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Predicting Flash Floods using Current-Generation Global Models

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Flash floods are devastating and often fatal, and are generally attributable to extreme rainfall over a small area. Our entry for the Harry Otten prize centres on using readily available global ensemble output to forewarn, for every location in the world.

We challenge the conventional wisdom that large scale models/ensembles, in which convection is parametrised, cannot predict flash floods. The standard approach, which instead involves using very expensive convection-resolving models /ensembles (resolution of order 2km), has several difficulties associated. Firstly, published studies show that obtaining useful skill for precipitation requires upscaling to scales of order 40-70km, which is larger even than the gridboxes of current-generation global ensembles. Secondly, it is only financially viable to create and run high resolution ensembles for a very small fraction of the earth (to configure for all land surfaces would cost 10,000 to 100,000 times more than our approach!). And thirdly, high resolution ensembles generally only extend about 2 days into the future, whereas our idea can in principal be applied at all leads, from short range out to climate change timescales. So whilst it is clearly important to continue developing high resolution models, we will show how global models offer an extraordinarily cost-effective alternative for this particular prediction problem.

At the heart of our idea is the notion that simple physically-relevant model-based (global model) parameters can be used to infer the likely sub-grid variability in precipitation. By describing a small scale flooding event in 2014 that triggered the idea, and other real world cases, we will illustrate different types of sub-grid variability that can arise, and show how these relate to the synoptic set up, and the model-based parameters that define this. Parameter values can thus be used to map gridbox precipitation totals, from a single model forecast, onto a probability density function (pdf) for point totals within that gridbox, on a gridbox by gridbox basis. Ultimately, within the flash flood prediction system we envisage, the forecast for a point would be the sum over all ensemble members of the pdfs derived from each member. In short, for each gridbox, we would be creating and combining an 'ensemble of ensembles'.

Whilst one might question the efficacy of this approach a short feasibility study, using tens of thousands of data points, has shown it to be entirely viable. The form of the point total pdfs (from observations) varied considerably as model parameter values varied, and thus gave very strong indications of when extreme localized rainfall was likely and when it was not. Although observations are necessary for calibration, we do not need special high density datasets; only freely available conventional measurements are used.

To conclude we will make the connection between point rainfall with flash flooding. Previous studies suggest that the best approach to flash flood prediction is probably the "rainfall comparison method", wherein rainfall amounts (forecast) at a location are compared with climatology for that location: as higher and higher return period thresholds are exceeded flash floods become more and more likely. In our technique climatology would be derived a priori, in 'synthetic' form, by applying the same post-processing techniques that we apply to the actual forecasts to re-forecast datasets.

In summary, the Harry Otten prize would allow us to create an operational system to deliver automated flash flood predictions, to 10 days ahead, for everywhere in the world within 6 months. In turn this would ignite a global step change in forecasting practice.