# The CONVEX project

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Climate change is likely to produce an increased intensity and frequency of climatic and hydrological extremes with resultant impacts on communities through increased risk of flooding. Although, climate models can reasonably simulate winter rainfall extremes they are deficient in simulating summer rainfall which tends to fall in short but intense bursts – as seen during the Boscastle flooding of 2004 and 'Toon Monsoon' in Newcastle in 2012.

A key focus of the CONVEX project was **CONV**ective **EX**tremes that are important contributors to flood generating events, particularly in urban areas. The project aimed to provide better guidance on using information from climate models, and better information on future UK summer flood risk. The project has used information from new observed datasets and from state-of-the-art climate modelling:

- In CONVEX we have produced a new quality-controlled hourly observed rainfall dataset for the UK: combining observations from the UK Met. Office Integrated Data Archive System (MIDAS), the Scottish Environmental Protection Agency (SEPA), and tipping bucket rain gauge data from ~1,300 gauges across England and Wales from the Environment Agency (EA).
- In CONVEX, the Met Office has run the first climate change experiments with a very high resolution "convection permitting" model for a region of the southern UK. We used 1.5km grid boxes instead of the usual 12km or larger – the same as their weather forecast model - allowing the process of convection to be represented dynamically which was not possible with previous coarser models. Results from this model have been compared with those from a 12km regional climate model (RCM) simulation to identify potential benefits from high resolution modelling.

## Headline Messages

1 **Very high resolution climate models add value**

Although, the 12km model has lower biases in mean rainfall intensity compared with the 1.5km model - a compensation of too much light rainfall and an underestimation of heavy rainfall – the new 1.5km model better represents "very extreme" (multi-) hourly summer rainfall events (i.e. those with long return periods and associated with the greatest impacts). At daily timescales however, the 12 km model rainfall extremes become more comparable with the observations and with the 1.5 km model. In winter, both model simulations have comparable simulations of extremes.

We conclude that coarse resolution models are inadequate in their representation of summer rainfall extremes. The convection-permitting 1.5 km model provides added value in the simulation of summer extremes, particularly for the most extreme events. In winter, the 12 km model adequately simulates winter extremes, and thus the added value of the 1.5 km model for this season is relatively low although there is some evidence that the more detailed orography used at the high resolution is beneficial for representing changes in heavy rainfall over mountains in winter.

2 **Heavier summer downpours with climate change**

The climate change simulations from the very high resolution model suggest that extreme summer rainfall may become more frequent in the UK. Results show that while summers are expected to become drier overall by 2100, intense rainfall indicative of serious flash flooding could become several times more frequent. The very high resolution model has allowed us to examine these changes for the first time and produces heavier summer downpours in the future. For example, the model suggests intense rainfall associated with flash flooding (more than 30mm in an hour) could become almost five times more frequent by 2100.

These results are based on one climate model, and so modelling uncertainty cannot be assessed. However, the intensification of summertime convective rainfall events in a warmer, moister environment is consistent with theoretical expectations and the limited observational studies of hourly rainfall to date.

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3 **Summer rainfall intensities increase with temperature but circulation changes can be important**

No statistically significant trends have been found in hourly rainfall intensities within the new UK observed dataset. However, UK extreme summer hourly precipitation intensities are found to be linked to temperature and these increase according to the Clausius-Clapeyron relationship - at a rate of ~7% per $^{0}$C. This work identifies a warming atmosphere as a potential mechanism for the increased intensity of UK summer rainfall.

Furthermore, unlike coarse resolution models, the 1.5km model is able to reproduce this observed rate of increase in intense hourly rainfall with increasing temperature. This provides increased confidence in future projections of intense rainfall from the very high resolution model.

Importantly, results from the 1.5km model suggest that this relationship cannot simply be extrapolated into the future. In fact, the future relationship for the UK is more akin to relationships that have been observed in the tropics, with declines in precipitation intensities at temperatures above ~22°C. Our model results suggest this is caused by a shift to more anticyclonic conditions, with strong daytime heating but lower humidity. We conclude that although changes to intense precipitation are dominated by local changes in temperature, changes in large scale circulation can have important regional effects, and may serve to suppress precipitation intensities in the future. As such, although they are important, regional surface temperatures may not provide an adequate predictor of changes in precipitation intensity.

4 **Guidance on future change in hourly rainfall for the UK should be revisited**

Our results suggest that there will be significant changes to extreme summer rainfall in the future and that projections from very high resolution models are very different from those from coarse resolution models. Since these coarse models have been used in the development of guidance, for example for urban drainage design, and for climate scenarios such as UKCP09, these must be revisited in the light of new understanding from CONVEX. We are working with UKWIR, DECC and DEFRA and other appropriate public bodies to ensure that these results are incorporated, as appropriate, into new guidance as it is developed.