School of Mathematics

FACULTY OF MATHEMATICS AND PHYSICAL SCIENCES

UNIVERSITY OF LEEDS

MATH3001
Flood Analysis

use LaTex?

Assessing and communicating mitigation of river floods to policy makers and the general public

better title, also distinctive.

- Discuss how your work fits within team and make it distinctive

ANTONIA FEILDEN (I.D 200989495)

- restructure
  - expand.
    a) Read two other reports
    b) let two other people read yours plus any comments
    c) make a new interim report 2 weeks after exams
    d) Share again e) make improvement.

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Needs to be latex

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verification testing recodes in R/python

1. INTRODUCTION

1.1. PROJECT OBJECTIVES

The objectives of this project are

(i) to analyse (river-gauge) data of 6-12 (more extreme) river floods in the UK as a team why?

(ii) to make a cost-effectiveness analysis for each based on flood-excess volume and flood policies

(iii) to communicate findings to policy makers and the public. (and peers)

Expand: personal choices etc

1.2. RELEVANT FIELDS

Expand

This project incorporates the following fields of mathematics:

- Computation (Python 3.2)
- Fluid Dynamics
- Financial (Cost-effect analysis)
- Error analysis
- Statistics

Other fields incorporated include Business and Politics. Outline.

1.3. IMPORTANCE OF FLOODING

A flood is defined as *"a great flowing or overflowing of water, especially over land not usually submerged."*[1] partial sentence

The frequency of extreme flooding in the UK has been predicted to increase with climate change. 17,000 properties were affected by flooding in the winter 2015-2016 in the north of the UK. December 2015 has been reported as the wettest month ever recorded. [2]
In 2017, flooding was a natural hazard identified as a major threat to the UK on the UK's Risk Register. [3]

four recorded

There are ~~4~~ main categories of flooding: **fluvial** (caused by a river bursting its banks), **pluvial** (caused by surface water run-off), **coastal** (caused by extreme tidal conditions) and **reservoir** (caused by dam failure). [4]

the

This project studies river floods. Fluvial, pluvial and reservoir flooding are in scope of this project whilst coastal flooding is out of scope.

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1.4. KEY DEFINITIONS,CONCEPTS & EQUATIONS

horizontal

no indent

1.4.1. Stage h/m

The height of the river in meters.

$h(x,y,t)$!

no indent

dependencies

h is recorded in-situ on river using appropriate instrumentation.

$\bar{h}(x,t)$

$\bar{h}$ is the mean stage over the cross sectional area of the river. $\bar{h} \approx h$ as a river's free surfaces varies little along its cross sectional profile.

h_t is the threshold height. This is defined as the stage for which $h > h_t$ is considered to be a flood. h_t is determined empirically by a review of historical data and field observations.

h_{max} is the maximum stage during a defined time interval.

h_m is the arithmetic mean of multiple measurements of h over a defined time interval and can be calculated using the following formula

define N, the

$$h_m = \frac{1}{N}\sum_{k=1}^{N} h(t_k),$$

Where subscript k is the time index and denotes the time interval at which h was recorded.

$\bar{h}$

1.4.2. Discharge Q/m³

A rating curve is a graph used in hydrology which shows the relationship between the discharge volume of a river $Q = Q(\bar{h})$ (m³) as a function of the stage h (m).

The rating curve equation for $Q(h)$ has the following form

uniform use

$\bar{h}$

$$Q(\bar{h}) = C_i(h - a_i)B_i ,$$

term

have units

Where C_i, a_i, B_i are parameters which have been fitted using historical data and in-situ measurements of the river. The subscript i denotes the interval for the range of h values for which the parameters are valid.

Q_{max} (m³) is the maximum discharge of the river over a defined time interval. It can be measured directly or calculated using the rating curve equation.

$$Q_{max} = Q(h_{max}) .$$

only 2x

Q_t (m³) is the threshold discharge which is the volume of water for which $Q > Q_t$ is considered a flood. It can calculated using the rating curve equation.

$$Q_t = Q(h_t) .$$

no Q_t is threshold

Formulas part of sentence: include punctuation.

The discharge volume Q can be generated indirectly from measurements of the stage of river, using $Q = Q(h)$, or measured directly using appropriate instrumentation.

$Q(t) = Q(h(t))$. dependencies?

1.4.3. Flood Effective Volume (FEV) V_e / m^3

The volume of water responsible for causing flooding. There are 3 methods for calculating V_e.
T_f is the defined period of flooding and can be estimated using the times flood warnings were released and ended.

why

Estimate 1 , V_{e1}

$$V_e \approx V_{e1} = (Q_{max} - Q_t)\, T_f ,$$

Where the defined time interval for Q_{max} is T_f. This estimate is appropriate if stage h and discharge Q data are available, but the frequency of measurements is considered to be significant in comparison to T_f.

why

Estimate 2 , V_{e2}

$$V_e \approx V_{e2} = \sum_{k=1}^{N} (Q(h(t_k)) - Q_t)\ \Delta t ,$$

Where the subscript k denotes the time interval at which $h(t_k)$ is recorded and $\Delta t = t_{k+1} - t_k$, $\forall\, t = 0,1,\dots,N$
This estimate is appropriate if the frequency of measurements is considered to be less significant in comparison to T_f

why

Estimate 3 , V_{e3}

$$V_e \approx V_{e3} = T_f \frac{Q_{max}}{h_{max}} (h_m - h_t) ,$$

Where the time interval for h_m is T_f. This estimate is appropriate where automatic reading of river stage and rating curves are absent. $T_f, Q_{max}, h_{max}, h_m, h_t$ can all be estimated.

reinder

Need to add reference to Aire paper and talk about derivation of formula.

Need more story!

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2. ASSESSMENT OF 3 YORKSHIRE RIVERS

Include graphs/ comparison with other graphs, uncertainties and criticisms

2.1. Don
2.2. Aire
2.3. Calder

Why?

3. ASSESSMENT OF RIVER OUSE

3.1. Rational for River Choice
3.2. Rational for Flood Event Choice
3.3. Analysis of Flood Events
3.4. Proposed work

Where? Flood mitigation plan.

4. FURTHER WORK NEEDED

4.1. FEV MODEL

why avoid → NFM EA report

3 ARXIV article

4.1.1. Literature Review

A need for a literature has been identified. The material provided does not reference a literature review. Other models may already exist which could be improved. There may be the opportunity to collaborate with other researchers who are also working on this at present.

→ an new submission of NFM article

4.1.2. Estimating h_t and T_f

There is no standardised or consistent way of estimating h_t and T_f. The empirical methods used to estimate these lead to uncertainties which propagate when the FEV is calculated.

!

4.1.3. Representativeness of Data

The data used to calculate FEV are taken from a single monitoring station. The material reviewed does not discuss in detail how representative this could be of the flood experienced to local area. This could be improved by considering the locations the land between two monitoring stations.

some

4.1.4. Worst-case scenario

The material reviewed does not use the "worst-case scenario" approach. This approach takes the most undesired situation (e.g the upper bound of flooding). This can lead to mitigation strategies of all risk events simultaneously.

Expand

4.2. ANALYSIS OF RIVER OUSE FLOOD EVENTS

5. REFERENCES

1. Dictionary. *Definition of "Flood"*. [Online]. 2019. [Accessed 2 January 2019]. Available from: https://www.dictionary.com/browse/flood

2. Environmental Agency. *Climate change means more frequent flooding, warns Environment Agency.*[Online].2018.[Accessed 2 January 2019]. Available from: https://www.gov.uk/government/news/climate-change-means-more-frequent-flooding-warns-environment-agency

3. UK Government. *National Risk Register Of Civil Emergencies 2017 Edition.* [Online].2017.[Accessed 2 January 2019]. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/644968/UK_National_Risk_Register_2017.pdf

4. Ambiental. *Types of flood and flooding impact.*[Accessed 2 January 2019]. Available from: https://www.ambiental.co.uk/types-of-flood-and-flooding-impact/