours into the forecast. The control is used as reference here as well. The lower rank correlation (0.47) reflects the larger scatter of the members, but a similar relation can be established, as the correlation coefficient is 0.62.

5 Conclusions & Future Work

These results suggest that members of the regional ensemble can be used to determine which member to downscale in order to have a larger differences at the convective scale. However, these results are obtained from one case study alone and several more need to be analysed to have meaningful statistics. Furthermore, other variables at different heights will also be explored. Finally, so far we have investigate the differentiation from the control, while a more comprehensive picture of the ensemble can be drawn if the difference between members are also analysed.

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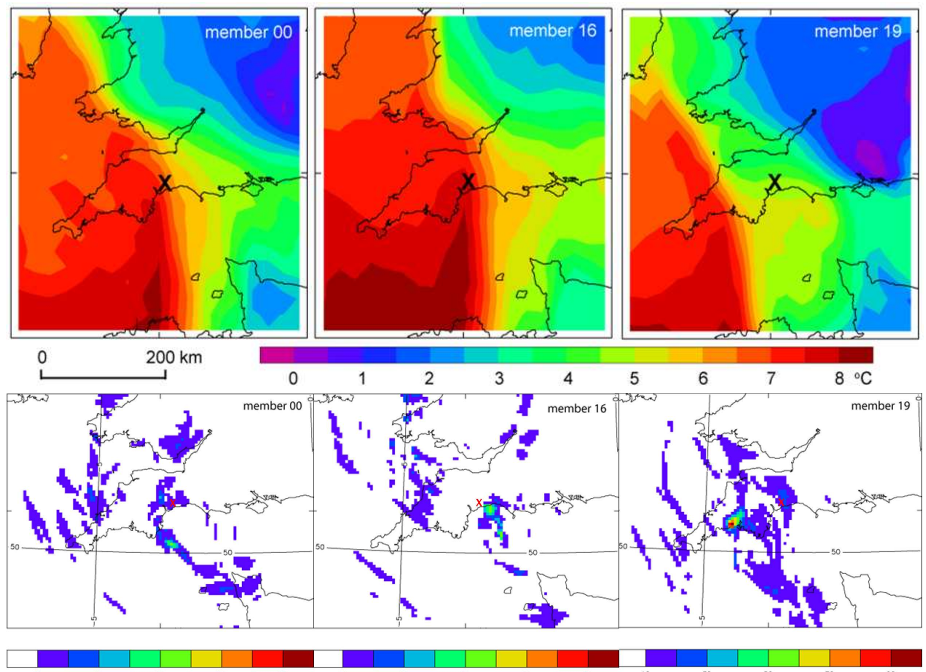

Figure 1: The top row panels show the θ_w at 950 hPa for members 00 (control), 16 and 19 from left to right, for the Ottery storm. The bottom row shows the highest 6 hour accumulations for the same members.

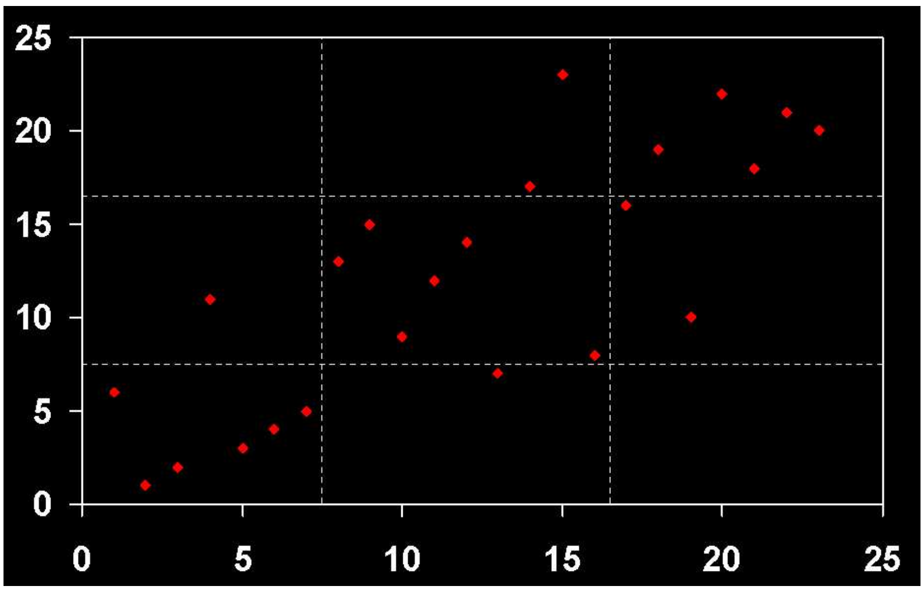

Figure 2: Ranks of L_{match} for the regional ensemble (x axis) versus the ranks of the same parameter for the convective ensemble (y axis). See text for details.

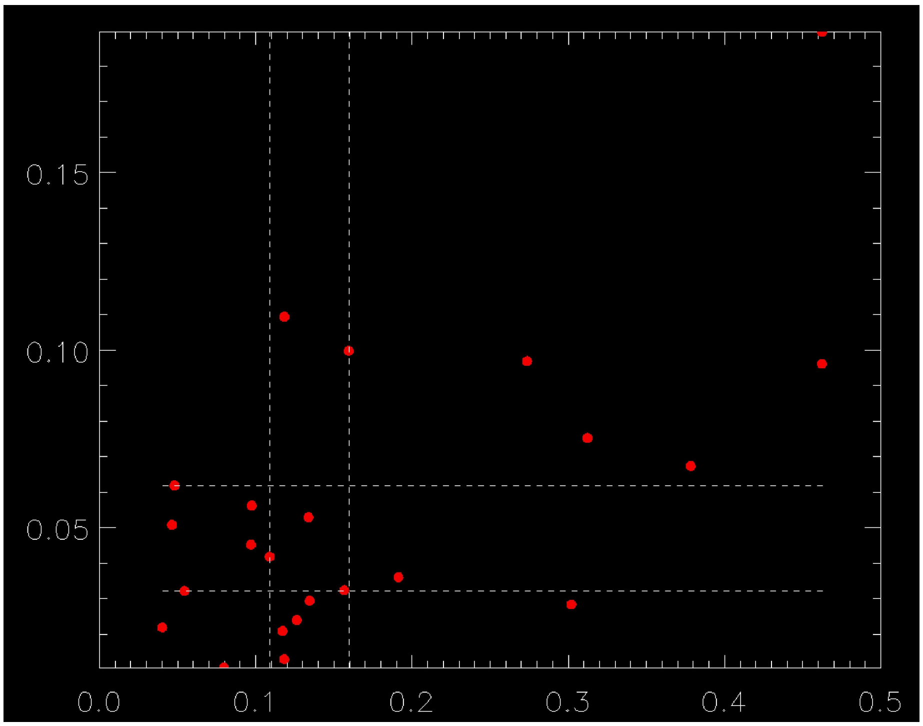

Figure 3: Scatter plot of the L index for the regional ensemble (x axis) versus L of the convective ensemble. See text for details.