Department for Environment Food & Rural Affairs

Department for Business, Energy & Industrial Strategy

Met Office Hadley Centre

Environment Agency

Working together on UK Climate Projections

Future surface water flood hazard risk

Using high resolution sub-daily climate projections at the national scale

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SEPA Scottish Environment Protection Agency
Buidheann Dìon Àrainneachd na h-Alba

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- SEPA is responsible for producing surface water flood hazard maps including climate change impacts.
- UKCP09 could not be used to assess impacts of extreme rainfall on surface water flood risk.
- Potential challenge of using UKCP18 data is the volume of high resolution data andits appropriate analysis to obtain the required impact metric relevant for surface water flood risk.

Flood risk management in Scotland

The Flood Risk Management (Scotland) Act 2009 formalised the approach of sustainable flood risk management and placed new responsibilities on Scottish Environment Protection Agency (SEPA) for the delivery of information and co-ordination of flood risk management (FRM) in Scotland. According to the Act, SEPA must produce maps showing hazard and risk from river, coastal and surface water flooding. Version 1.0 of SEPA's surface water flood hazard maps, showing flood risk from rainfall before it enters the river or drainage system, were published in 2013.

Figure 1. SEPA's flood hazard maps are used to inform SEPA's Flood Risk Management Strategies which set the direction of flood risk management in Scotland, helping to target investment and coordinate actions across public bodies http://map.sepa.org.uk/floodmap/map.htm

According to the Act, and in line with the requirements of the EU Floods Directive (Directive 2007/60/EC), SEPA must take into account the possible impacts of climate change on the occurrence of floods when undertaking flood risk assessments, mapping flood hazard and risk and when setting objectives and identifying measures to reduce the impact of flooding. Typically a 100 year timeframe is used when appraising flood risk management actions, but the 6 year planning cycle in the FRM Act allows decisions to be revised as improved information becomes available.

Exploiting UKCP18 data

SEPA is interested in extreme rainfall and therefore the data from the high resolution downscaled 2.2 km model as it is able to simulate weather events that produce extreme rainfall more realistically. SEPA's analysis of future surface water flood risk requires uplifts (percentage increases) in rainfall for extreme rainfall events with a range of durations and annual exceedance probabilities. These uplifts will be used with existing depth duration frequency (DDF) models, such as the Flood Estimation Handbook 2013 DDF model[1], which give expected rainfall depths for different durations and annual exceedance probabilities based on present day observed rainfall (see Figure 2). The annual exceedance probability (AEP) is the probability that an event of the same or greater magnitude will occur in any one year.

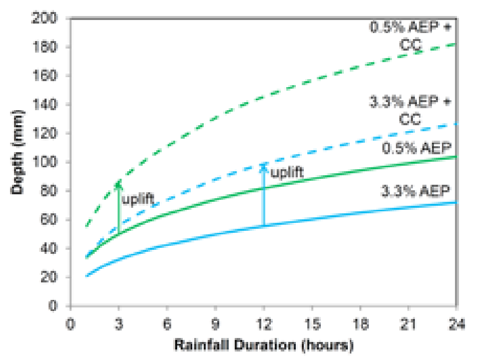

Figure 2. Example of uplift factors that need to be applied to existing rainfall depth duration curves.

Find out more

This project is part of a portfolio of demonstration projects that have worked with the UKCP18 team to understand the implications of the next set of UK Climate Projections for their sector.

To find out more about the UKCP18 project and other demonstration projects, please visit https://www.metoffice.gov.uk/research/collaboration/ukcp

Calculating uplifts

Uplifts will be calculated for all pairs of future and baseline models to give uncertainty estimates in the percentage uplifts. The approach used to calculate uplifts will follow that in the recent UKWIR project looking at extreme rainfall for sewer design[2]:

1. Calculation of rainfall depths over 1 hour, 3 hour, 6 hour, 12 hour and 24 hour accumulation windows. The 24 hour rainfall calculated in this way differs from daily rainfall as it would require depths to be calculated over any 24 hour period, not just a calendar day.

2. Defining the threshold at which rainfall can be considered to be extreme (usually the 99th percentile of all wet values) for each grid cell and storm duration (so for each grid cell there would be 5 thresholds, one for each storm duration).

3. Extracting extreme events over this threshold.

4. Declustering to remove events which are not independent (i.e. caused by the same weather system).

5. Fitting an extreme value distribution to the extreme events for each accumulation window to allow estimation of rainfall depths for annual exceedance probabilities (AEP) from 50% to 0.1%. The most important events are the 3.3% AEP event for sewer design and the 0.5% AEP which is used to define the medium to high risk area for land use planning.

As well as the UKCP18 data and present day rainfall data in the form of a DDF model, the approach used to produce surface water flood risk maps requires an elevation model of the ground surface typically from LIDAR, and information on whether areas are rural or urban so that an appropriate allowance can be made for how much water enters the ground.

An alternative approach

SEPA is interested primarily in flood depths and damages and running a large number of flood models to calculate these each time a new set of projections is released is resource intensive. More efficient ways to generate "probabilistic" future surface water flood risk information have been looked at.

One such approach follows that of the future flood explorer used in the latest Climate Change Risk Assessment[3]. This involves developing GIS geoprocessing models to interpolate flood depths and damages for future scenarios from existing model runs based on present day extreme rainfall. Figure 3 shows an interpolated flood extent for an input rainfall equivalent to the 2% Annual Exceedance Probability, based on a linear interpolation between the modelled 3.3% AEP and 1% AEP depths and associated input rainfall values for these scenarios. The interpolated depths compare well to the modelled depths for the same scenario. Investigation into whether damage curves can be calculated on a grid and future values interpolated from these in a similar way without remapping is currently underway.

What to be aware of with UKCP18

The 2.2 km dataset needs to be processed before use in surface water flooding risk analysis in order to obtain the appropriate statistics for extreme rainfall. The complete hourly time series at each Scottish grid cell for each pair of baseline and future model run needs to be processed. This will involve large data volumes which can be challenging.

Previous use of UKCP09

Surface water flooding is typically caused by very heavy rainfall falling for a short duration, such as might be experienced in a summer thunderstorm, but the UKCP09 regional climate model was too coarse resolution to resolve this type of rainfall so the outputs could not be used to look at how surface water flood hazard and risk would change in future and to plan for it.

SEPA's flood risk maps

The Flood Risk Management (Scotland) Act 2009, requires SEPA to produce flood hazard maps (see http://map.sepa.org.uk/floodmap/map.htm). These maps are used to support:

1. The National Flood Risk Assessment which identifies areas potentially vulnerable to flooding where flood risk mitigation actions are targeted.

2. Flood Risk Management Strategies which set the national direction for future flood risk management, helping to target investment, coordinate actions across public bodies and inform the public (see http://apps.sepa.org.uk/FRMStrategies/).

3. Local Authority Surface Water Management Plans for reducing the risk of surface water flooding.

4. Screening for pluvial flooding issues within the land use planning system by Local Authorities.

5. Helping the public understand their flood risk through the hazard map viewer on SEPA's website.

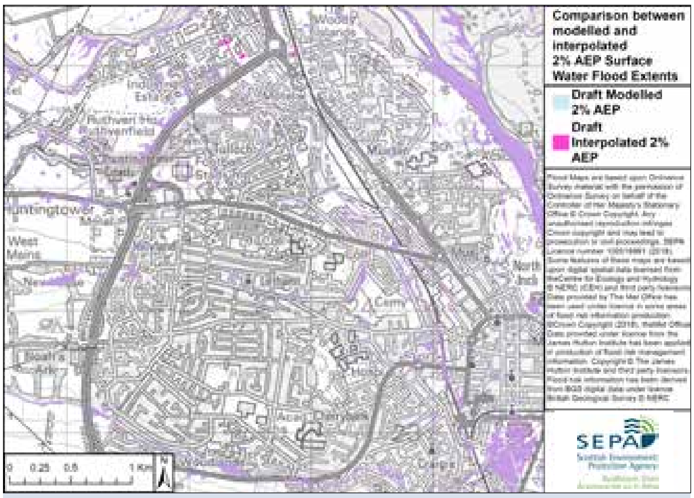

Figure 3. Comparison of an interpolated flood extent for an input rainfall equivalent to the 2% Annual Exceedance Probability with the modelled flood extent.

[1]*Faulkner, D., 1999. Flood Estimation Handbook, Vol 2: Rainfall frequency estimation. Institute of Hydrology, Wallingford, UK, 110 pages.*
[2]*Chan S, Dale M, Gill E and Potter R. 2017. Rainfall Intensity for Sewer Design – Stage 2 Technical Report, UK Water Industry Research Limited, London.*
[3]*Sayers, P.B; Horritt, M; Penning-Rowsell, E; McKenzie, A. (2015) Climate Change Risk Assessment 2017: Projections of future flood risk in the UK. Research undertaken by Sayers and Partners on behalf of the Committee on Climate Change. Published by Committee on Climate Change, London.*