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A new framework for estimating return levels using regional frequency analysis

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We propose a new framework for incorporating more spatial and temporal information into the estimation of extreme return levels. Currently, most studies use extreme value models applied to data from a single site; an approach which is inefficient statistically and leads to return level estimates that are less physically realistic. We aim to highlight the benefits that could be obtained by using methodology based upon regional frequency analysis as opposed to classic single site extreme value analysis. This motivates a shift in thinking, which permits the evaluation of local and regional effects and makes use of the wide variety of data that are now available on high temporal and spatial resolutions.

The recent winter storms over the UK during the winters of 2013-14 and 2015-16, which have caused wide-ranging disruption and damaged important infrastructure, provide the main motivation for the current work. One of the most impactful natural hazards is flooding, which is often initiated by extreme precipitation. In this presentation, we focus on extreme rainfall, but shall discuss other meteorological variables alongside potentially damaging hazard combinations.

To understand the risks posed by extreme precipitation, we need reliable statistical models which can be used to estimate quantities such as the T-year return level, i.e. the level which is expected to be exceeded once every T-years. Extreme value theory provides the main collection of statistical models that can be used to estimate the risks posed by extreme precipitation events. Broadly, at a single site, a statistical model is fitted to exceedances of a high threshold and the model is used to extrapolate to levels beyond the range of the observed data. However, when we have data at many sites over a spatial domain, fitting a separate model for each separate site makes little sense and it would be better if we could incorporate all this information to improve the reliability of return level estimates. Here, we use the regional frequency analysis approach to define homogeneous regions which are affected by the same storms. Extreme value models are then fitted to the data pooled from across a region. We find that this approach leads to more spatially consistent return level estimates with reduced uncertainty bounds.