FUTURE-DRAINAGE Webinar

Hayley Fowler (Newcastle University), Lizzie Kendon (Met Office), Murray Dale (JBA Consulting), Xiaodong Ming (Loughborough University)

24th November 2021

https://www.instagram.com/p/By3SerGnDXi/?igshid=dopwsu601et2

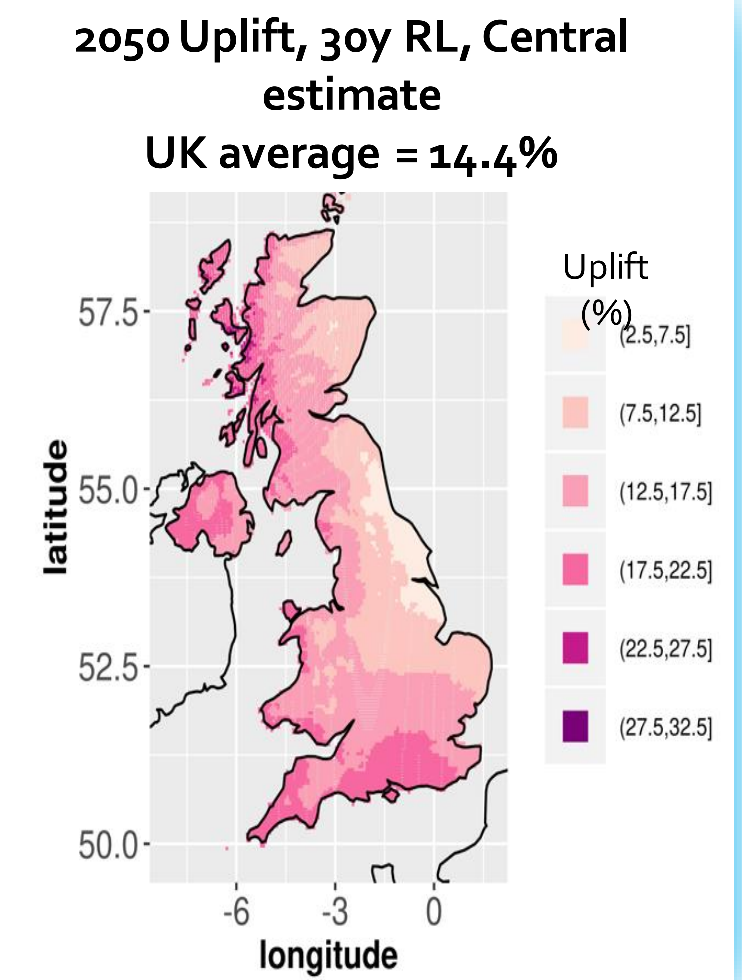
FUTURE-DRAINAGE

Professor Hayley Fowler, Newcastle University

FUTURE-DRAINAGE

<u>Aim:</u> To provide revised rainfall uplifts for climate change in line with UKCP18, to assess the uncertainty in these rainfall uplifts and provide new guidance for urban drainage design and modelling surface water flooding in urban areas

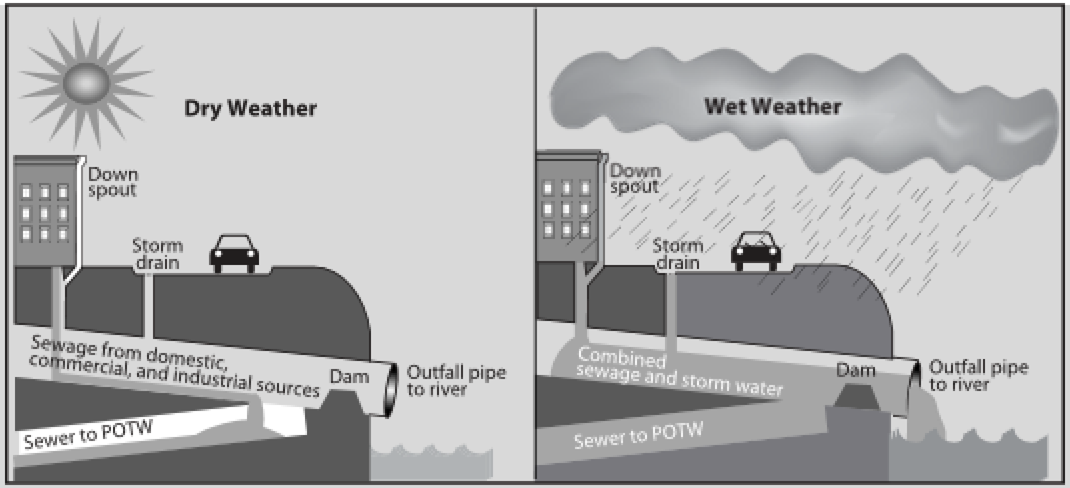
<u>In consultation with stakeholders, translated into information usable to UK water resource stakeholders for climate change adaptation</u>



Climate uplifts

The Customer: Interests of stakeholders (Dale 2021)

Who are the stakeholders? water resource management, insurance, emergency services, etc.



Surface (flash) flooding, overcoming flood defences, leading to human casualty and property damage

UK: Boscastle flood of 2004
Europe: 2002 Gard flood (24 fatalities, 1.2 billion € damages)
Historical: Johnstown flood 1889 (2200+ fatalities), 1975 Banqiao Dam failure and flood (85000+ fatalities); both dam failures after heavy precipitation

Combined sewage overflow, leading to water pollution, posing risks to public health and coastal environment

Emission of sewage water to sea is regulated in particular for the warm bathing season (**15 May – 30 Sep**): EU directives 76/160/EEC + 2006/7/EC, UK Statutory 2013 No. 1675

FUTURE-DRAINAGE webinar - outline

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Part 1:

- **UKCP Local projections through to rainfall uplifts** – Prof Lizzie Kendon, UK Met Office
  - UKCP Local
  - Method and assessing uncertainties
  - New uplifts
- **Uplift guidance and stakeholder consultation** – Murray Dale, JBA
  - Guidance on use of rainfall uplifts
  - Managing uncertainties in the projections
  - Recommendation on required revisions to RED-UP tool.

Met Office

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FUTURE-DRAINAGE webinar - outline

Part 2:

- **Impact of the revised uplifts on sewer flooding**

  - Using uplifts to generate urban flood risk projections in 6 UK cities

- **Using national RoFSW methodology – Murray Dale, JBA**
- **Using fully dynamic urban flood models – Dr Xiaodong Ming, Loughborough University**
- Recommendations

Part 1: FUTURE-DRAINAGE rainfall uplifts

Current UK Guidance

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Defra Guidance (2006)

Peak rainfall climate change allowances, for England and Wales

Parameter	1990-2025	2025-2055	2055-2085	2085-2115
Peak rainfall intensity (preferably for small catchments	+5%	+10%	+20%	+30%

UKWIR 2017 values		
North West UK	Central estimate	35%
	High estimate	*65%*
North East UK	Central estimate	20%
	High estimate	*50%*
South UK	Central estimate	15%
	High estimate	*35%*

Environment Agency 2011 guidance (2011)

Change to extreme rainfall intensity compared to a 1961-90 baseline

Applies across all of England	Total potential change anticipated for 2020s	Total potential change anticipated for 2050s	Total potential change anticipated for 2080s
Upper end estimate	+10%	+20%	+40%
Change factor	+5%	+10%	+20%
Lower end estimate	0	+5%	+10%

Met Office

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UKCP Local climate projections through to uplifts

Professor Lizzie Kendon, Met Office

Thanks to: Steven Chan

What are UKCP Local 2.2km?

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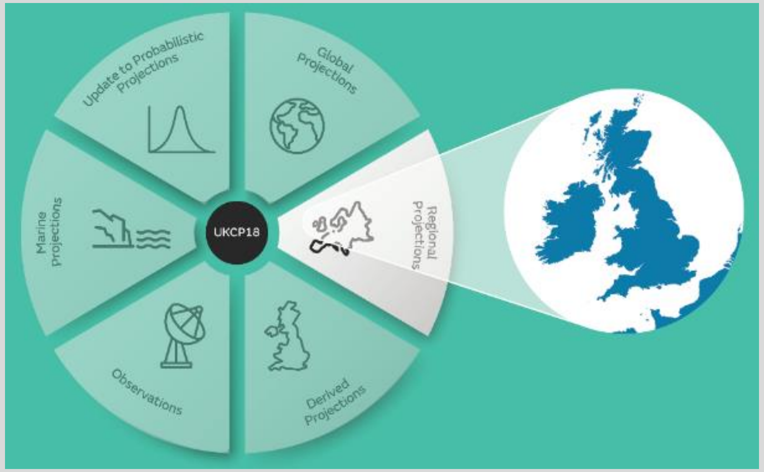
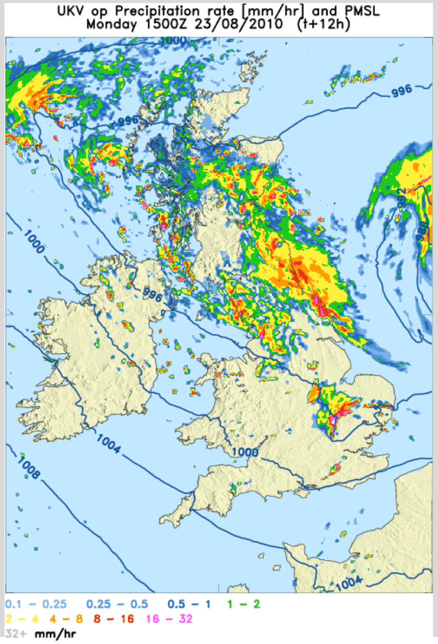


UKCP18 2.2km ensemble

- 2.2km resolution for UK
- 12 members
- Driven by 12km RCM
- Data for 1981-2000, 2021-40, 2061-80
- High emissions scenario RCP8.5

New set of 12 climate projections using a model as detailed as that typically used for weather forecasts.

Updated July 2021



New estimates of changes in daily and hourly extremes
- Storms
- Summer downpours
- Severe wind gusts

Supports UK risk assessments

Hydrological impacts modelling e.g. flash floods

Climate change for cities e.g. urban extremes

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Local (2.2km)

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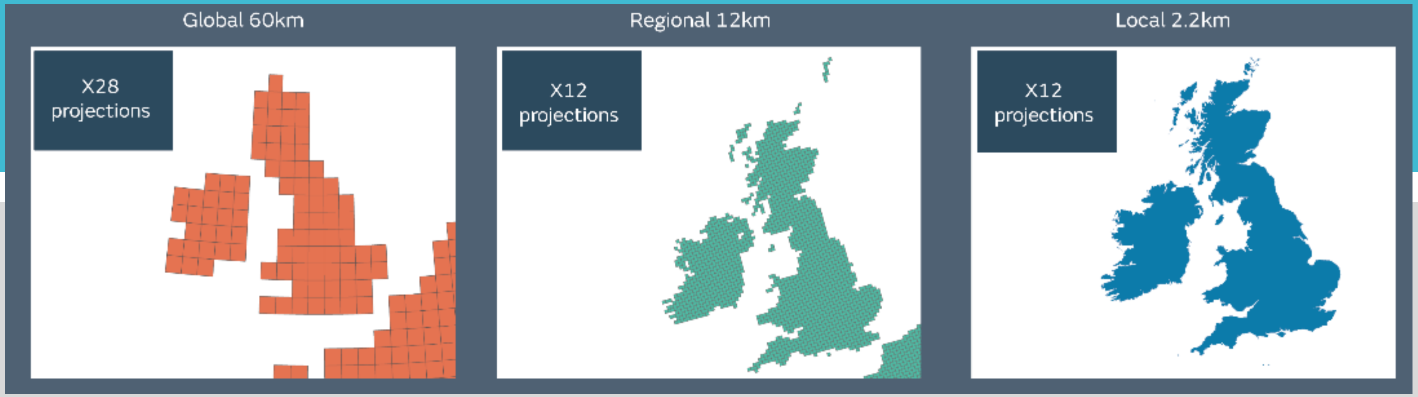
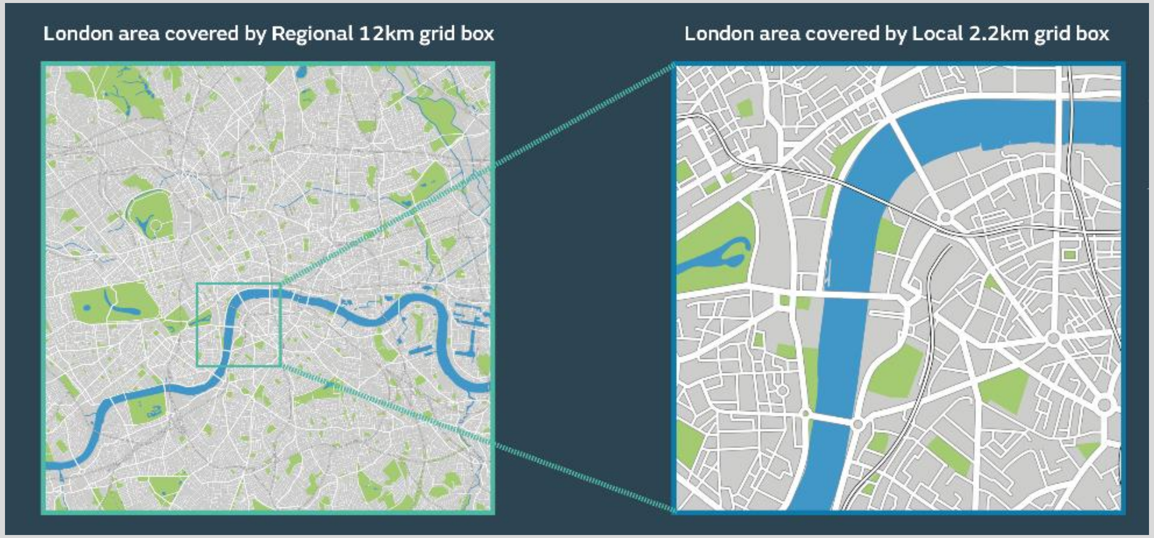


The Local (2.2km) model better represents small scale behavior in the real atmosphere, such as convection.

Local (2.2km) better captures the influence of mountains, coastlines and urban areas, due to the high resolution.

Specification of urban areas is much more precise



Local (2.2km) describes the types and extremes of weather for your local area over coming decades.

Present-day hourly rainfall extremes

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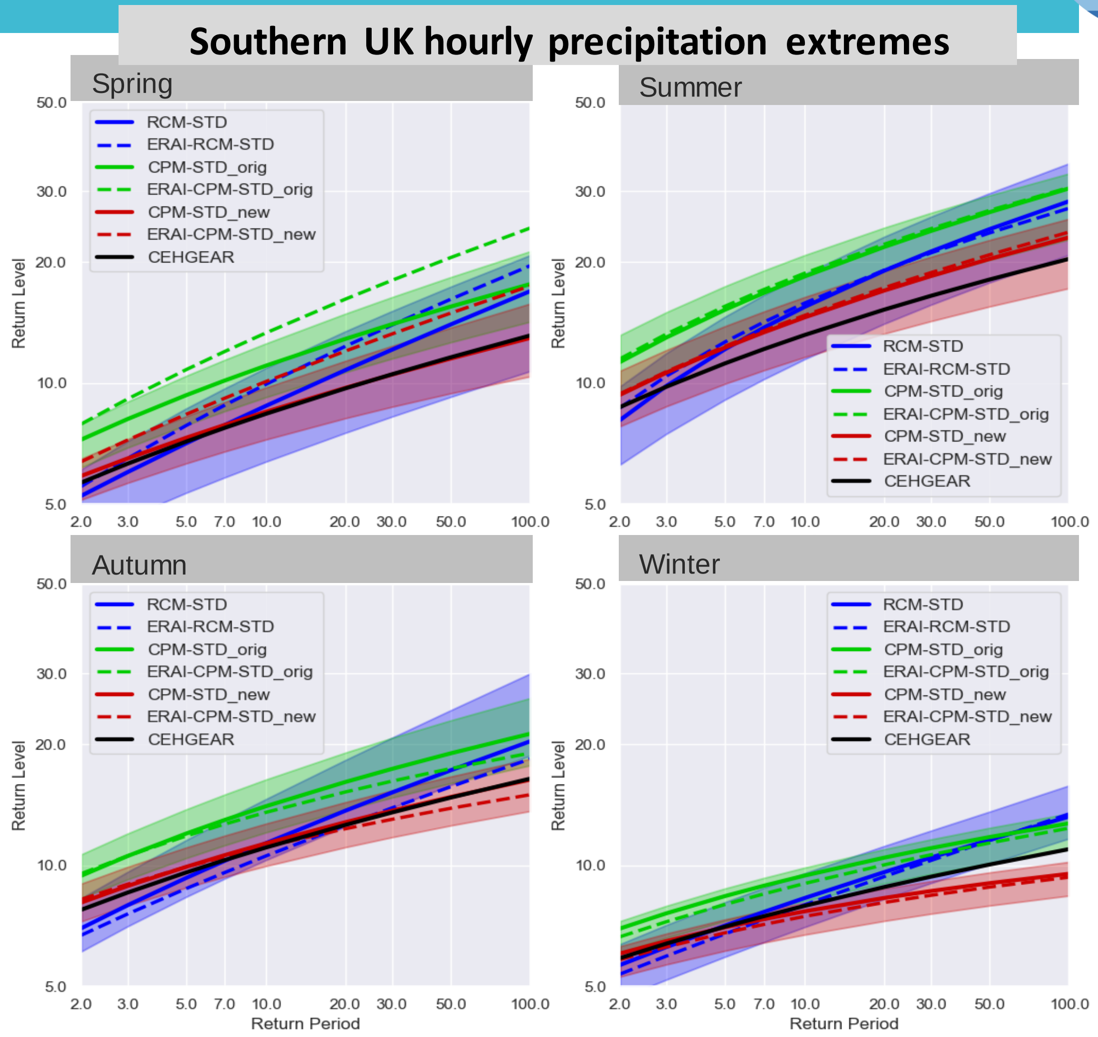
UKCP Local (2.2km) provides credible projections of future changes in hourly rainfall extremes

- 2.2km CPM shows good agreement with observations, which are within ensemble spread (except high return periods in winter)
- 2.2km CPM captures the present-day rate at which extremes increase with return period unlike 12km RCM
- High return period extremes are overestimated in 12km RCM likely due to unphysical grid point storms



Met Office

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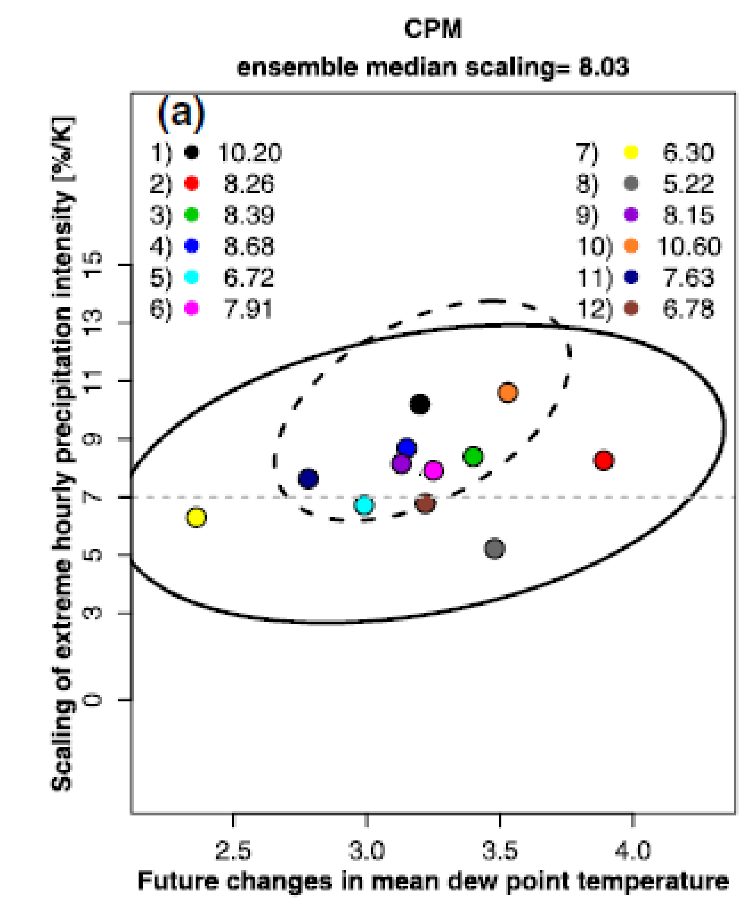
Calculating uplifts from UKCP Local

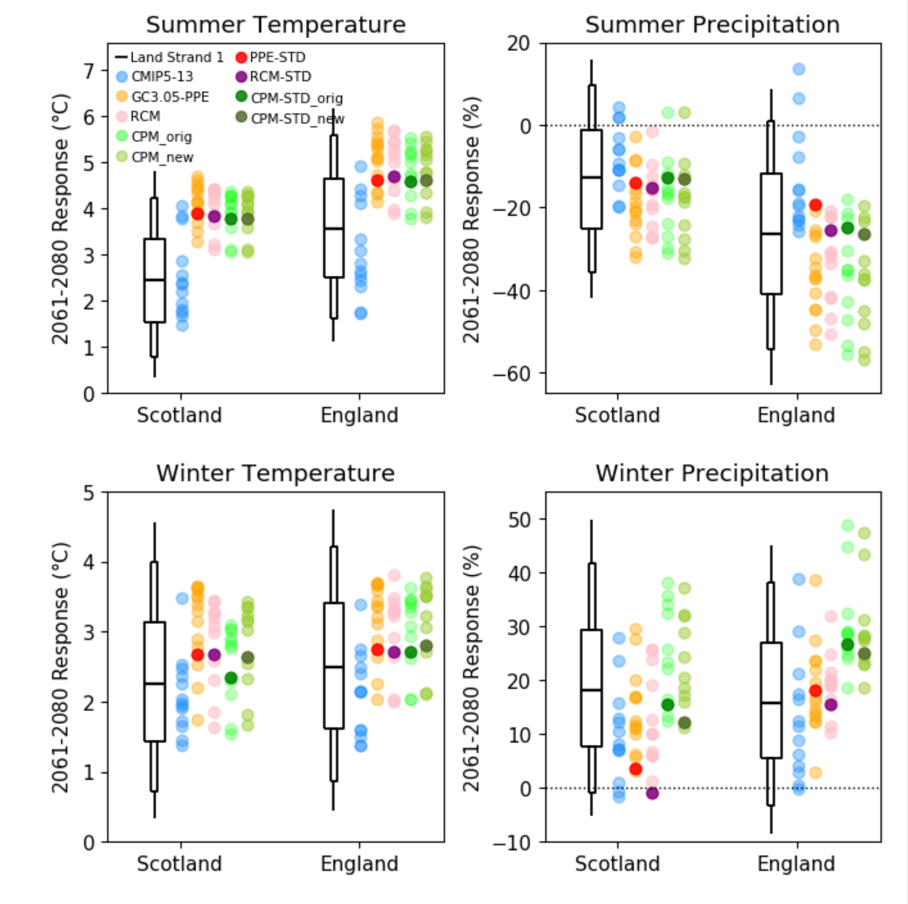
- **Advanced spatial statistical model** (Youngman 2018) used to produce robust and smooth estimate of return levels, accounting for local processes (i.e. orography, prevailing flow) and using all available model data.
- Spatial and temporal correlation in the data accounted for to some extent using experimental technique (Ribatet et al. 2012).
- There are two uncertainties attached to the return levels and uplift estimates, which are combined to produce **'central' and 'high' estimates**:
  - Uncertainties in the extreme fit itself (for each ensemble member and time period)
  - Uncertainties due to the climate model ensemble spread (due to variation in driving model physics)



*Scaling factor between dewpoint and extreme 1h precipitation intensity (Fosser et al. 2020). **Solid line**: total uncertainty (ensemble plus natural variability). **Dashes:** uncertainty due to natural variability for single ensemble member*

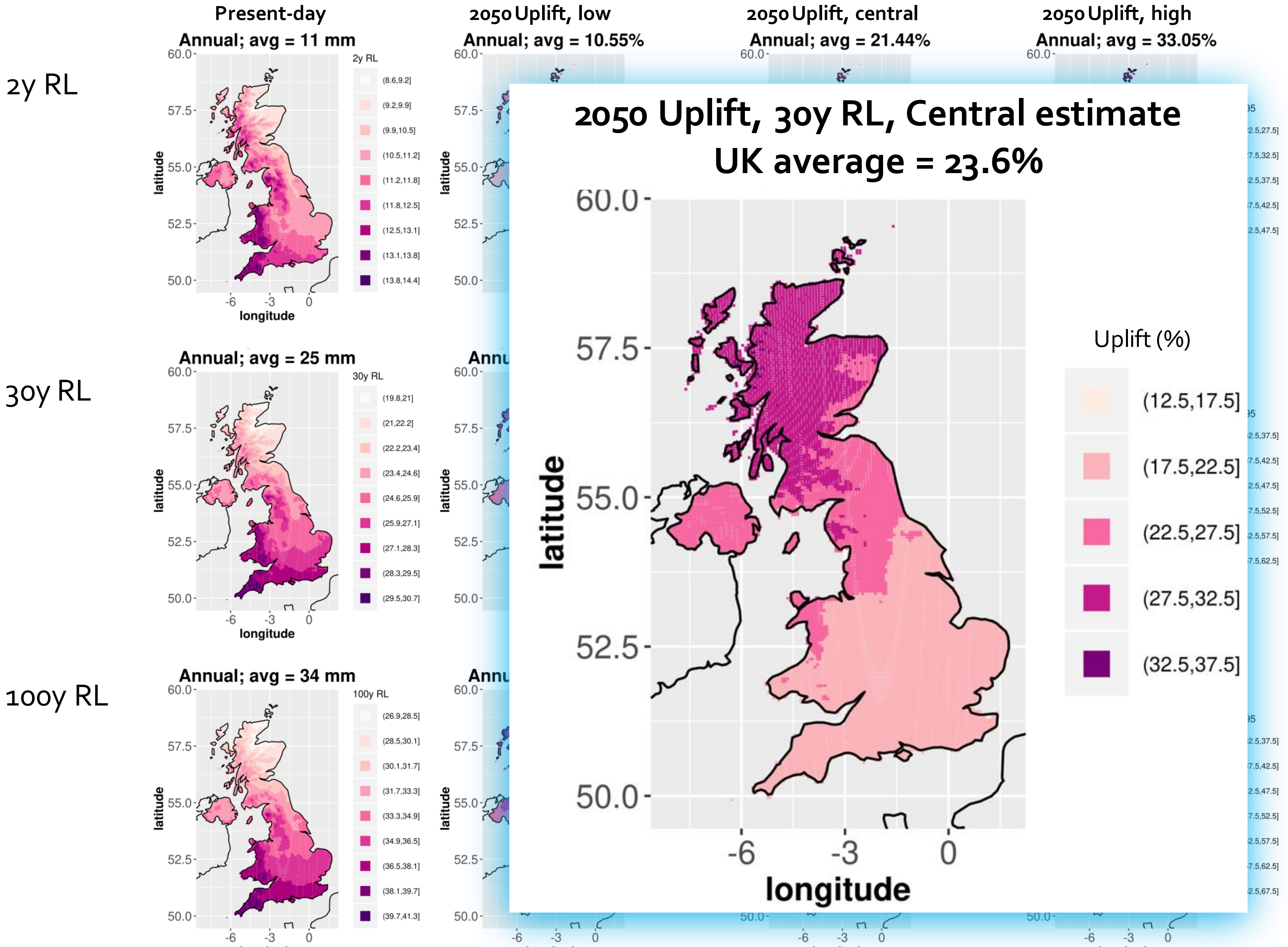
Sampling of uncertainty by UKCP Local (2.2km)

- Local 2.2km projections for first time give some estimate of uncertainty at local and hourly scales due to uncertainty in model physics, but do not sample full range of uncertainty.
- Local 2.2km projections only downscale Hadley Centre models that simulate relatively high levels of global warming.
- In summer, Hadley Centre models (yellow) sample warmer drier outcomes compared to CMIP5 (blue).
- Unexplored uncertainties include the uncertainty due to emission scenario – RCP8.5 is high-end emission scenario, so diagnosed uplifts can be seen as the relative high case.



Projected changes to 2061-2080 for RCP8.5

Hourly precipitation, return levels (1980-2000) and uplifts (2050 RCP8.5)

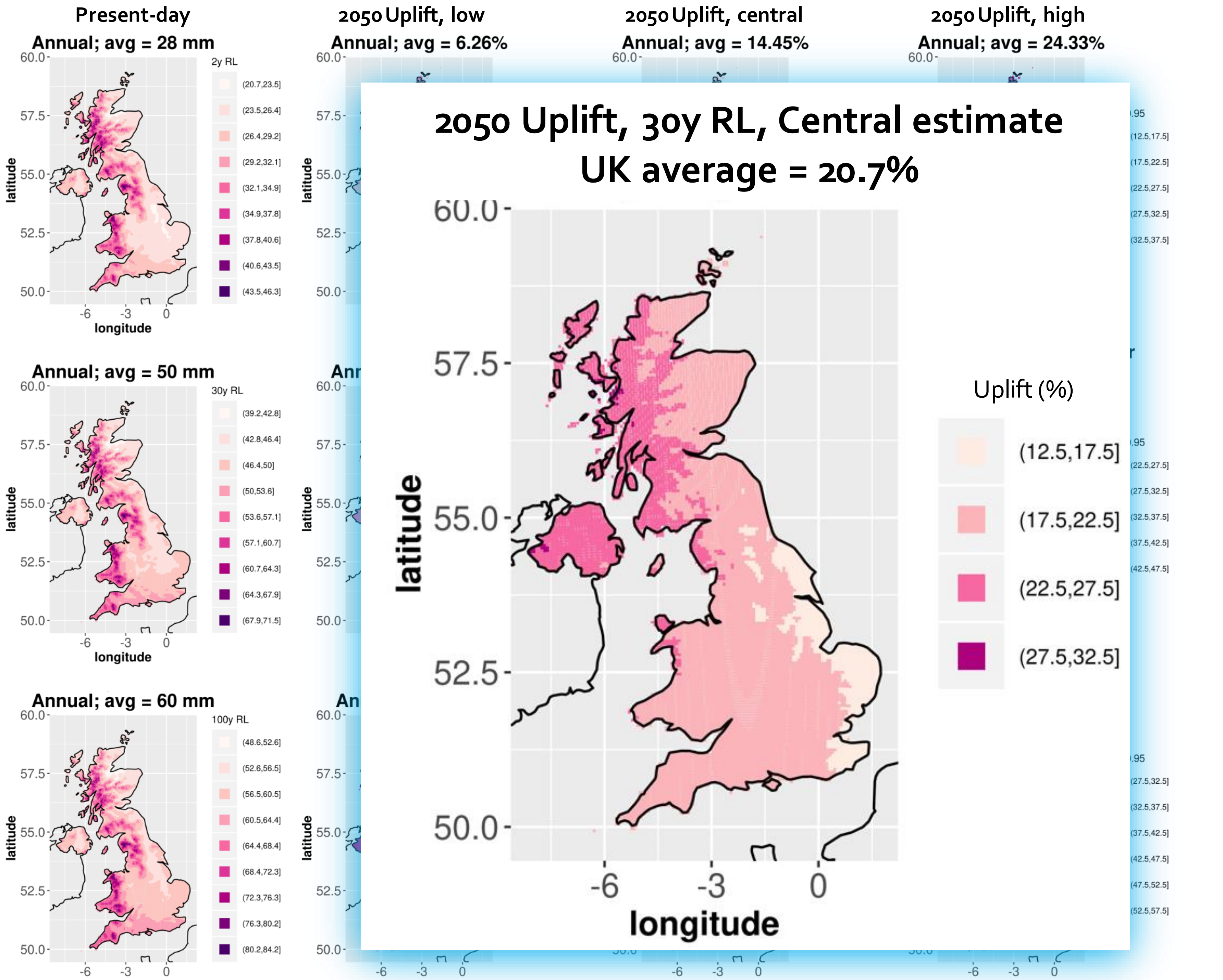


6 hourly precipitation, return levels (1980-2000) and uplifts (2050 RCP8.5)

2y RL

30y RL

100y RL

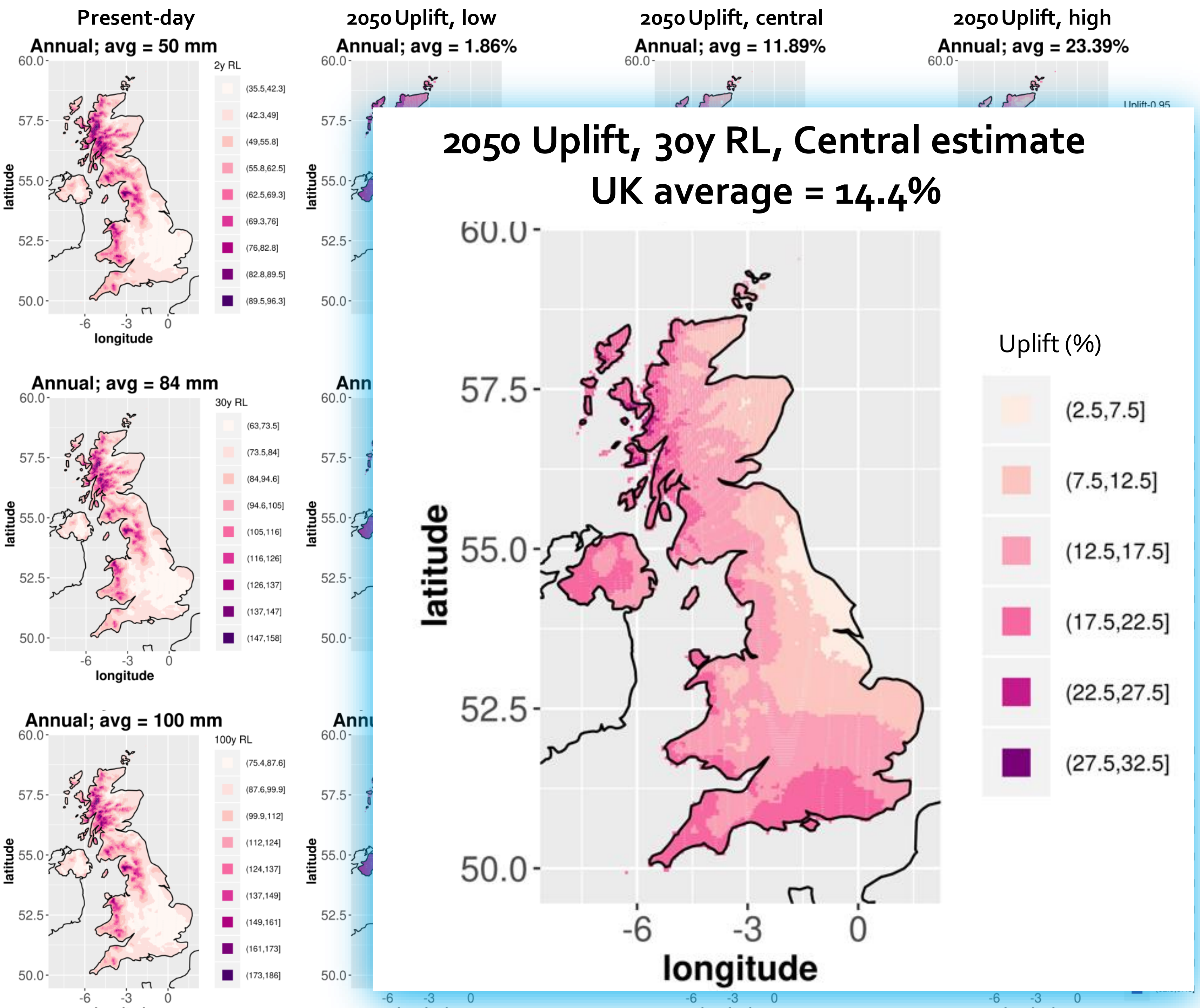


Daily precipitation, return levels (1980-2000) and uplifts (2050 RCP8.5)

2y RL

30y RL

100y RL



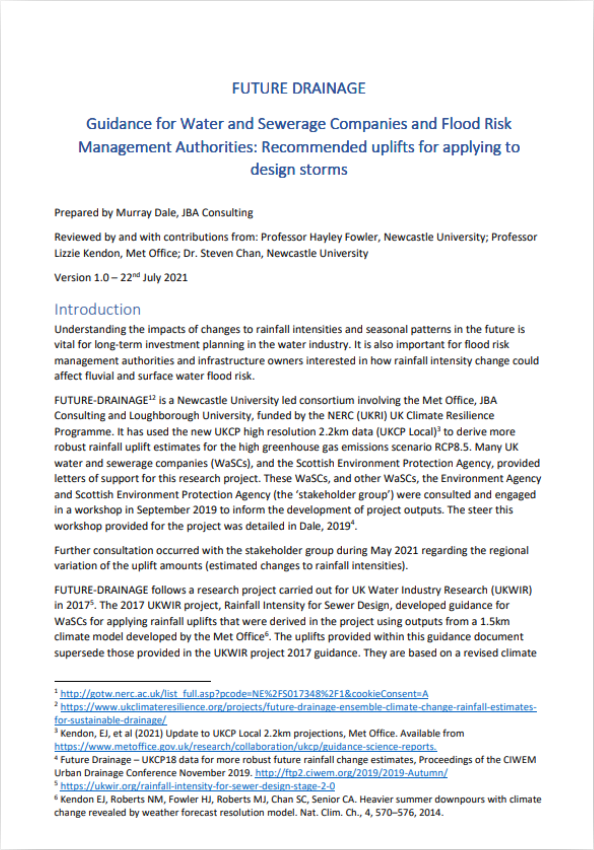
Uplift guidance and stakeholder consultation

Murray Dale, JBA Consulting

Guidance

Guidance and uplift shapefiles released on 22nd July

- Details how to access the uplift shapefiles
- The format of the output
- How to apply the uplifts
- Broad comparison with 2017 UKWIR project results



FUTURE DRAINAGE

Guidance for Water and Sewerage Companies and Flood Risk Management Authorities: Recommended uplifts for applying to design storms

Prepared by Murray Dale, JBA Consulting

Reviewed by and with contributions from: Professor Hayley Fowler, Newcastle University; Professor Lizzie Kendon, Met Office; Dr. Steven Chan, Newcastle University

Version 1.0 – 22nd July 2021

Introduction

Understanding the impacts of changes to rainfall intensities and seasonal patterns in the future is vital for long-term investment planning in the water industry. It is also important for flood risk management authorities and infrastructure owners interested in how rainfall intensity change could affect fluvial and surface water flood risk.

FUTURE-DRAINAGE[1,2] is a Newcastle University led consortium involving the Met Office, JBA Consulting and Loughborough University, funded by the NERC (UKRI) UK Climate Resilience Programme. It has used the new UKCP high resolution 2.2km data (UKCP Local)[3] to derive more robust rainfall uplift estimates for the high greenhouse gas emissions scenario RCP8.5. Many UK water and sewerage companies (WaSCs), and the Scottish Environment Protection Agency, provided letters of support for this research project. These WaSCs, and other WaSCs, the Environment Agency and Scottish Environment Protection Agency (the 'stakeholder group') were consulted and engaged in a workshop in September 2019 to inform the development of project outputs. The steer this workshop provided for the project was detailed in Dale, 2019[4].

Further consultation occurred with the stakeholder group during May 2021 regarding the regional variation of the uplift amounts (estimated changes to rainfall intensities).

FUTURE-DRAINAGE follows a research project carried out for UK Water Industry Research (UKWIR) in 2017[5]. The 2017 UKWIR project, Rainfall Intensity for Sewer Design, developed guidance for WaSCs for applying rainfall uplifts that were derived in the project using outputs from a 1.5km climate model developed by the Met Office[6]. The uplifts provided within this guidance document supersede those provided in the UKWIR project 2017 guidance. They are based on a revised climate

[1] http://gotw.nerc.ac.uk/list_full.asp?pcode=NE%2FS017348%2F1&cookieConsent=A
[2] https://www.ukclimateresilience.org/projects/future-drainage-ensemble-climate-change-rainfall-estimates-for-sustainable-drainage/
[3] Kendon, EJ, et al (2021) Update to UKCP Local 2.2km projections, Met Office. Available from https://www.metoffice.gov.uk/research/collaboration/ukcp/guidance-science-reports.
[4] Future Drainage – UKCP18 data for more robust future rainfall change estimates, Proceedings of the CIWEM Urban Drainage Conference November 2019. http://ftp2.ciwem.org/2019/2019-Autumn/
[5] https://ukwir.org/rainfall-intensity-for-sewer-design-stage-2-0
[6] Kendon EJ, Roberts NM, Fowler HJ, Roberts MJ, Chan SC, Senior CA. Heavier summer downpours with climate change revealed by weather forecast resolution model. Nat. Clim. Ch., 4, 570–576, 2014.

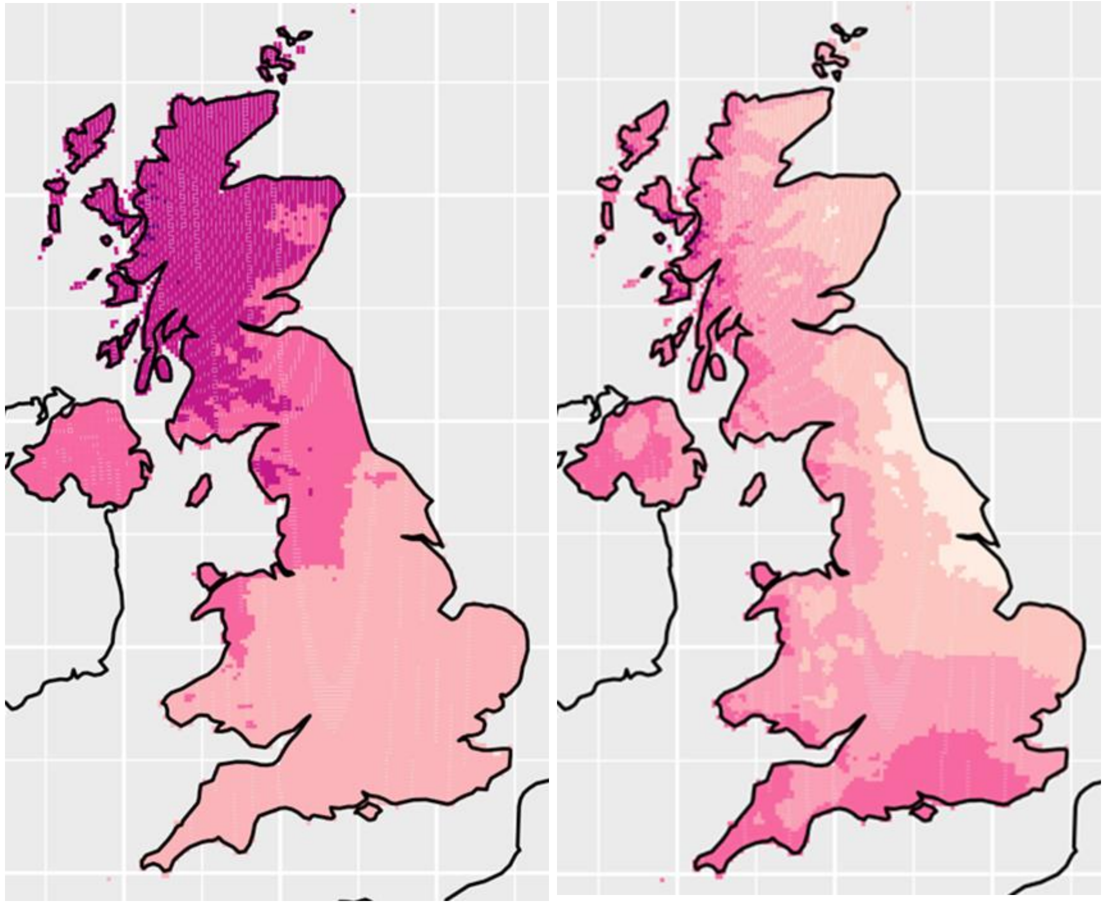
https://artefacts.ceda.ac.uk/badc_datadocs/future-drainage/FUTURE_DRAINAGE_Guidance_for_applying_rainfall_uplifts.pdf

Guidance – headline messages

Uplifts differ by:

- Location
- Rainfall event duration
- Return period
- Time horizon (2050 and 2070)

A central and upper estimate of change provided



Uplifts – consultation with stakeholders

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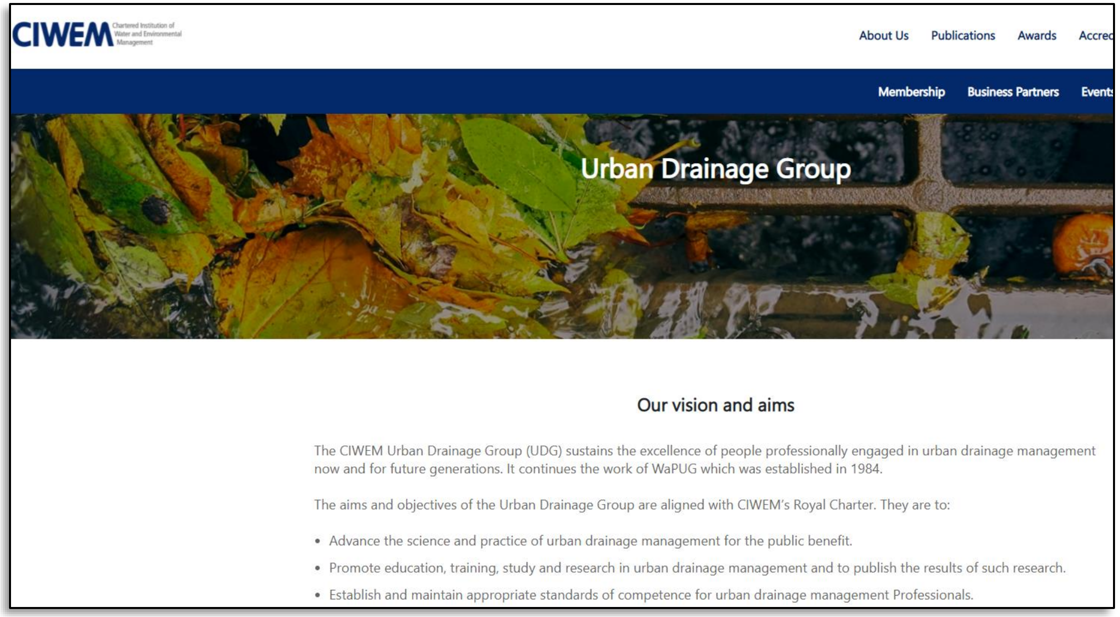
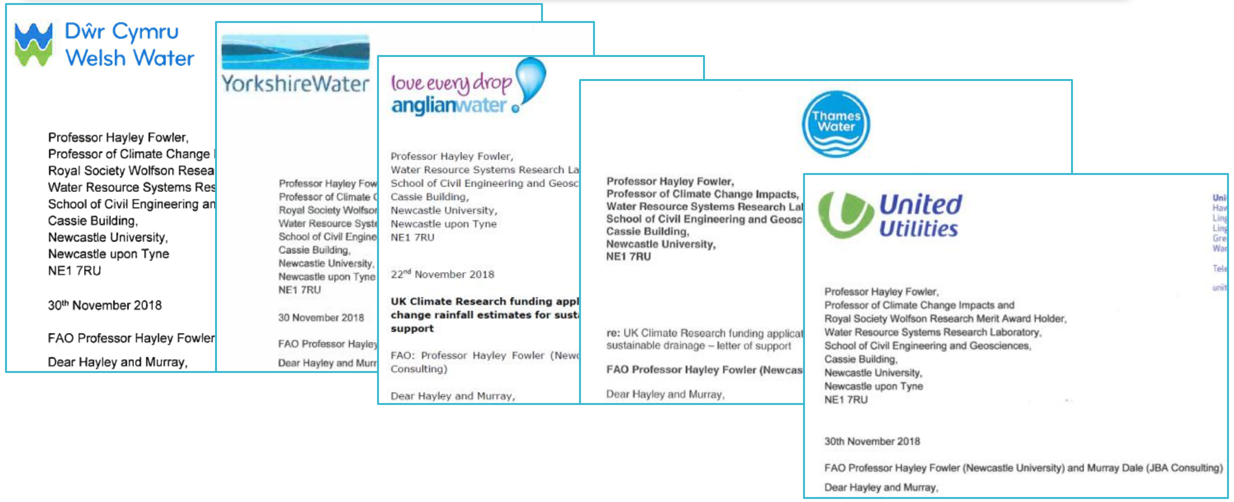
Stakeholder workshop held in London on 26th September 2019

Paper presented at CIWEM UDG Annual Conference in Nov, 19

Approach agreed with stakeholders:

- Rainfall uplifts would be provided to supersede those produced by the UKWIR 2014-17 project
- New regional uplift groupings
- 2050 important time horizon for DWMPs (Drainage and Wastewater Management Plans
- Return periods of 30 and 100-years are useful and 200-year return periods would be of interest if possible





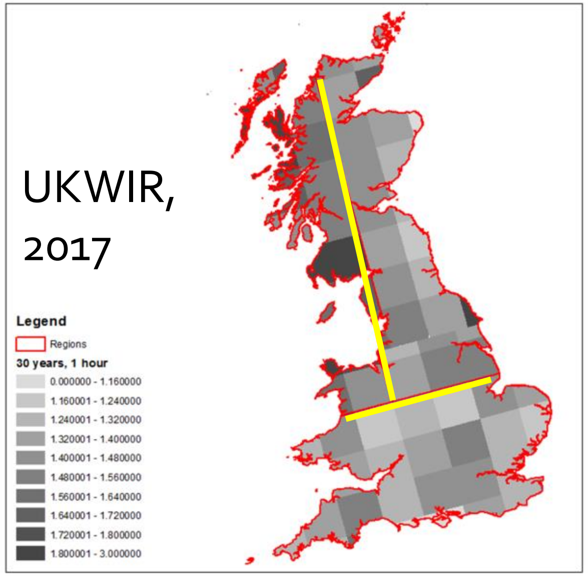
Uplift regionalisation

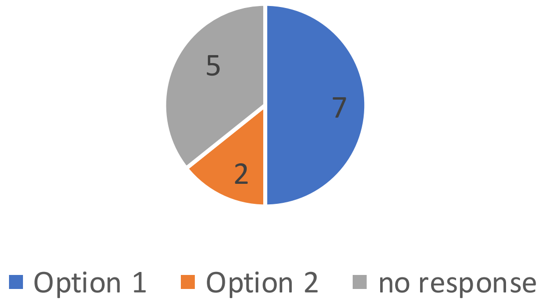
Options put to stakeholders:

1. We produce uplift values shown in maps with 5% uplift increments across the country that are informed from the climate model output only.

2. We produce uplift values rounded to the nearest 5% for each Water and Sewerage company (WaSC) area (two for Scotland divided by river basin district*) in the form of tables.

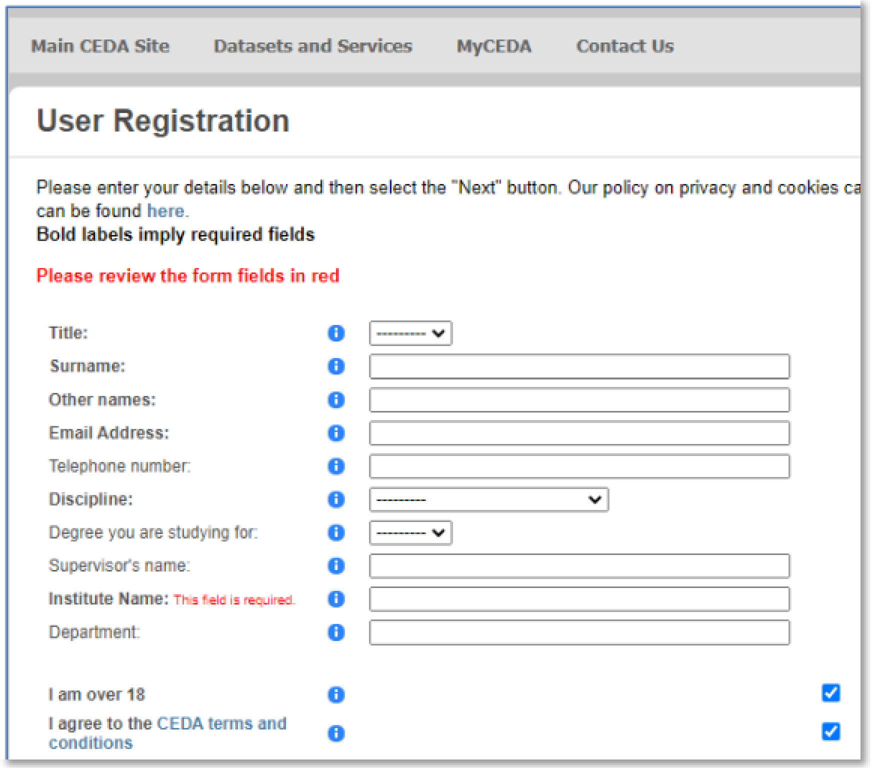
Preference expressed for option 1 (78% of responders)

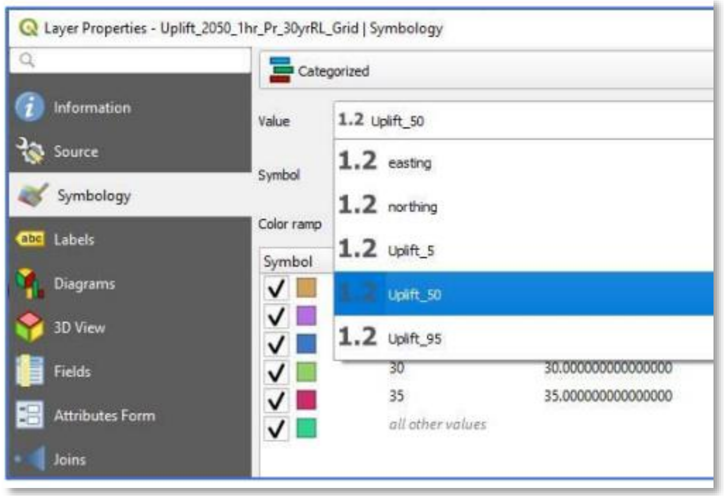




Scottish Water
Northumbrian Water
Yorkshire Water
United Utilities
Dwr Cymru Welsh Water
Severn Trent Water
Anglian Water
Thames Water
Southern Water
Wessex Water
South West Water
Northern Ireland Water
Environment Agency
SEPA

Uplift access





Uplift application

We do not recommend using results from individual grid cells, but to take results from a region (e.g. consider the Lake District as a whole, and consider what the range of values are across the region).

There are geographic features that give rise to local differences, but otherwise we do not expect results to differ significantly from one adjacent grid cell to the next.

If a location of interest is on the border of two uplift zones, we propose using either an uplift value that is an average of the two uplift amounts (e.g. if on the border between an uplift of 25% and 30%, use a value of 27.5%), or, if taking a more precautionary approach, use the higher of the two values.

In either case, we recommend that you document the option that has been taken so that there is a record justifying the value used.

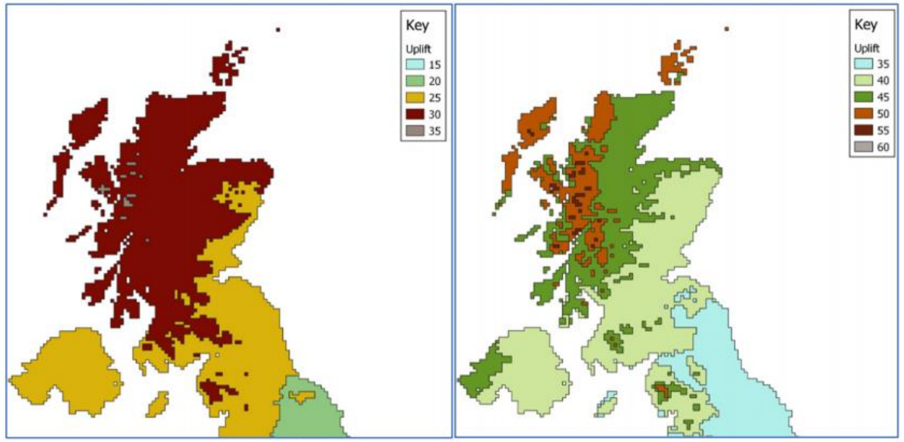


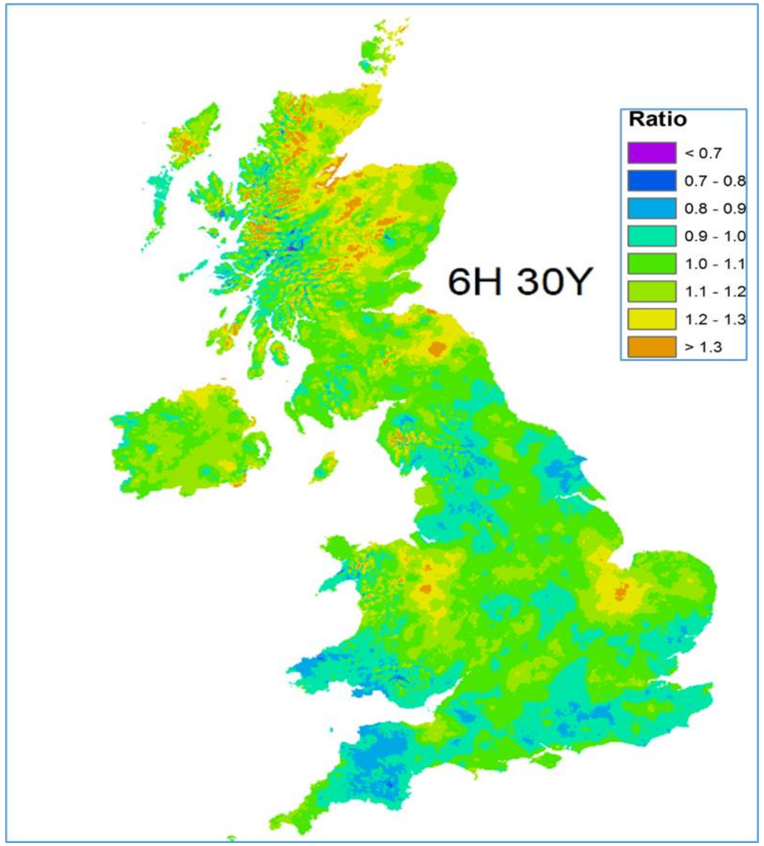
Figure 2 - 1-hour, 30-year uplifts for Scotland for the central estimate (left) and high estimate (right)

Baseline data

The uplifts have been developed against a baseline period of 1981 – 2000. They are appropriate for use with FEH13 depth-duration-frequency (DDF) data.

We are aware that a new version of the FEH DDF model will be released in the Spring of 2022, FEH22.

As the baseline data that are used to derive the FEH22 DDF model will change (i.e. become later in time), it may be appropriate to scale back the uplifts based on the change in the baseline data period, if the centre point of the data period differs substantially from the UKCP Local baseline centre point (1990).



Approximate comparison with prior research & guidance

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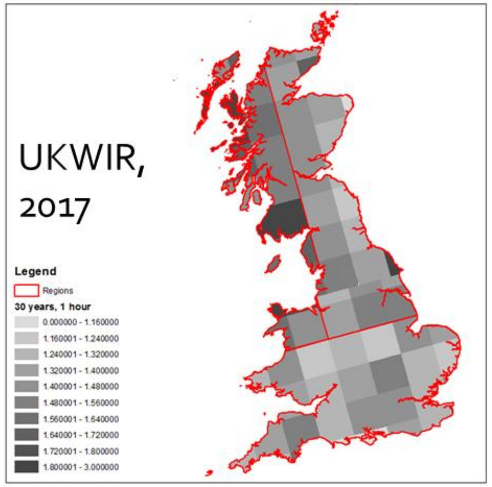
Table 1 – Approximate comparison of uplifts to the UKWIR 2017 values for 2050, 30-year return period.

UKWIR 2017 values			FUTURE-DRAINAGE Range	
			From	**To**
North West UK	Central estimate	35%	15%	30%
	High estimate	*65%*	*35%*	*45%*
North East UK	Central estimate	20%	10%	30%
	High estimate	*50%*	*25%*	*45%*
South UK	Central estimate	15%	20%	25%
	High estimate	*35%*	*25%*	*35%*



Environment Agency

Table 1: peak rainfall intensity allowance in small catchments (less than 5km^2) or urban drainage catchments (based on a 1961 to 1990 baseline)

Applies across all of England	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Upper end	10%	20%	40%
Central	5%	10%	20%

SEPA
Scottish Environment Protection Agency

Table 2: Peak rainfall intensity allowance

Region	Total potential change for 2100
East	35%
West	55%

Conclusions

- Uplifts for short-duration extremes (1hr) are higher than 24hr uplifts
- Spatial patterns of current return levels are different to uplifts
- Spatial pattern of uplifts differs between different durations
- In many locations the FUTURE-DRAINAGE uplifts exceed current guidance

Questions

Part 2: Impact of the revised uplifts on sewer flooding

Professor Hayley Fowler, Newcastle University

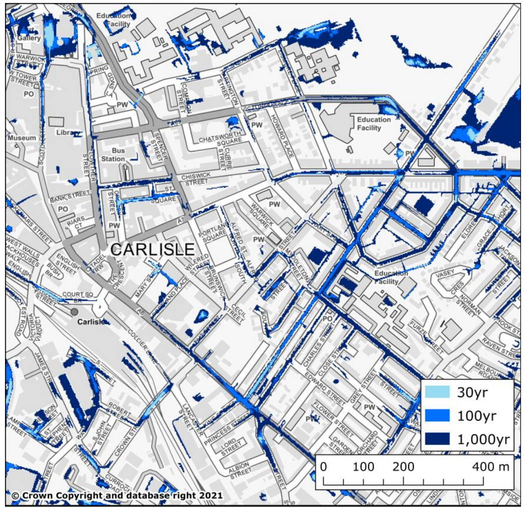
Part 2: Introduction

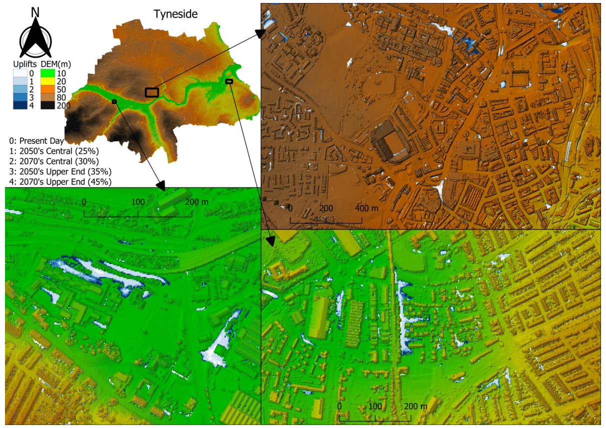
Aimed to compare outputs modelled using:

1. The RoFSW methodology, which is efficient enough to apply nationally,

2. Detailed hydrodynamic urban flood models that take into account the effect of continuous infiltration and drainage flow dynamics using a dual-drainage approach

3. Advise on whether more detailed physically-based models are needed for surface water flood predictions





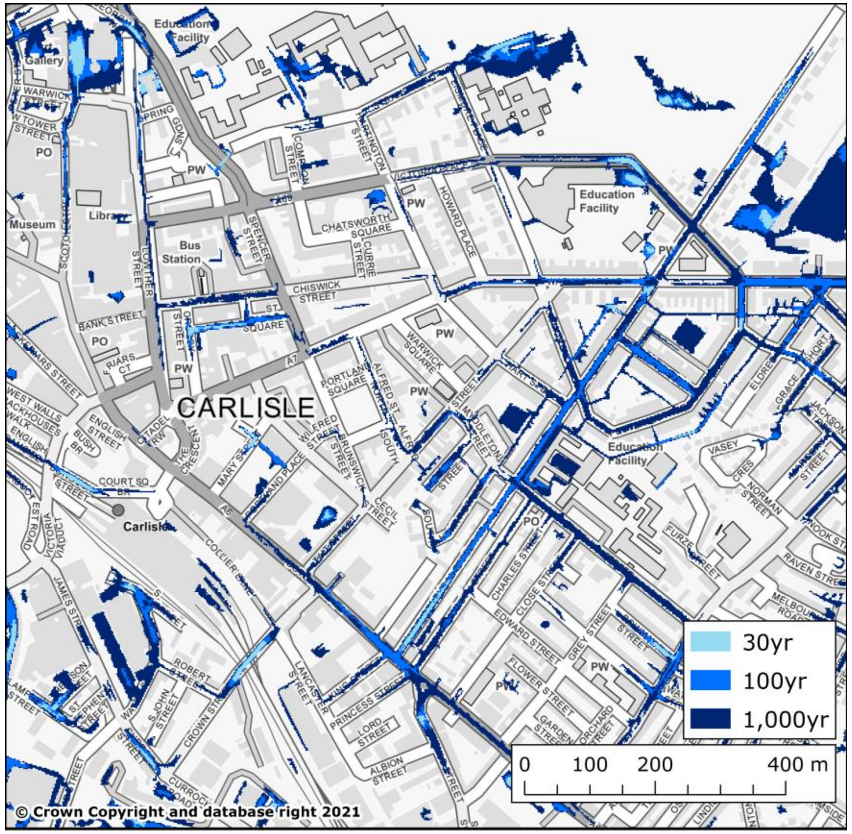
Surface water flood modelling - JBA

Murray Dale, JBA Consulting

Risk of Flooding Surface Water (RoFSW)

National-scale, present-day, surface water mapping used to assess flood risk. Comprised, in order of increasing preference:

- JBA's broadscale national JFlow® mapping
- EA approved detailed local models from the private sector, Boosting Action for Surface Water (BASW) grants, Lead Local Flood Authorities (LLFAs) projects etc.



JBA provide the annual iterative update of the RoFSW to the EA. The national scale modelling and post-processing methodologies were adopted in this research to provide comparable datasets.

Study locations

- Carlisle
- Greater London
- Greater Manchester
- Rhondda
- Tyneside

Climate Change Uplift Values

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The uplift values used for each model area varied based on the following factors:

- Region
- Epoch / Allowance
- Return Period
- Storm Duration

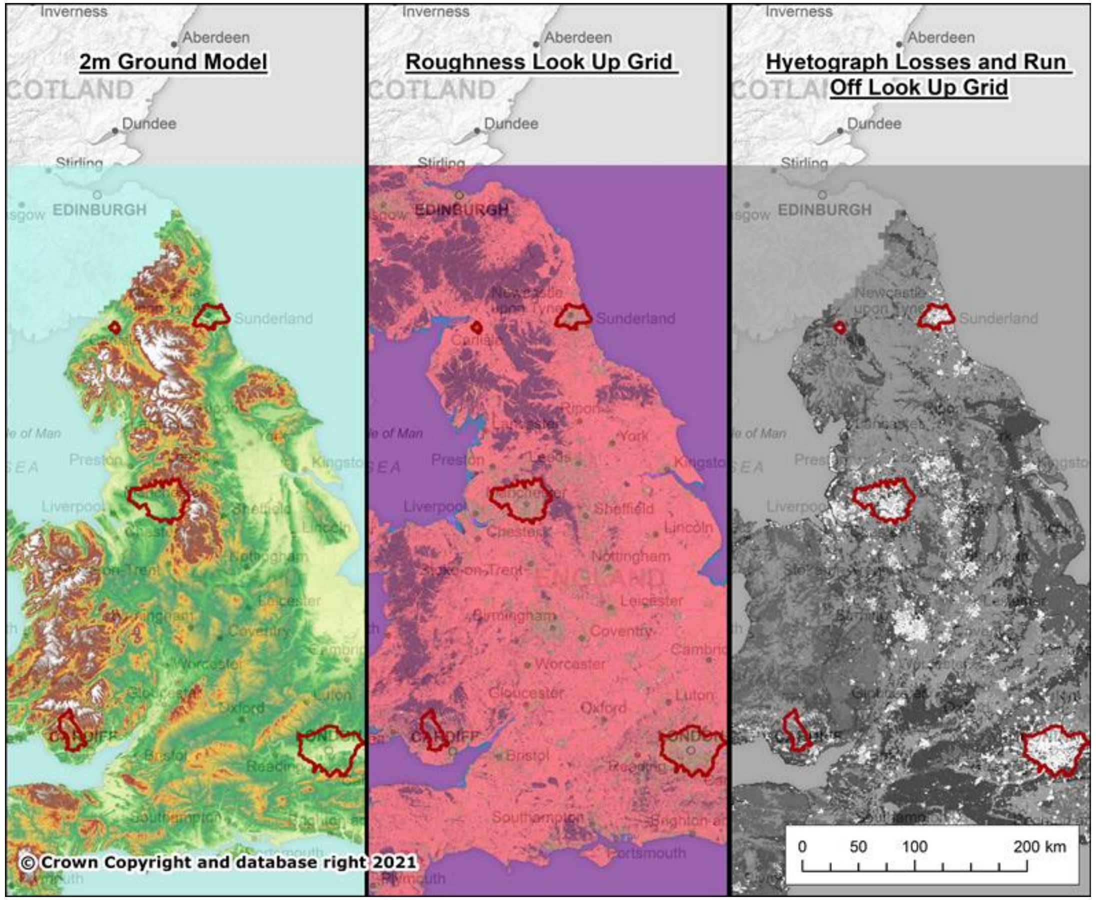
Site Name	Area	Region		30-yr											
				1-hr Duration				3-hr Duration				6-hr Duration			
		1 & 3hr	6hr	2050s C	2050's UE	2070's C	2070's UE	2050s C	2050's UE	2070's C	2070's UE	2050s C	2050's UE	2070's C	2070's UE
Carlisle	United Utilities	WNC	WNC	25%	35%	30%	40%	20%	35%	30%	40%	20%	30%	30%	40%
Greater London	Thames	SE	SE	20%	35%	25%	40%	20%	35%	25%	35%	20%	30%	25%	40%
Greater Manchester	United Utilities	WNC	WNC	25%	35%	30%	40%	20%	35%	30%	40%	20%	30%	30%	40%
Rhondda	Wales	WNC	WNC	25%	35%	30%	40%	20%	35%	30%	40%	20%	30%	30%	40%
Tyneside	Northubria	WNC	WNC	25%	35%	30%	40%	20%	35%	30%	40%	20%	30%	30%	40%

Site Name	Area	Region		100-yr											
				1-hr Duration				3-hr Duration				6-hr Duration			
		1 & 3hr	6hr	2050s C	2050's UE	2070's C	2070's UE	2050s C	2050's UE	2070's C	2070's UE	2050s C	2050's UE	2070's C	2070's UE
Carlisle	United Utilities	WNC	WNC	25%	40%	30%	40%	25%	40%	30%	45%	25%	35%	30%	45%
Greater London	Thames	SE	SE	20%	40%	25%	40%	20%	40%	25%	40%	20%	35%	25%	40%
Greater Manchester	United Utilities	WNC	WNC	25%	40%	30%	40%	25%	40%	30%	45%	25%	35%	30%	45%
Rhondda	Wales	WNC	WNC	25%	40%	30%	40%	25%	40%	30%	45%	25%	35%	30%	45%
Tyneside	Northubria	WNC	WNC	25%	40%	30%	40%	25%	40%	30%	45%	25%	35%	30%	45%

Model set-up

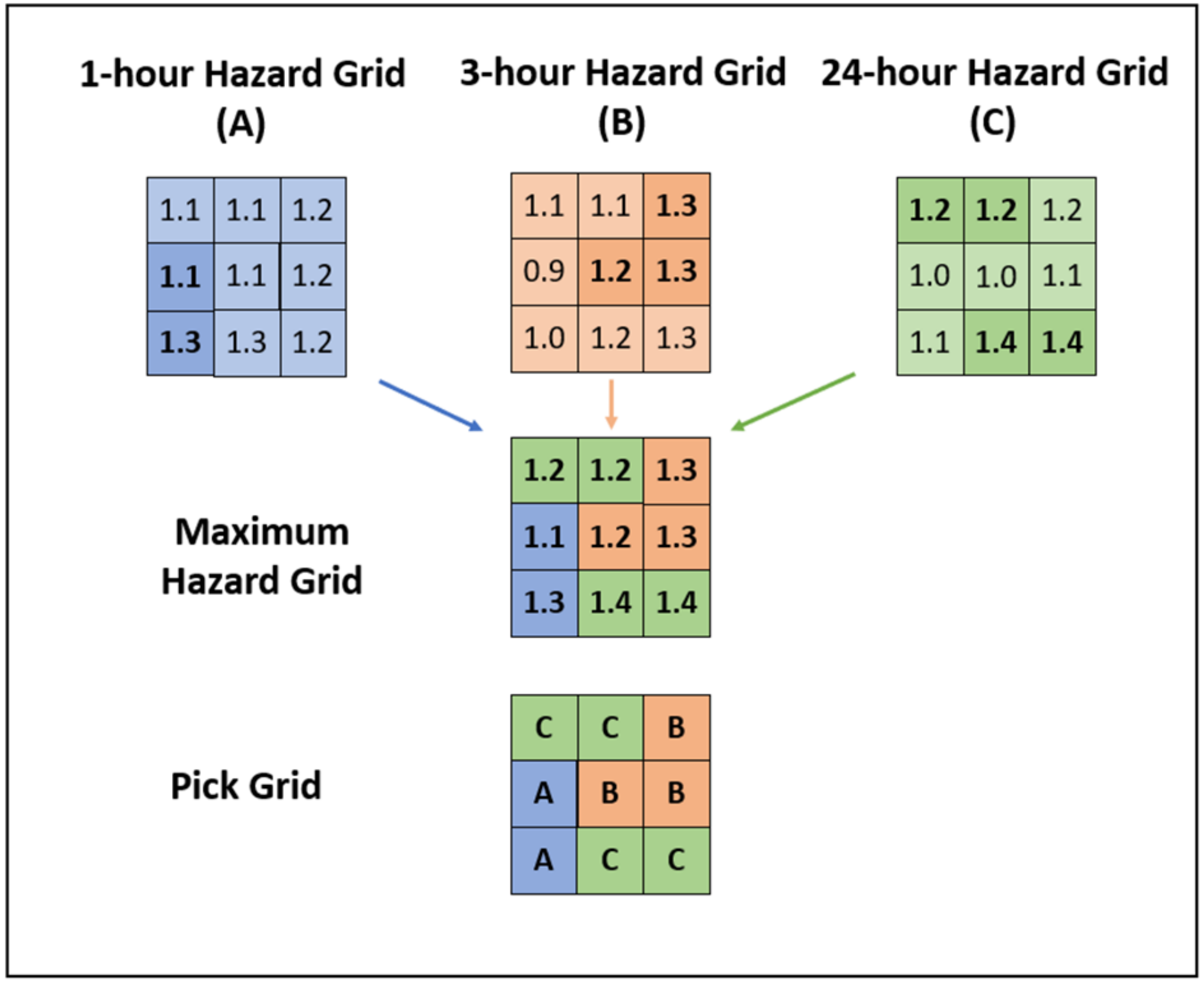
Retained model inputs:

- JFlow 7® Software
- 2m Model Resolution
- FEH 99 (uplifted to represent climate change)
- Ground Model
- Roughness Grid
- Hyetograph Loss and Run Off Grid



Post-processing

Combined Storm Durations Pick Grid Method



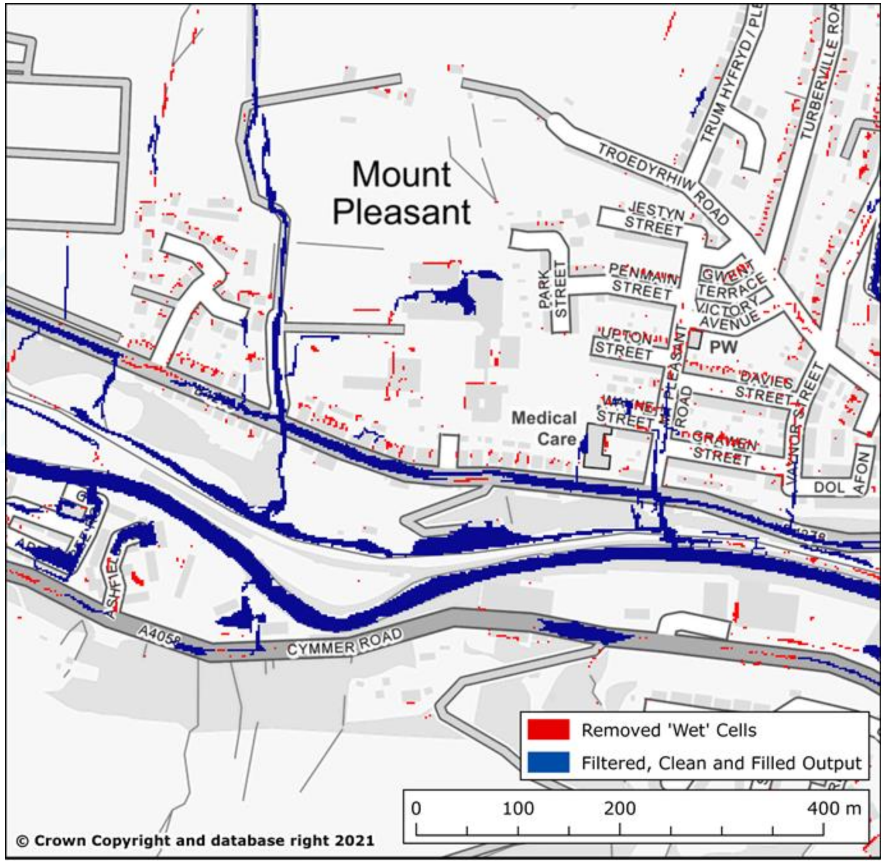
Post-processing (2)

Threshold, clean & fill

- Threshold on Hazard Index 0.575
- Filled isolated ‘dry islands’ ≤ 48m²
- Removed ‘wet’ areas ≤ 96m²

Velocity (m/s) \ Depth (m)	0.05	0.1	0.2	0.25	0.3	0.4	0.5	0.75	1	2	3	4	5
0.05	0.53	0.56	0.61	0.64	1.17	1.22	1.28	1.41	1.55	2.1	2.65	3.2	3.75
0.1	0.53	0.56	0.62	0.65	1.18	1.24	1.3	1.45	1.6	2.2	2.8	3.4	4
0.2	0.54	0.57	0.64	0.68	1.21	1.28	1.35	1.53	1.7	2.4	3.1	3.8	4.5
0.25	0.54	0.58	0.65	0.69	1.23	1.3	1.38	1.56	1.75	2.5	3.25	4	4.75
0.3	0.54	0.58	0.66	0.7	1.24	1.32	1.4	1.6	1.8	2.6	3.4	4.2	5
0.4	0.55	0.59	0.68	0.73	1.27	1.36	1.45	1.68	1.9	2.8	3.7	4.6	5.5
0.5	0.55	0.6	0.7	0.75	1.3	1.4	1.5	1.75	2	3	4	5	6
0.75	0.56	0.63	0.75	0.81	1.38	1.5	1.63	1.94	2.25	3.5	4.75	6	7.25
1	0.58	0.65	0.8	0.88	1.45	1.6	1.75	2.13	2.5	4	5.5	7	8.5
2	0.63	0.75	1	1.13	1.75	2	2.25	2.88	3.5	6	8.5	11	13.5
3	0.68	0.85	1.2	1.38	2.05	2.4	2.75	3.63	4.5	8	11.5	15	18.5
4	0.73	0.95	1.4	1.63	2.35	2.8	3.25	4.38	5.5	10	14.5	19	23.5
5	0.78	1.05	1.6	1.88	2.65	3.2	3.75	5.13	6.5	12	17.5	23	28.5

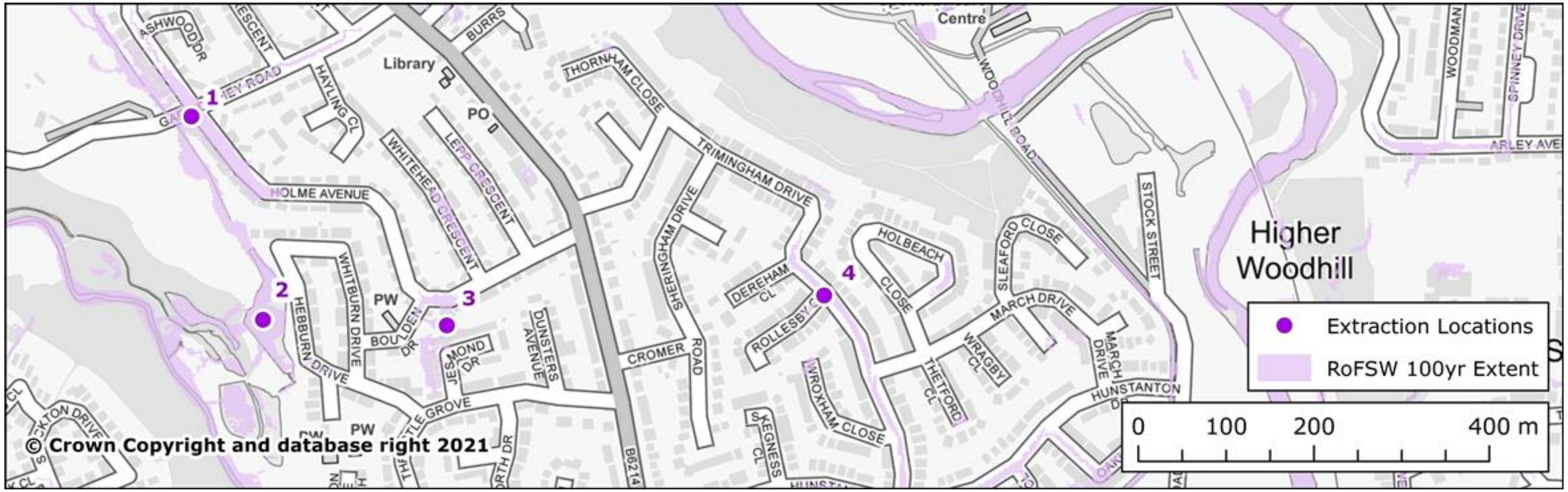
Key	Hazard Rating	Description
	<0.75	Very low hazard - caution
	0.75 to 1.25	Danger for some - includes children, the elderly and the infirm
	1.25 to 2	Danger for most - includes the general public
	>2	Danger for all - includes the emergency services



Results – Carlisle (100-year)

Results – London (30-year)

Results – Manchester (100-year)



Location	Depth (mAOD)			Hazard Index			Velocity (m/s)		
	RoFSW 100-yr Present Day	100 yr 2070's Upper End	Increase %	RoFSW 100-yr Present Day	100 yr 2070's Upper End	Increase %	RoFSW 100-yr Present Day	100 yr 2070's Upper End	Increase %
1	0.27	0.35	**30.41**	1.20	1.29	**7.29**	0.33	0.36	**7.03**
2	0.41	0.46	**10.22**	1.32	1.41	**6.99**	0.27	0.40	**47.57**
3	0.32	0.45	**42.92**	1.16	1.23	**5.86**	0.06	0.08	**43.92**
4	0.26	0.33	**28.41**	1.09	1.27	**16.93**	0.24	0.33	**40.09**
	Average Increase %		**27.99**	Average Increase %		**9.27**	Average Increase %		**34.65**

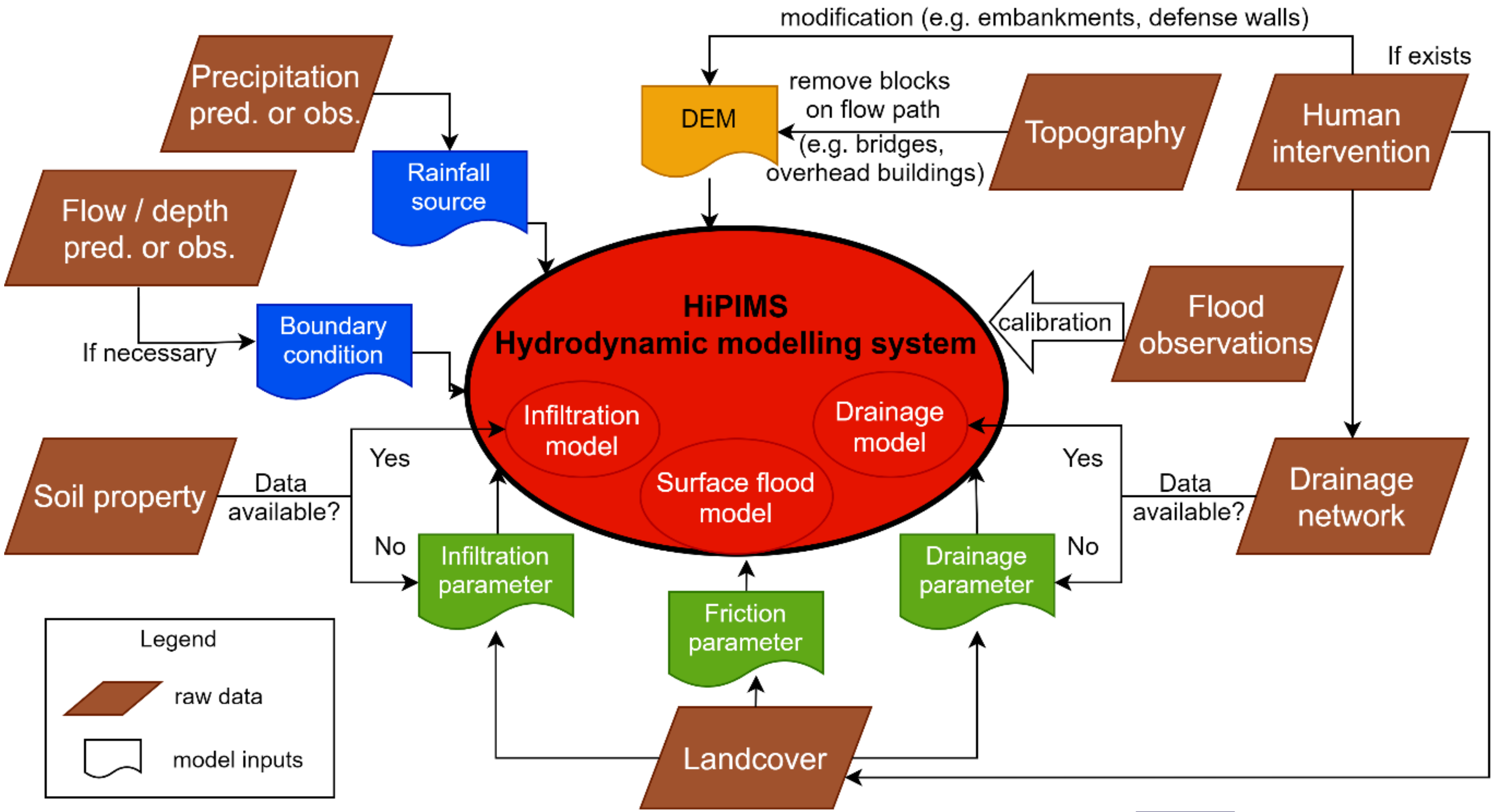
Surface Flood Modelling Using HiPIMS

Dr Xiaodong Ming, Loughborough University

Urban flood modelling

- Extreme events
- Complex topography
- Large domain
- Human intervention

- Stability
- Accuracy
- Speed
- Flexibility



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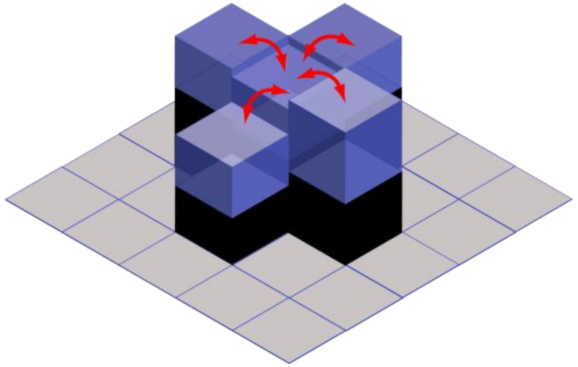
HiPIMS flood model

High-Performance Integrated hydrodynamic Modelling System (HiPIMS)



Fully physically based

- Governing equation is the full version of 2D shallow water equations

State-of-the-art numerical schemes

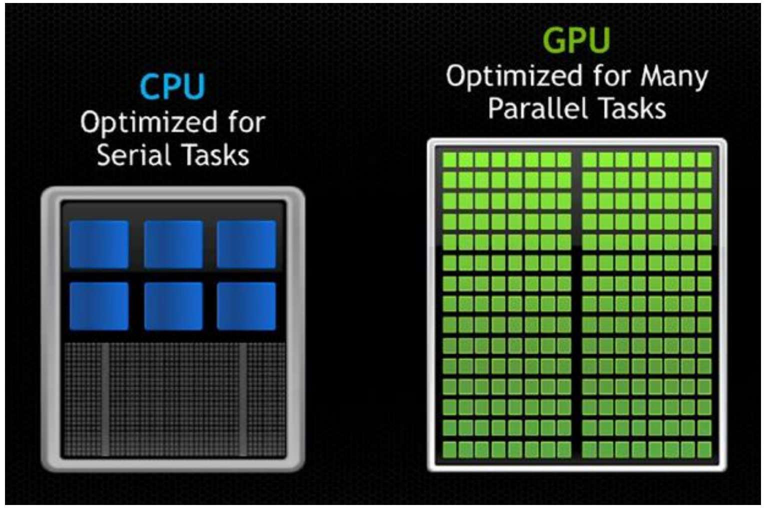
- Godunov-type scheme

Parallel computing: Multi-GPU acceleration

- CUDA/OpenCL

Improved numerical methods

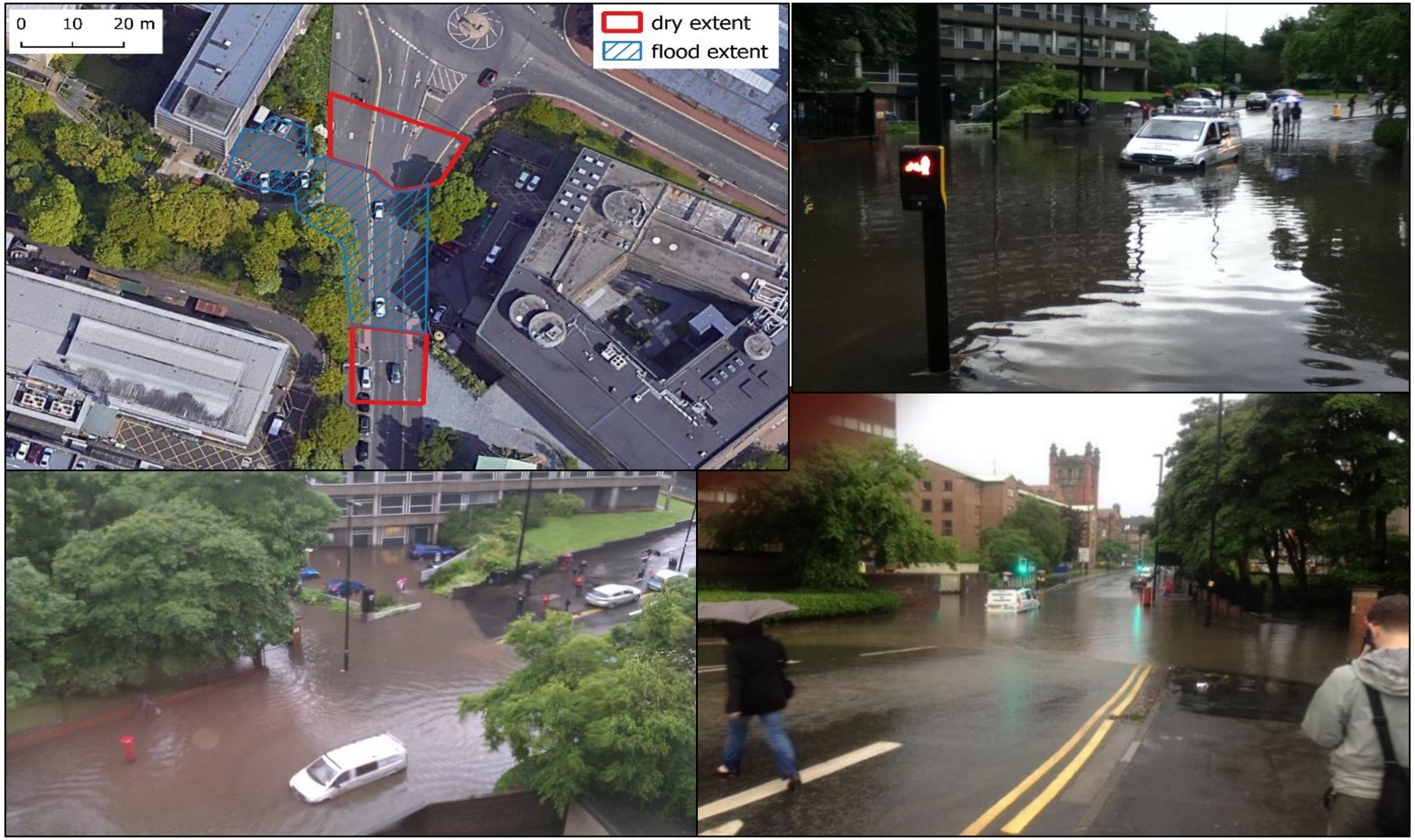
- Surface reconstruction method (SRM) for slope source terms
- Fully-implicit scheme for friction terms



HiPIMS model setup

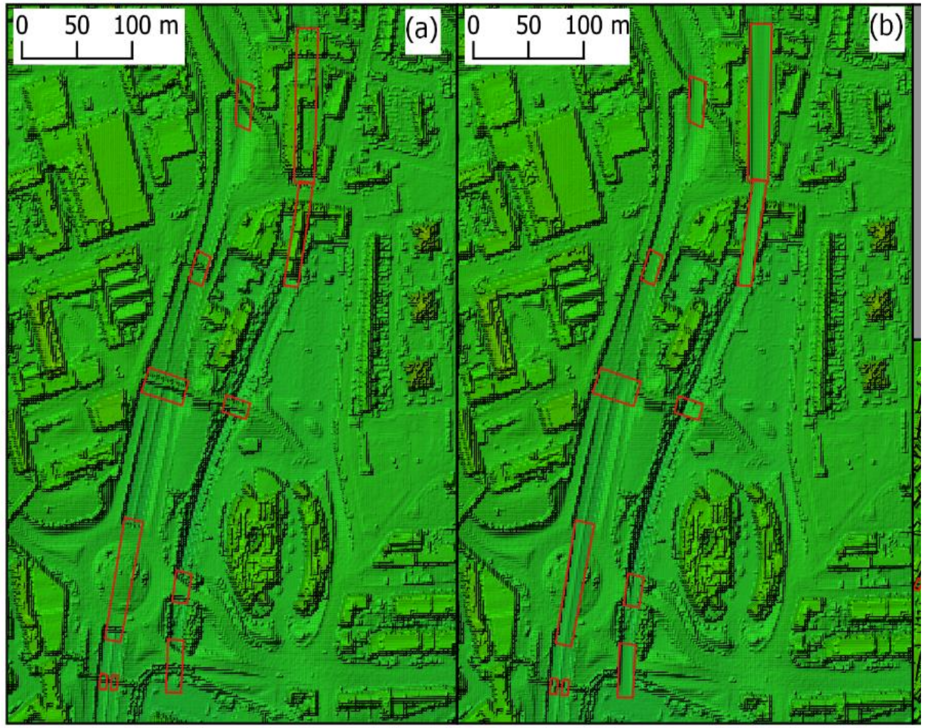
- Data
  - DEM: LiDAR DEM data (1m/2m) & OS DTM data (5m)
  - Landcover: OS Mastermap (high resolution) & Land Cover Map Great Britain 25m
  - Crowd-sourced photos
  - Rainfall (NIMROD radar observation)
- Parameter (EA suggestion)
  - Infiltration: 30% reduction to rainfall
  - Drainage: 12 mm/h reduction to rainfall
- Parameter
  - Infiltration: unpaved land/paved land
  - Drainage on road surface : city centre/suburban region

HiPIMS model setup



Observations from crowd-source data

DEM edit



HiPIMS model setup

View on Queen Victoria road at 16:40

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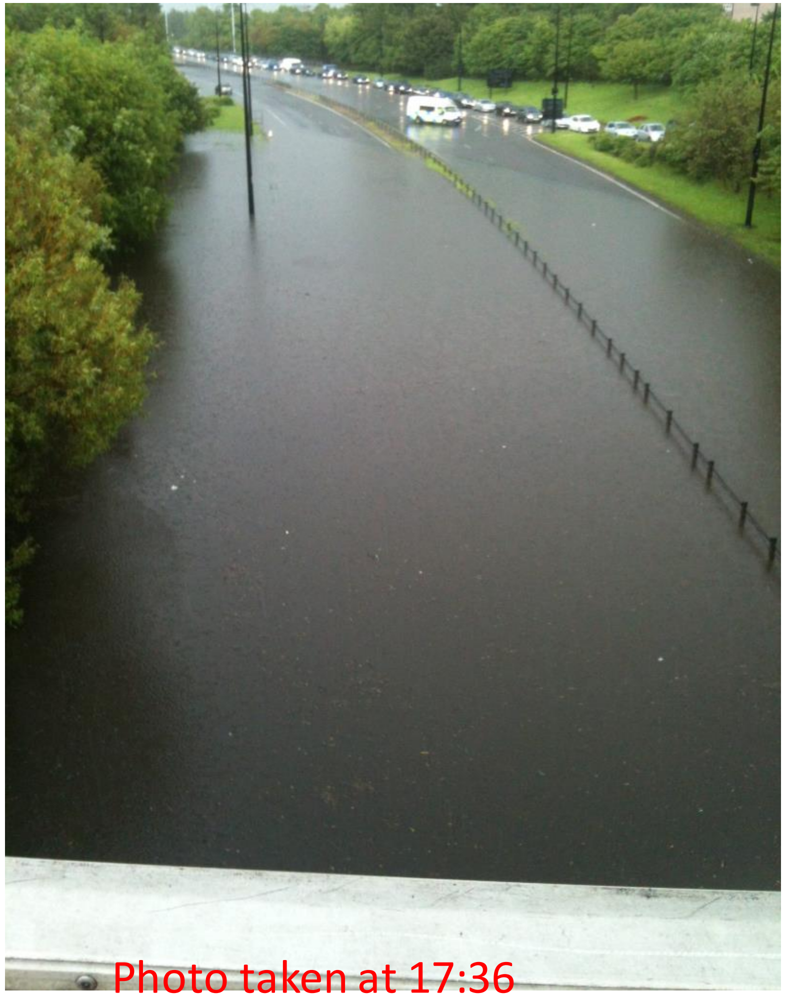
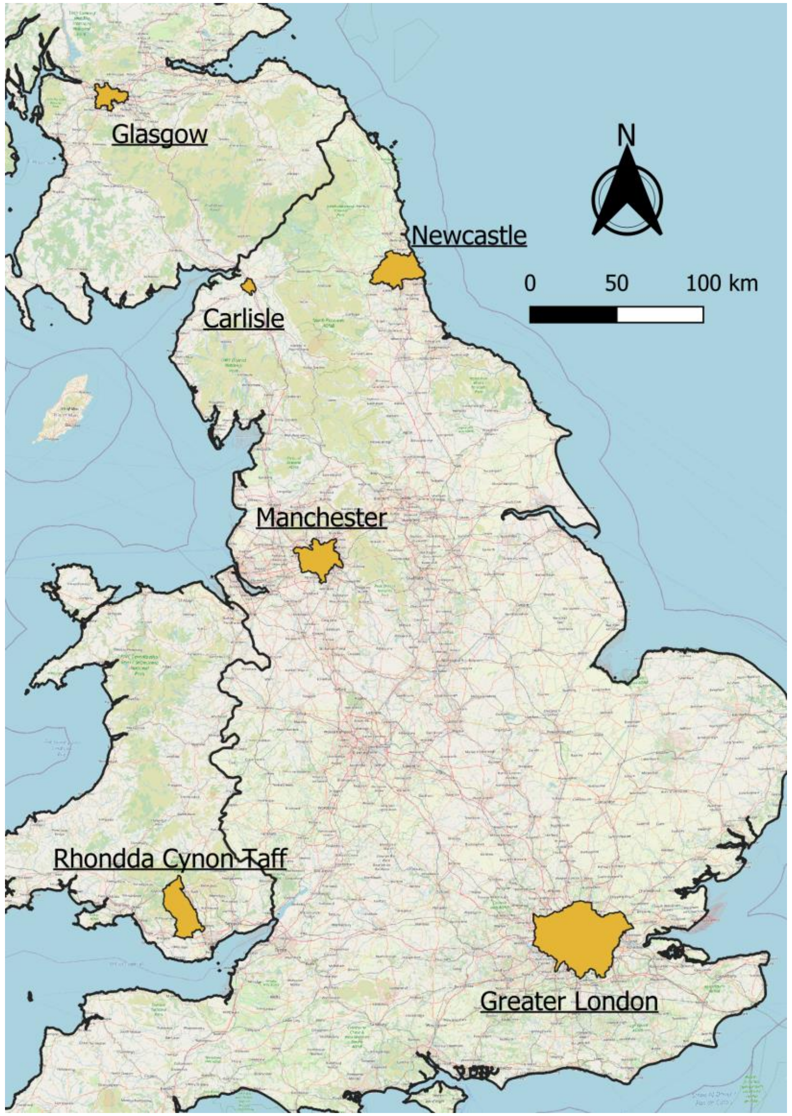
HiPIMS model setup



View on a bridge over A167 road

Research sites



City	Area (km²)	Res	Valid cells (Million)
Newcastle	411	2m	102.8
Glasgow	176	5m	7.0
Manchester	387	5m	15.5
Carlisle	47	1m	47.0
London	1595	5m	63.8
Rhondda	424	5m	17.0

Rainfall scenarios

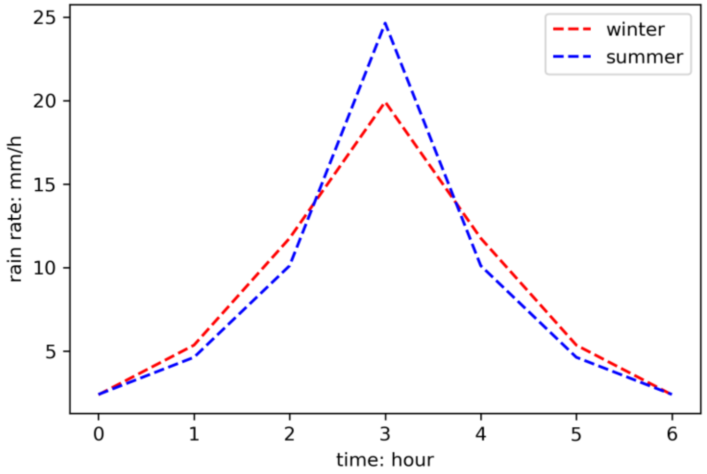
- Return periods
  - 30 years, 100 years
- Durations
  - 1-hour, 3-hour, 6-hour
- Ensemble members
  - 2050 Central estimate (50^{th})
  - 2050 Upper estimate (95^{th})
  - 2070 Central estimate (50^{th})
  - 2070 Upper estimate (95^{th})
- Number of simulations
  - 30 for each city
  - 180 in total

Flood Estimation Handbook Web Service

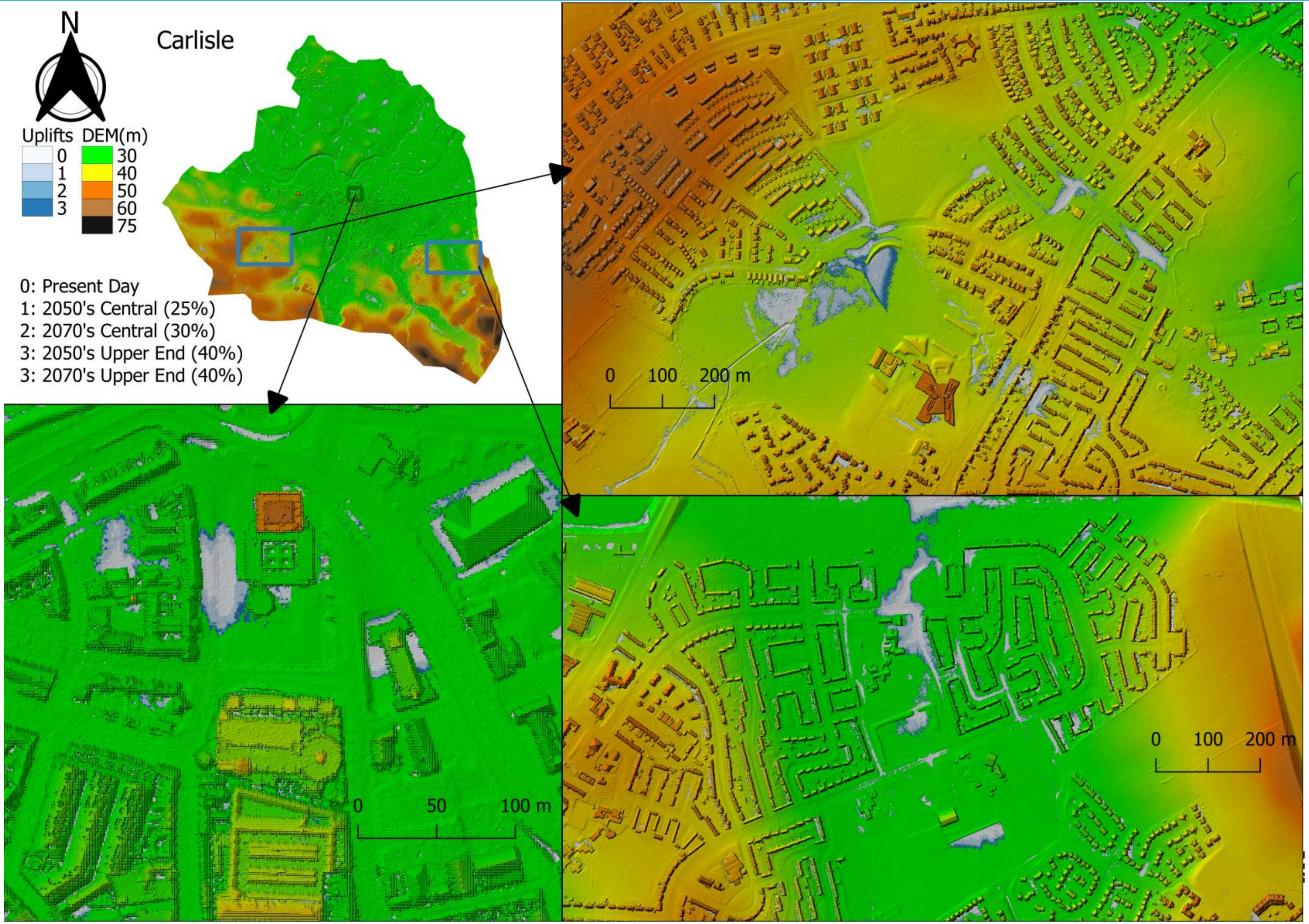
FEH 2013 DDF

Micro-FSR (Flood Study Report) formula

Rainfall profile

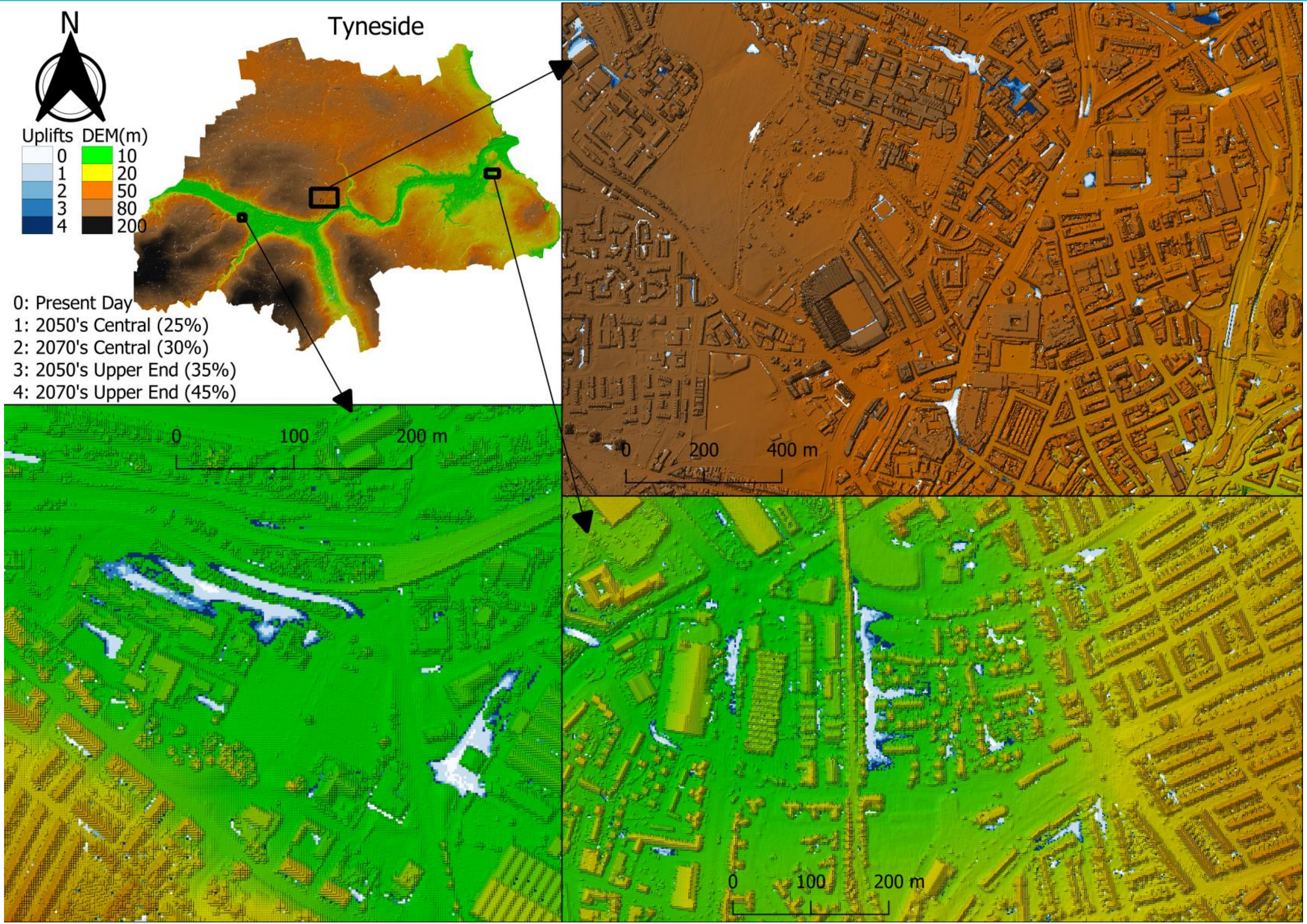


Simulated results



Carlisle:
1 hour
100 year

Simulated results



Newcastle:
6 hour
100 year

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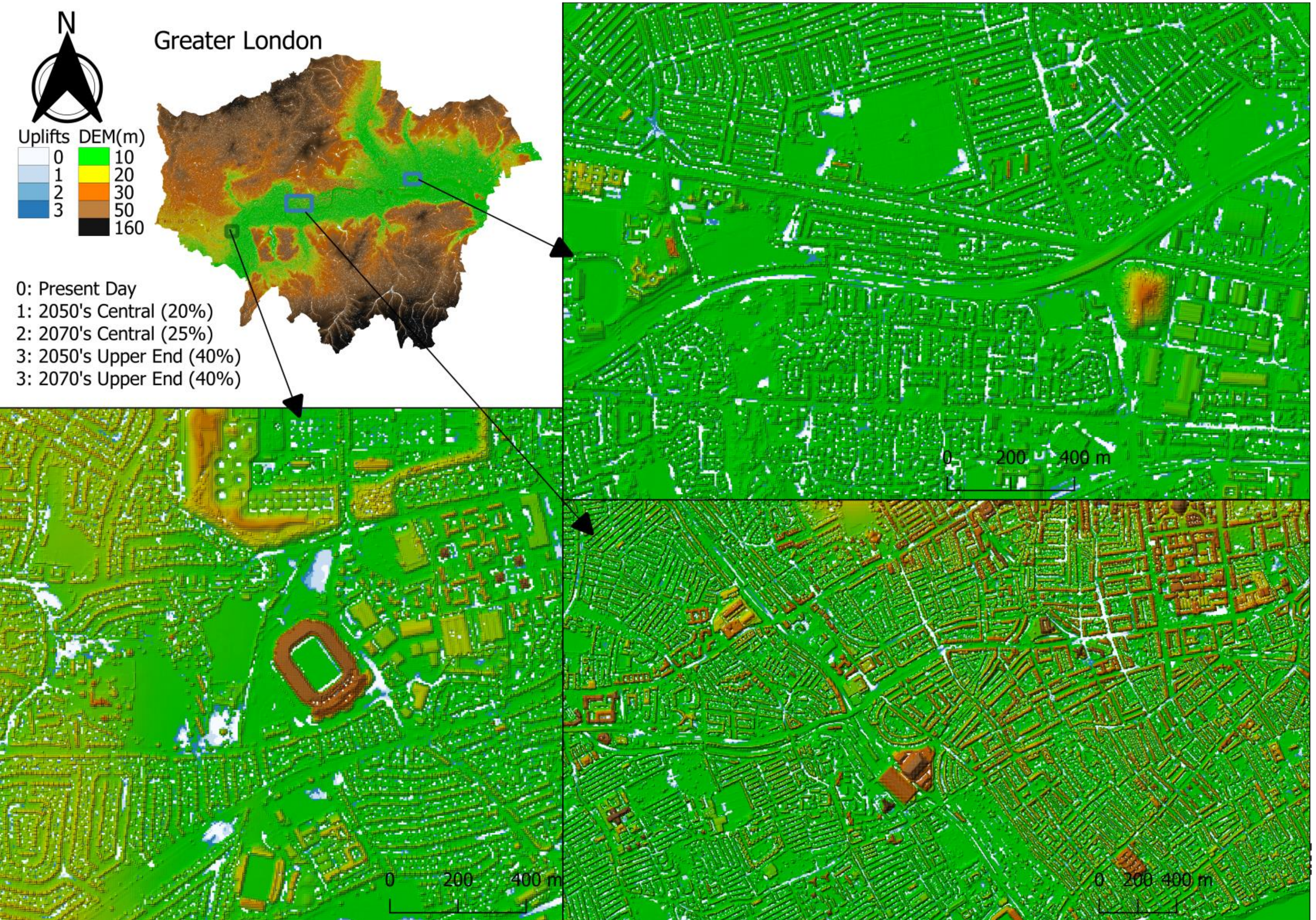
Simulated results



Greater London:
3 hour
100 year

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Simulated results: Changes

Flood Depth (>=, m)	Rainfall uplifts				
	0%	25%	30%	35%	40%
	Inundated area(m^2)	Inundation increase (%)			
2	11.0	154.55	190.91	290.91	400
1	635.0	234.96	304.57	387.87	509.92
0.5	10744.0	151.68	188.65	230.58	276.64
0.3	50539.0	139.08	173.03	209.34	246.56
0.2	154960.0	107.87	132.32	156.79	182.88

Carlisle results (1hr 30yr)

Simulated results: Changes

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Flood Depth (>=, m)	Rainfall uplifts			
	0%	25%	30%	40%
	Inundated area(m^2)	Inundation increase (%)		
2	45.0	373.33	484.44	697.78
1	3161.0	166.43	207.28	312.81
0.5	35803.0	124.89	156	222.51
0.3	157312.0	90.68	111.51	154.79
0.2	399982.0	70.57	85.08	114.51

Carlisle results (1hr 100yr)

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Simulated results: Changes

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City	2050s C		2050's UE		2070's C		2070's UE	
Carlisle	25%	90.68%	40%	154.79%	30%	111.51%	40%	154.79%
Glasgow	25%	48.31%	40%	75.75%	30%	57.47%	40%	75.75%
Greater London	20%	60.90%	40%	114.61%	25%	76.10%	40%	114.61%
Greater Manchester	25%	83.62%	40%	137.22%	30%	101.69%	40%	137.22%
Rhondda	25%	41.93%	40%	65.51%	30%	48.89%	40%	65.51%
Tyneside	25%	81.29%	40%	137.44%	30%	99.48%	40%	137.44%

1hr 100yr , inundation >= 0.3m

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Simulated results: Changes

City	2050s C		2050's UE		2070's C		2070's UE	
Carlisle	25%	139.08%	35%	209.34%	30%	173.03%	40%	246.56%
Glasgow	25%	68.38%	35%	96.25%	30%	82.26%	40%	110.66%
Greater London	20%	80.44%	35%	154.56%	25%	103.94%	40%	181.60%
Greater Manchester	25%	111.99%	35%	168.84%	30%	139.77%	40%	199.29%
Rhondda	25%	52.46%	35%	73.59%	30%	63.24%	40%	83.86%
Tyneside	25%	91.12%	35%	146.40%	30%	110.84%	40%	173.65%

1hr 30yr , inundation >= 0.3m

Conclusions

- JBA and Loughborough results both indicate that there will be increased flood impacts in urban areas as a result of the changes
- Different input data and modelling methodologies result in some (unexplored) variation in the results
- Maps showing extent of flooding changes may not tell the full story
- More in-depth analysis could point to impacts related to properties and critical infrastructure affected, damage costs and the role modelling methodology plays in estimating impacts

Questions

Contact details

Website: www.ukclimateresilience.org

Twitter: @UKCRP_SPF

YouTube: UK Climate Resilience programme

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The UK Climate Resilience programme is supported by the UKRI Strategic Priorities Fund.
The programme is co-delivered by the Met Office and NERC on behalf of UKRI partners AHRC, EPSRC, ESRC.