Summer convective storms: spatial analysis of numerical weather forecasts

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1. Introduction

In the earth's atmosphere there is a finite range of predictability (Lorenz 1969). To sample the uncertainty in numerical weather prediction a group of forecasts , known as an ensemble, is run with each forecast starting from different initial conditions. This is particularly important for high resolution forecasts where errors grow faster (Hohenegger and Schär 2007). There are important implications for modelling convective storms:

- We need ensembles as part of a probabilistic framework.
- Models should be evaluated at scales that are skilful. This may not be at the grid scale.

We present a methodology for characterising the scales at which convective ensembles are believable and demonstrate how these scales can be used to investigate physical relationships in the forecast.

2. Cases Studies

Four days with summer convection are considered in the period July-August 2013. The forcing and spatial predictability of the convection varies throughout these cases.

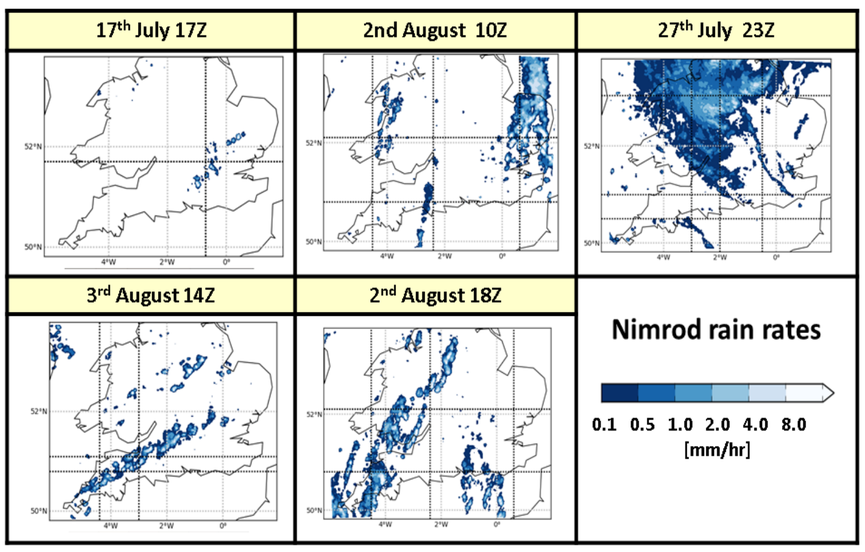

Figure 1: Nimrod radar derived instantaneous rain rates for the cases considered. Cases with deep (top) and shallow (bottom) convection are shown.

- 17th July: heavy isolated thunderstorms.
- 2rd August: deep convection moving in from France combined with convergence over the Southwest peninsula.
- 3rd August: peninsula convergence.
- 27th July: Mesoscale convective system.

3. Ensemble mean

The ensemble mean is not physically representative of the ensemble. An example for the 17th July case is shown in Figure 2. For this case

- 7/12 ensemble members capture the line of thunderstorms.
- There are differences in the location of the storms and orientation of the line.
- The ensemble mean suggests a wide scattering of light showers.

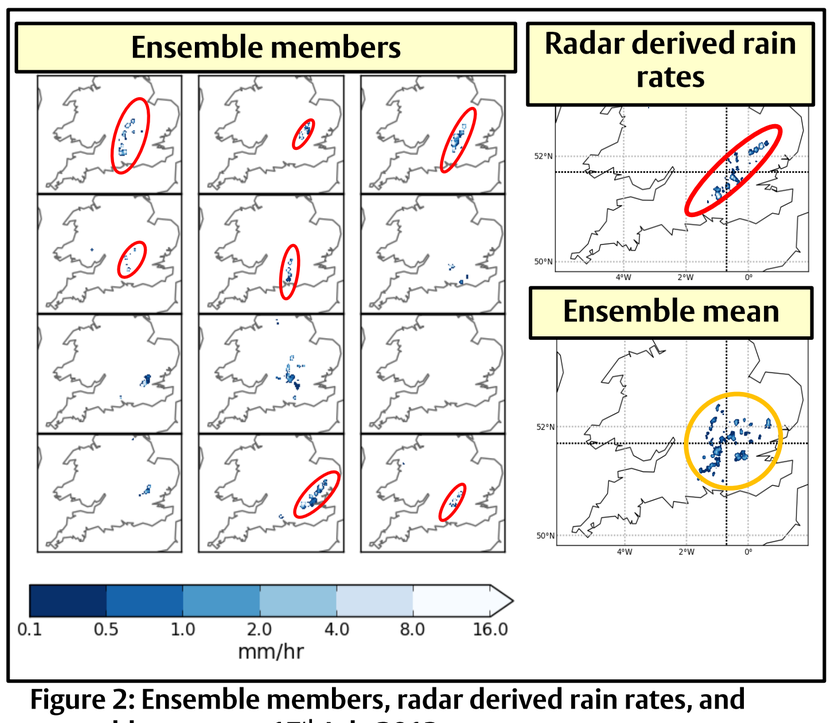

Figure 2: Ensemble members, radar derived rain rates, and ensemble mean on 17th July 2013.

4. Spatial analysis

To investigate the spatial predictability of precipitation twelve forecasts from the Met Office UK 2.2km resolution ensemble are compared. Consider the schematic in Figure 3: compared at central point only these forecasts are different but when considering the total over the 9 grid point area they are suitably similar. The area over which the forecasts are deemed suitably at a given point is defined as the minimum area over which Equation 1 is met.

$$\frac{(A_{i,j} - B_{i,j})^2}{{A_{i,j}}^2 + {B_{i,j}}^2} < 0.5\left(1 + \frac{L}{L_{max}}\right)$$

Equation 1: Criterion for forecasts to be suitably similar. $A_{i,j}, B_{i,j}$ are the total of values inside neighbourhood for fields A and B, L is the total neighbourhood width and L_{max} is the maximum neighbourhood width considered.

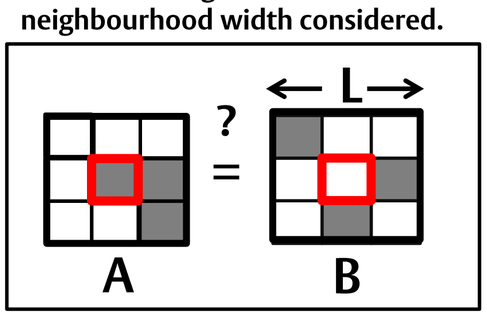

Figure 3: Schematic representing two forecasts with grid points of rain (grey) and no rain (white)

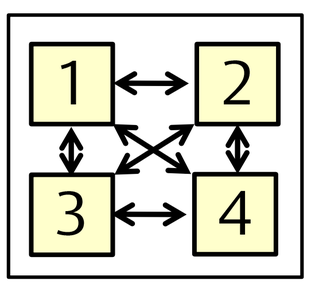

Figure 4: Schematic showing the possible comparison of 4 forecasts

All ensemble member pairs are compared separately as shown schematically in Figure 4 for an ensemble of 4 members. The mean spatial scale calculated from all these pairs gives a measure of the total spatial agreement from the ensemble. Results for the mean spatial agreement from the ensemble rain rates, calculated at each grid point, are shown in Figure 5.

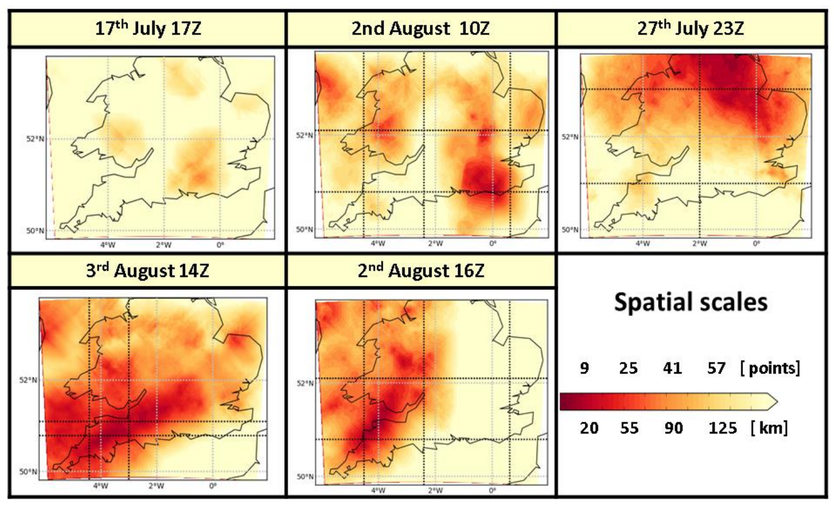

Figure 5: Mean spatial agreement for the six cases calculated using Equation 1.

- Spatial predictability varies across the domain. For example, on the 2nd August at 18Z rain to the west of the domain is more predictable than that to the east.
- Peninsula convergence cases are highly spatially predictable according to the ensemble with scales less than 10km.
- Method provides a useful overview of information from the ensemble .

5. Summary

Different ensemble forecasts of rain rates have been investigated for summer convective cases.

1. Results show that the ensemble mean is not physically representative of individual member behaviour.
2. Spatial methods applied to the ensemble do give physically meaningful information which is of use for forecasting and ensemble interpretation.

Future work will apply these techniques to a large number of cases to give an overview of the spatial predictability. Additionally, we are investigating other ensemble evaluation methods including multivariate correlations.

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References

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