Wetropolis: a public engagement project on the science of flooding

Onno Bokhove[1], Wout Zweers[2], Tom Kent[1] and Tiffany Hicks[1]

[1] School of Mathematics, University of Leeds, Leeds, UK; [2] Wowlab, The Netherlands

UNIVERSITY OF LEEDS

Extreme weather

Is it going to rain more in the future?

Probably not, but there is likely to be greater regional and seasonal variation in rainfall and more extreme rainfall events.

The UK has already seen an increase in the frequency of heavy winter rainfall events in the past 45 years.

What is extreme precipitation?

Downpours/flash floods describe heavy rainfall over a short time period (e.g. one hour, as in the Hebden Bridge floods of 2012).

Sustained rainfall describes rainfall over much longer periods (e.g. Leeds Boxing Day 2015 floods where Bingley received 96mm in 48 hours).

Can we predict flooding?

Forecasting requires large datasets but extreme weather events are rare! It is particularly difficult to predict new record-breaking floods as there is no comparable data.

Furthermore, standard statistical techniques do not predict extreme events well. Tackling this uncertainty is a key challenge.

However, sustained rainfall and river flooding are relatively easy to predict, as done by the Met Office and Environment Agency.

Can we control and/or mitigate flooding?

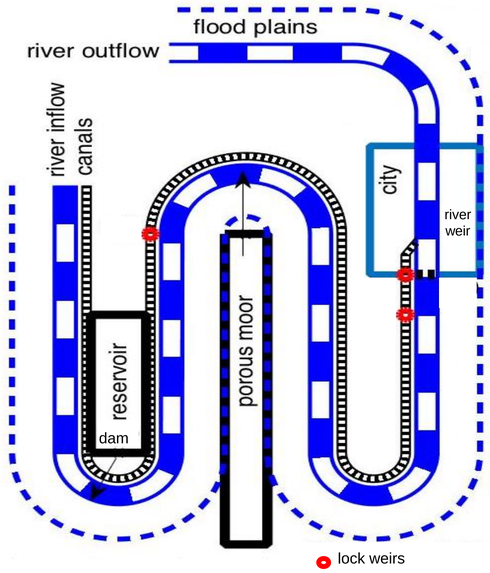
We can reduce flood risk by creating space for water (e.g. by merging waterways, as in Leeds city centre, and widening riverbeds). Water levels can also be managed using sluice gates and weirs, which can be controlled by mathematical models.

In some areas, natural flood management (e.g. tree planting and wetland creation) can store or slow down water flow.

Infrastructure can be adapted to protect communities from flooding. Houses on stilts are common in some areas of the world including South East Asia. In the Netherlands, amphibious homes float when water levels rise.

Wetropolis and the role of mathematics

Wetropolis is an interactive model of extreme rainfall and river flooding in an urban environment.
Mathematical techniques are used to model different rainfall scenarios over the course of a Wetropolis day (10 seconds).
The occurrence of flooding is determined by rainfall on the current and previous days, as in the real world.



Mathematics is integral to:

- The design process – fluid dynamics enables the time- and length-scales of Wetropolis to be determined before construction. The rainfall simulator uses ideas from probability and statistics to mimic reality.
- The testing and validation of computational models – once constructed, we can use Wetropolis to validate complex numerical models for flood prediction and as a testbed for flow control and data assimilation.

Wetropolis uses two modified Galton boards to randomly determine:
1) Rainfall amount (1 second, 2 seconds, 4 seconds, or 9 seconds)
2) Rainfall location (moor, moor and reservoir, reservoir, or no rainfall)

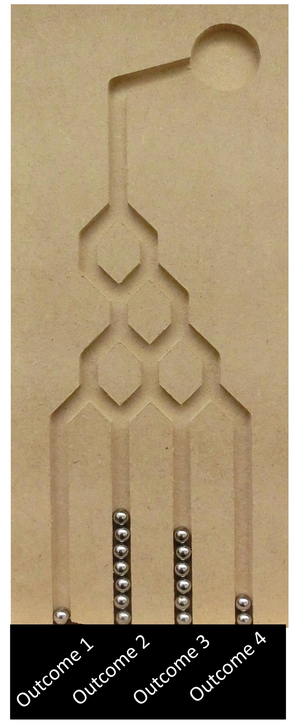
Ball bearings travel down each board and land in one of four columns. Each column represents a possible rainfall outcome. At each junction, there is a 50% chance of the ball going left or right.

The Galton boards demonstrate the principles of probability. Common conditions (e.g. moderate rainfall) occur frequently but rare events (e.g. heavy rainfall) occur infrequently, as in the real world. Consecutive extreme events are very rare but can and do occur.

Watch the water level change inside the moor. Moorland helps to control the risk of flooding to towns and villages by storing more water in the landscape and slowing its passage downstream.

Imagine a ball travelling down through the board. What is the probability of it ending up in the third column from the left?

What is the most extreme rainfall event that can occur in Wetropolis in a single (10 second) day?



The Leeds Boxing Day 2015 floods were caused by maximum rainfall scenarios (e.g. nine seconds over moor and reservoir) occurring on two consecutive days.

Wetropolis is a public engagement project awarded by the Maths Foresees network. Maths Foresees is funded by the Engineering and Physical Sciences Research Council (EPSRC) under the Living With Environmental Change (LWEC) umbrella.

Get in touch!

facebook.com/resurging.flows
@MathsForesees