The sensitivity of urban pluvial flooding to the temporal distribution of rainfall

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Introduction

- Pluvial flooding:
  - Water from sky > water evacuated from ground
- Risks lives/homes/livelihoods
  - Pluvial flooding is BAD!
- Accurate models can help protect us
  - Rapidly developing, recent advances etc
  - Still gaps in understanding how flooding is impacted by the *characteristics* of rainfall events
    - (i.e. not just their total rainfall depth)

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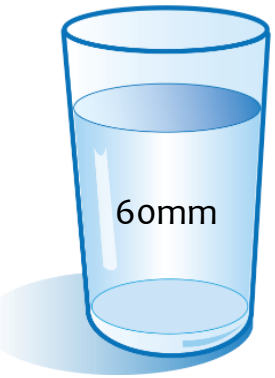
Current assumptions

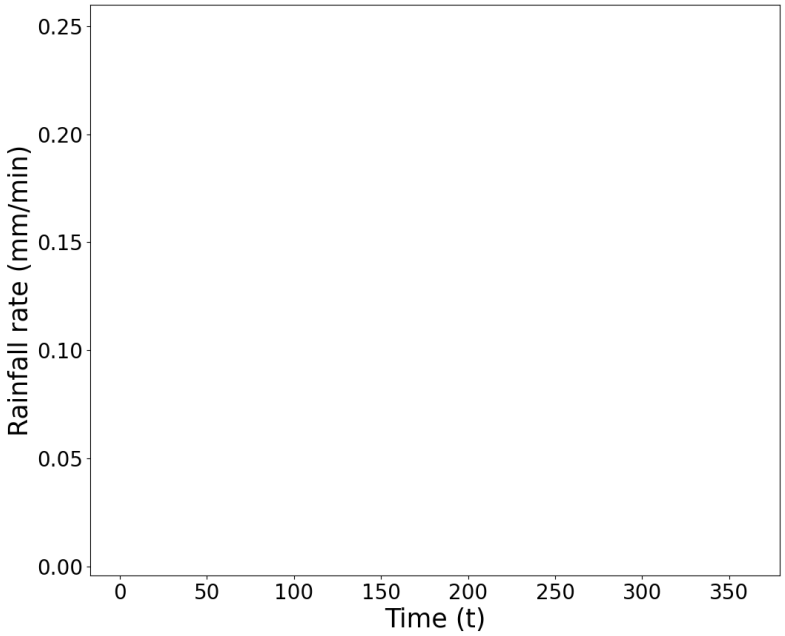
- How rainfall is distributed over time during extreme rainfall events
  - The UK assume this is the *only* way

6 hours



1-in-100 year return period event

Hyetograph



Not just UK (lots of other countries make similar assumptions!)

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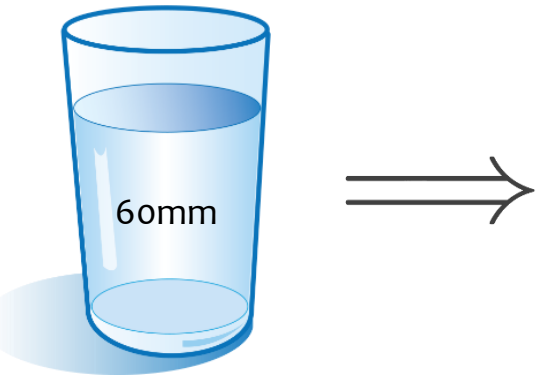
New evidence

- How rainfall is distributed over time during extreme rainfall events
  - Infinite variety

6 hours



1-in-100 year return period event

- Studied 70,000 extreme UK events
  - Distilled to summary profiles for different durations

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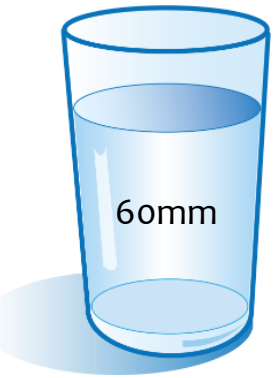
Villalobos Herrera, R., 2022. *Great British Rainstorms–An events-based characterization of the properties of sub-hourly to daily annual maximum producing rainfall events* (Doctoral dissertation, Newcastle University).

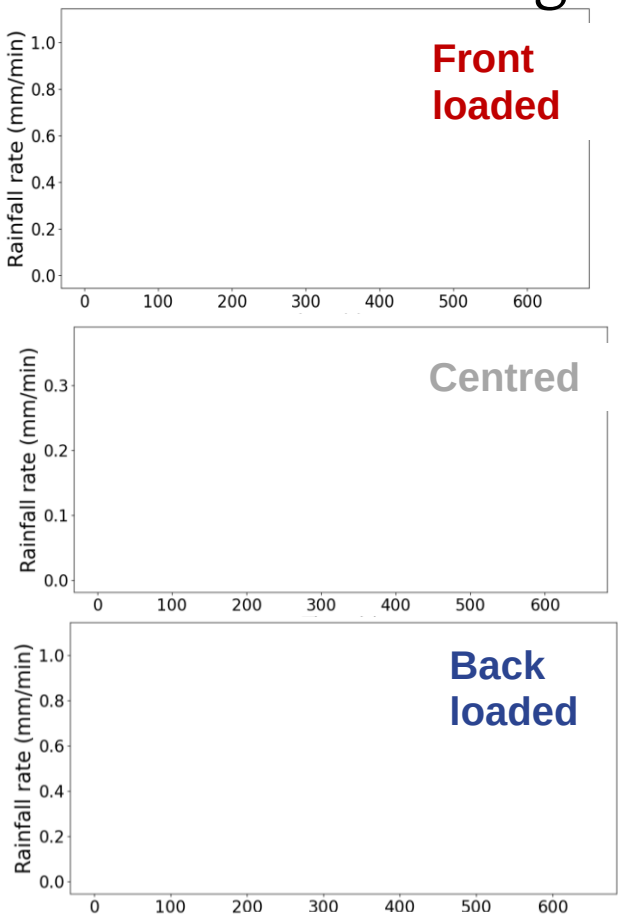
New evidence

- How rainfall is distributed over time during extreme rainfall events
  - ➢ Infinite possibilities!

6 hours



1-in-100 year return period event



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Does it matter?

- Rainfall is distributed over time in rainfall events in many different ways
  - But does this matter? (for pluvial flooding?)

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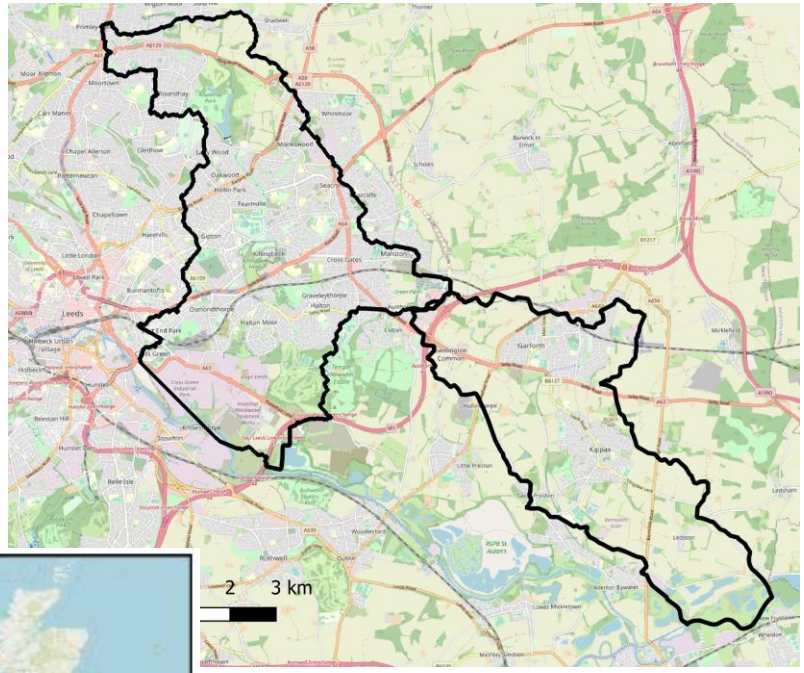
Let's find out!

- Rainfall is distributed over time in rainfall events in many different ways
  - ➢ But does this matter? (for pluvial flooding?)



- Experiments using two urban catchments in Leeds
  - (north of England!)

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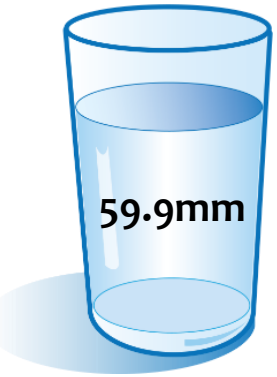
Catchment experiments

Rainfall depth → **Hyetograph** → **Flood model** → **Outputs**

i.e. the distribution of rainfall over time



6hr, 100 year return period

2 catchments, Leeds

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Catchment experiments

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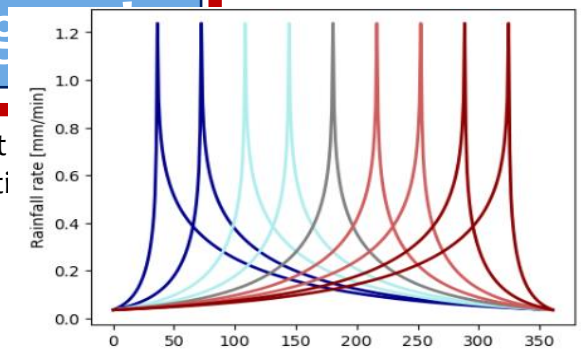
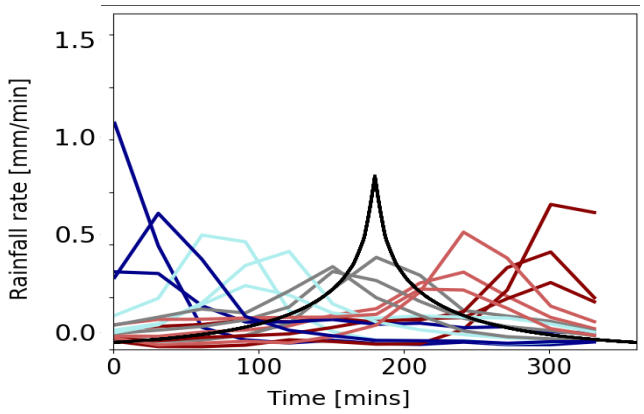


- 9 profiles
  - 1 centred, symmetrical profile
  - 4 **front loaded** and 4 **back loaded** versions
  - Not physically realistic, but allow isolated testing of timing of peak

Observed



- 15 profiles
  - From Villalobos-Herrera (2022)
  - 6 **front loaded** and 6 **back loaded** versions, 3 centred
  - Physically realistic, with variations in both **timing** and **magnitude** of peak intensity

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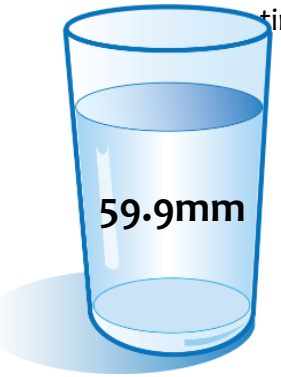
Catchment experiments

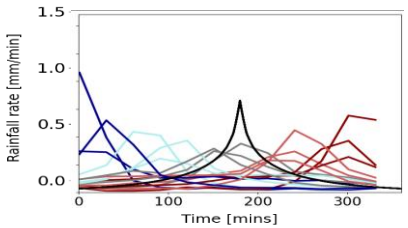
Rainfall depth

i.e. the distribution of rainfall time

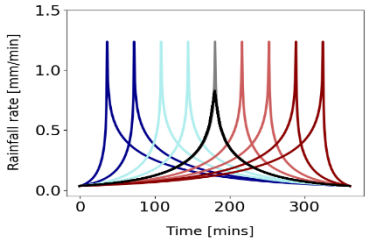


6hr, 100 year return period

Observed



Idealised



Flood model

2 catchments, Leeds

Outputs

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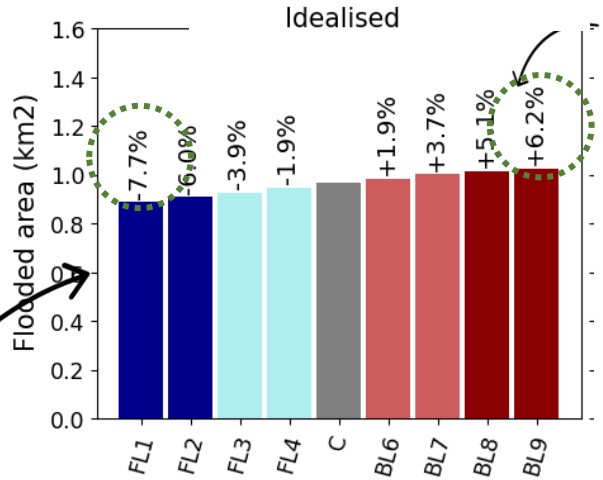
Results

Total area affected by flooding

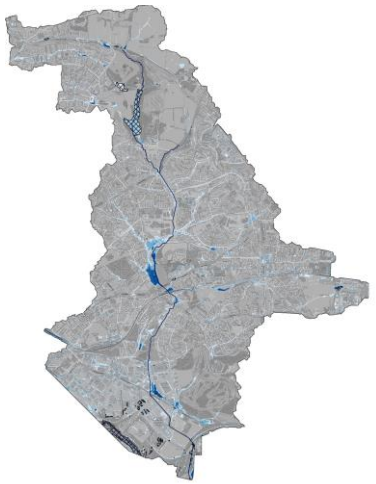
(excluding areas of permanent water)

Outputs

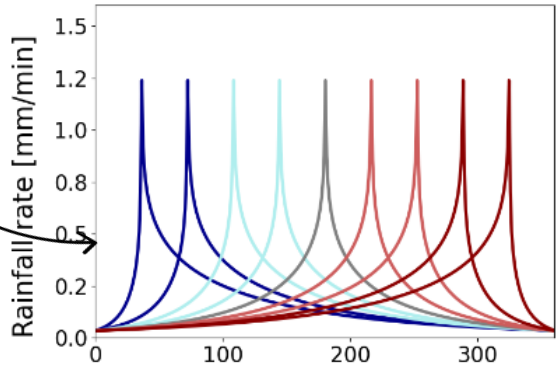
% Differences relative to centred profile



Most back loaded profile: *Largest flooded area*



Most front loaded Profile: *Smallest flooded area*



(* Result here for just one of the catchments)

Back loaded profiles lead to more extensive flooding

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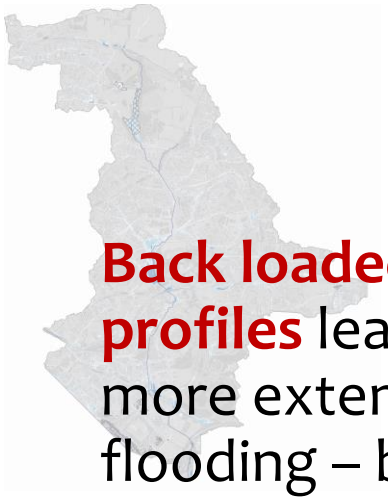
Results

Outputs

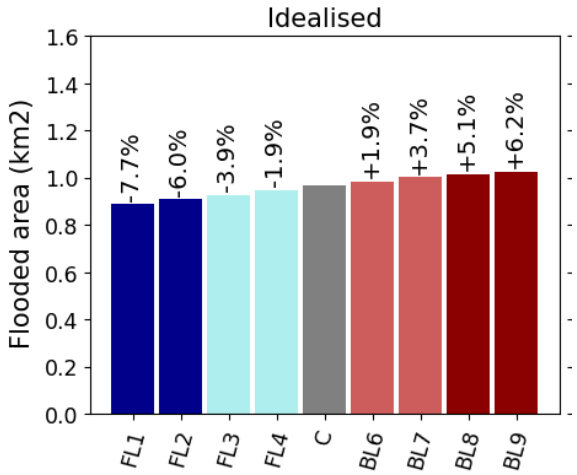


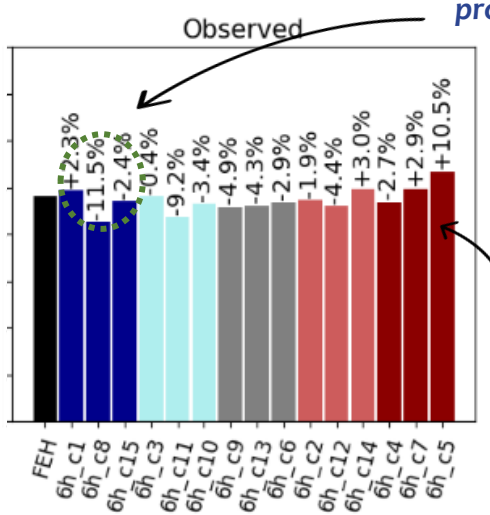
Back loaded profiles lead to more extensive flooding – but magnitude of peak still very important

Total area affected by flooding

(excluding areas of permanent water)

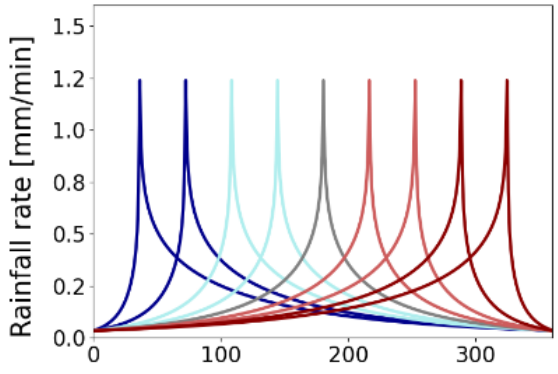
Least flooding: ***Front loaded profile***

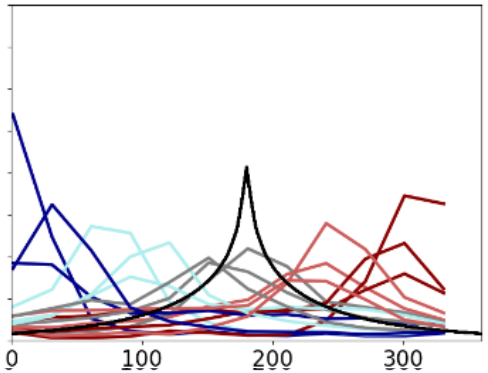




% Differences relative to ***centred*** *profile*

Most flooding: ***Back loaded profile***





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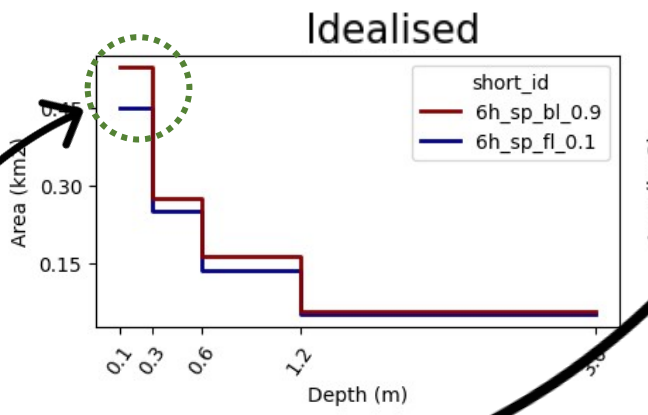
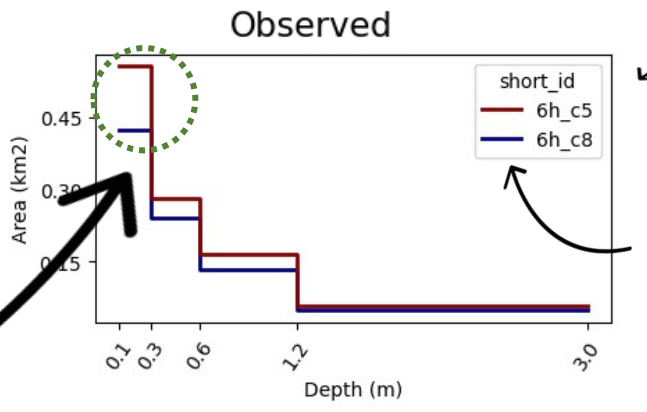
Results

Outputs

Flood severity (depth)
(excluding areas of permanent water)





Most back loaded profile

Most front loaded profile

Around 60% of extra flood affected area is of 0.1-0.3m depth

Extra flooding in **back loaded** profiles is mostly extension of shallower areas, but also some extra deep(er) flooding

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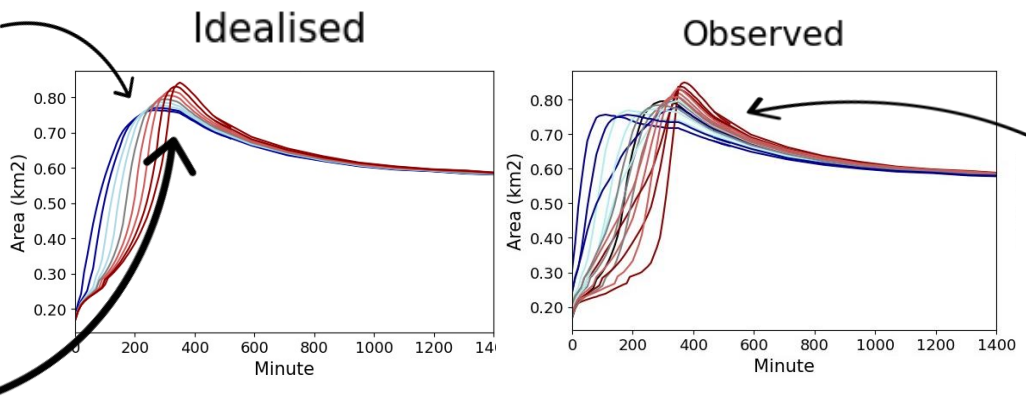
Results

Outputs

Flooded area over time
(excluding areas of permanent water)

Maximum flooded area occurs earlier in ***front loaded profile***

.. and is only 89% as big as for the ***back loaded profile***



Same trends.

Even greater differences in timing of peak

but more noisy

Back loaded profiles reach their maximum flooded extent later, and this area is bigger

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Key findings

Temporal distribution of rainfall in events *does* matter for pluvial flooding

- Idealised profiles show:
  - ➢ Clearly and systematically that profiles with **later peaks in intensity**, lead to more extensive and severe flooding
- Observed profiles show:
  - ➢ Corroborate this, but make clear that the magnitude of the peak also plays a strong part
  - ➢ Failing to represent true range of temporal distributions may lead to mis-specification of the pluvial flood risk

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NB: Candidate for BYST ☺

Thank you and Questions

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