Beyond PPS25: Should uncertainty in flood risk Mapping Make a difference

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Programme for Today (1)

10.30-10.45 Keith Beven, Lancaster University

Introductions and relationship with flood mapping, aims and agenda

10.45-11.00 Keith Beven, Lancaster University

Sources and understanding of uncertainty in data, modelling and mapping?

11.00-11.15 Kate Donovan, University of Oxford

Communicating flood science to Local Authorities - An introduction to FOSTER: Flood Organisation Science and Technology Exchange Research

11.15-11.25 *Short Q&A Session*

11.25-11.50 Refreshment break

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Programme for Today (2)

WORKSHOP DISCUSSION SESSION (4 groups) Led by Simon McCarthy, Flood Hazard Research Centre, Middlesex University

11.50-12.15 **Uncertainty in Practice**
How is flood risk mapping uncertainty currently communicated to you or from you to other stakeholders?

In your organisation and work role how do you incorporate uncertainty in flood hazard mapping into decision making?

12.15- 12.30 *Group feedback*

12.30-13.20 Lunch (LEC Atrium)

Programme for Today (3)

13.20- 13.45 **Your experience of sources of uncertainty in data, modelling and mapping**
What are the dominant sources of uncertainty in flood risk mapping across spatial planning?
What sources of uncertainty are difficult to quantify?
13.45-14.00 *Group feedback*

14.00-14.35 **Your preferences for communication –** demonstration of tools available by Dave Leedal (Lancaster Environment Centre)
What forms of visualisation are most useful for different types of decision?
14.35-14.45 *Group feedback*

14.45-15.00 Refreshment break

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Programme for Today (4)

15.00-15.30 **Towards guidelines: What form should guidelines take?**

What are the key elements that would promote widespread uptake and use across spatial planning?

How could a CPD module best support this? What format should it take?

15.30-15.45 *Group feedback*

15.45-16.00 **Overview summary, closing remarks and next steps**

16.15 **Close**

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Introductions

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Sources and understanding of uncertainty in data, modelling and mapping?

Keith Beven

Lancaster Environment Centre, Lancaster University

Science into Practice…

Pitt Review following 2007 floods
– 94 recommendations including taking more account of uncertainties in the flood risk management process

- Suddenly a host of new Environment Agency projects on ensemble forecasting, probabilistic flood forecasting, probabilistic flood risk mapping, probabilistic incident management (and possibly more to come)

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Science into Practice…

- EU Floods Directive – requirement for mapping of flood risk areas by 2013
- Current EA flood maps at AEP 0.01 and 0.001 for fluvial flooding zones (AEP 0.005 and 0.001 for coastal flooding)
- Generalised indicative maps (web site); more detailed maps by deterministic hydraulic modelling
- But model predictions known to be uncertain………

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Result of FRMRC1 Risk and Uncertainty WP

- Uncertainty as risk of possible outcomes
- Decisions always made under uncertainty (…. but not always quantified)
- Some uncertainties can be quantified (…. but not all easily quantifiable - epistemic uncertainties)
- But might make a difference to decisions where impact highly sensitive to uncertainty (costs & benefits in estimating risk as probability * impact)
- FRMRC1 Concept of producing Guidelines for Good Practice in different areas of flood management

A NERC KT Project

Science into Practice…

- So…… if we are going to worry about uncertainty what are appropriate assumptions and what do results mean to users – what should "Good Practice" mean in informing decisions?
- Need for a *translatory discourse* between scientist and practitioners about nature and meaning of uncertainties (Faulkner et al., *Ambio*, 2007)

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NERC KT project "…..to enable the exchange of knowledge between the NERC research base and science user community to understand and manage uncertainty and risk related to water scarcity, flood risk and diffuse pollution management"

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Structure of CCN

Three focus areas

Change and Flood Risk Management
Change and Water Scarcity
Change and Diffuse Pollution

Mechanisms

Expert facilitator
www.catchmentchange.net (with blogs)
Workshops / Training / Annual Conference

Evolving Guidelines for Good Practice as a way of operationalising uncertainty in the science

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Raises many questions…

- What are the dominant sources of uncertainty in flood risk mapping across spatial planning?
- What sources of uncertainty are difficult to quantify?
- What forms of visualisation are most useful for different types of decision?
- How to agree (and communicate) assumptions with stakeholders?

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Other questions for today…

How is flood risk mapping uncertainty currently communicated to you or from you to other stakeholders?

In your organisation and work role how do you incorporate uncertainty in flood hazard mapping into decision making?

What are the key elements that would promote widespread uptake and use across spatial planning?

How could a CPD module best support this? What format should it take?

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Evolving the Guidelines

Science/Practitioner Translationary Discourse

→ Defining and framing the type of application

→ Communication of sources of uncertainty considered

→ Communication of assumptions used in assessing sources of uncertainty

→ Communication of how uncertainties combined

→ Communication of meaning of probabilistic or possibilistic information

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Risk Mapping: Defining and framing the type of application

- Planning decisions
- Emergency planning
- Flood damage assessments and defence design
- Insurance
- Generating householder resilience
- ……

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Evolving the Guidelines

Guidelines as a set of decisions

→ Source – pathway – receptor framework

→ Assumptions to be agreed between analyst and stakeholder(s)……though many would prefer a "recipe"

→ Explicit agreement and record means that later review can be carried out

→ Default options, or decision tree of potential options

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Application to Flood Risk Mapping

Mapping requires a hydrodynamic model

→ Assumptions about multiple sources of uncertainty (frequencies, inputs, parameters, future change,…)

→ Epistemic as well as aleatory uncertainties

→ How to propagate uncertainties through a model?

→ How to constrain uncertainties using data?

→ How to present results to stakeholders?

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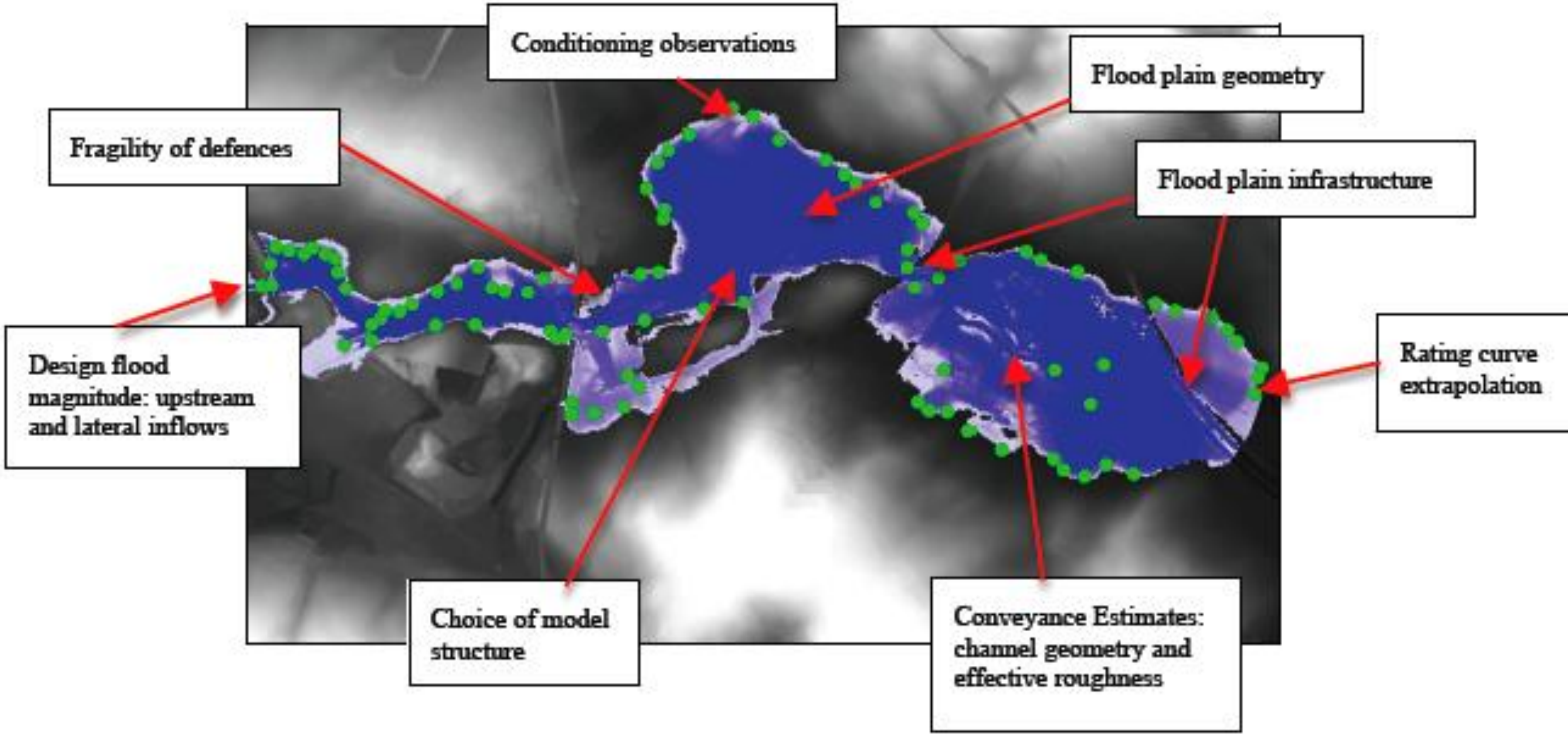
Sources of Uncertainty in Flood Risk Mapping



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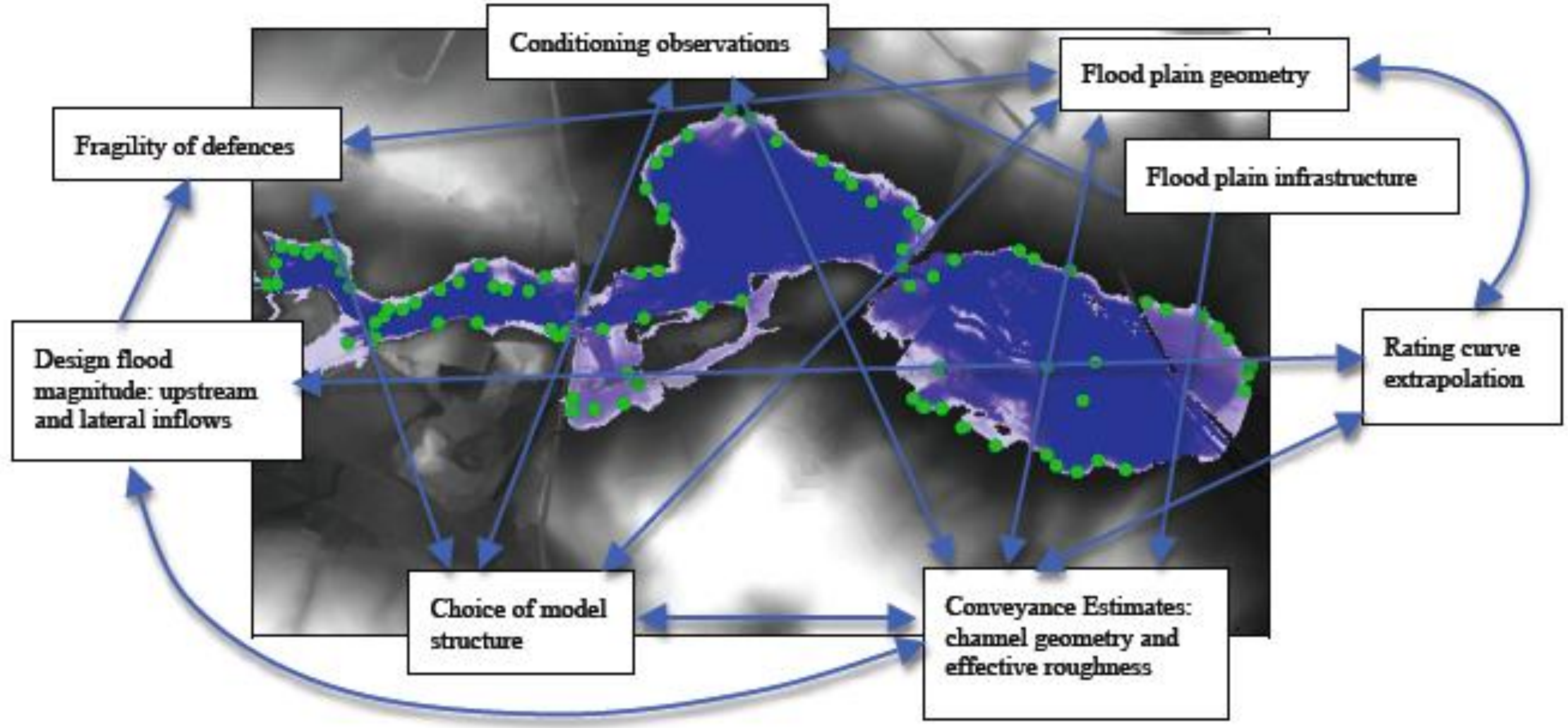
Interactions between Sources of Uncertainty



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Flood Risk Mapping: Decision trees (1)

Uncertainty in Sources

1. Uncertainty in design flood magnitude

2. Uncertainty in assessing effects of future climate change

3. Uncertainty in assessing effects of future catchment change

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Flood Risk Mapping: Design flood magnitude

Uncertainty in Sources

1. Design Flood Magnitude

D1.1 Are gauge data available?

D1.2 If yes: what is an appropriate frequency distribution to fit (Default: use of WinFAP to fit GL or GP distributions)?

D1.3 If no: what method of extrapolating to ungauged site to be used?

D1.4 Do multiple inputs to flood risk site need to be considered?

D1.5 If yes: generate correlated samples for design event AEP (using methods of Keef et al., 2009)

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Flood Risk Mapping: Decision trees (2)

Uncertainty in pathways

4. Uncertainty in hydrodynamic model structure

5. Uncertainty in conveyance / rating curve extrapolation

6. Uncertainty in effects of flood plain infrastructure

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Flood Risk Mapping: Conveyance

5. Uncertainty in Conveyance Estimates

D5.1 Are observations available to allow the calibration of channel and/or flood plain roughness values (if yes: go to section 7)?

D 5.2. If not: decide on a range of roughness values for channel and flood plain units (if possible obtain a credible range from the CES).

D5.2 Decide on a (probabilistic) interpretation of the estimated range.

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Flood Risk Mapping: Decision trees (3)

Uncertainty in Receptors

7. Uncertainty in fragility of defences

8. Uncertainty in consequences/vulnerability

Flood Risk Mapping: Decision trees (4)

9 Uncertainty in implementation

10 Uncertainty in conditioning uncertainty using observations

11 Defining a presentation method

12 Managing and reducing uncertainty

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Propagation and conditioning of uncertainty using GLUE

1. Run Monte Carlo simulations varying upstream discharge estimate and roughness coefficients
2. Evaluate each model run in predicting maximum inundation for 2007 event to determine behavioural simulations and weights
3. Apply behavioural models to predict AEP 0.01 event
4. Map CDF for inundation depths

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Uncertainty as a likelihood surface in the model space

Basic requirements of a likelihood as belief

- Should be higher for models that are "better"
- Should be zero for models that do not give useful results
- Scaling as relative belief in a hypothesis rather than probability

But how then best to determine weights from evidence given epistemic uncertainties??

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Likelihood and Model Evaluation

- Model evaluation normally based on residuals in space and time $\varepsilon(x,t)$

$$\varepsilon(x,t) = O - M(\boldsymbol{\Theta}, \mathbf{I})$$

- Made up of multiple contributions

$$\varepsilon(x,t) = \varepsilon_M(\theta, \varepsilon_\theta, I, \varepsilon_I, x, t) - \varepsilon_C(\Delta x, \Delta t, x, t) - \varepsilon_O(x,t) + \varepsilon_r$$

where $\varepsilon_M(\theta, \varepsilon_\theta, I, \varepsilon_I, x, t)$ is the model error (as affected by parameter and input error

$\varepsilon_C(\Delta x, \Delta t, x, t)$ denotes the commensurability error between observed and predicted values

$\varepsilon_O(x,t)$ is the observation error, and

ε_r is a random(?) error component

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Limits of acceptability

- The question that then arises within this framework is whether, for an particular realisation of the inputs and boundary conditions, $\varepsilon_M(\theta, I, \varepsilon_I, x, t)$ is acceptable in relation to the terms $\varepsilon_O(x,t) + \varepsilon_C(\Delta x,\Delta t, x,t)$. This is equivalent to asking if the following inequality holds:

$$O_{min}(x,t) < M(\theta, I, \varepsilon_I, x, t) < O_{max}(x,t) \text{ for all } O(x,t)$$

  where $O_{min}(x,t)$ and $O_{max}(x,t)$ are acceptable limits for the prediction of the output variables given $\varepsilon_O(x,t)$ and $\varepsilon_C(\Delta x,\Delta t, x,t)$

- Limits of acceptability should be evaluated **prior** to running the model **(but note I, ε_I in $M(\theta, I, \varepsilon_I, x, t)$**)

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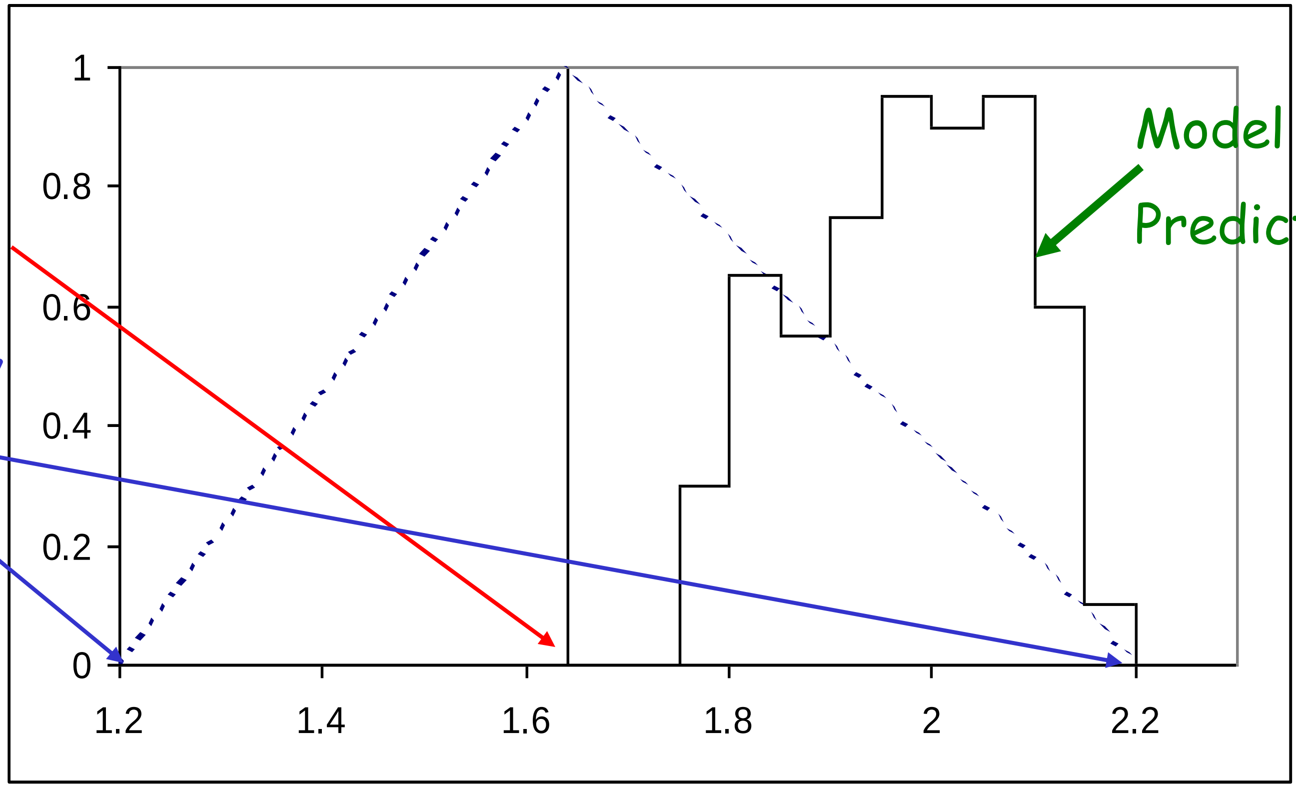
Predictive distribution over all behavioural models: what if predictions do not encompass new observation



Observation

Limits of acceptability

Model Predictions

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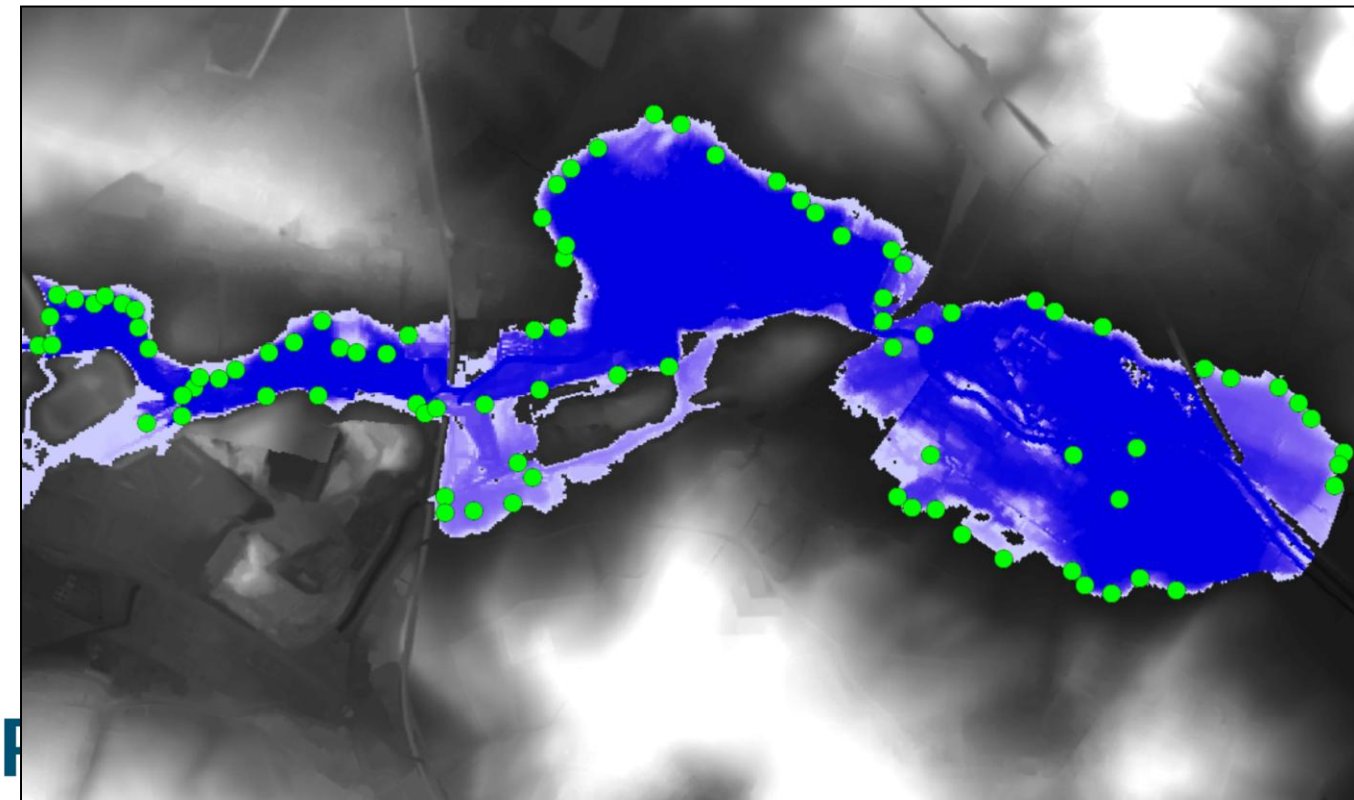
Mexborough: Summer 2007

Mapped maximum inundation and model predicted flow depths for Summer 2007 floods at Mexborough, Yorkshire using 2D JFLOW model



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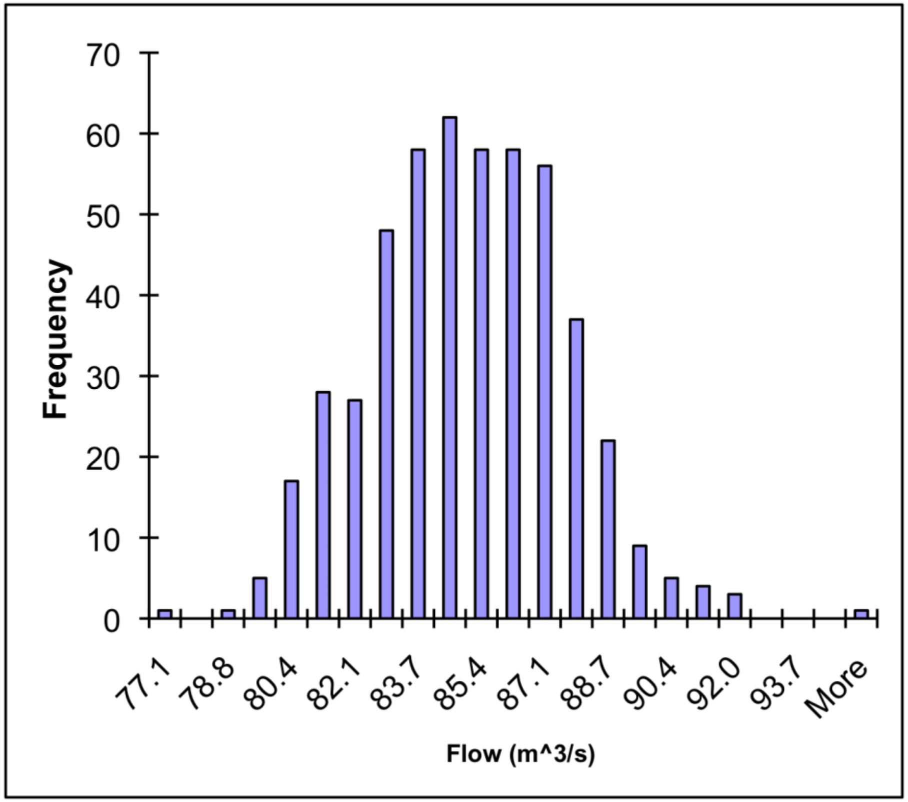
Mexborough Risk Mapping: Defining Input Uncertainties

WinFAP estimate of 0.01 AEP (T100) flood peak at Adwick



Mean: 86.6 (m^3s^{-1})

Var: 6.25 (m^3s^{-1})

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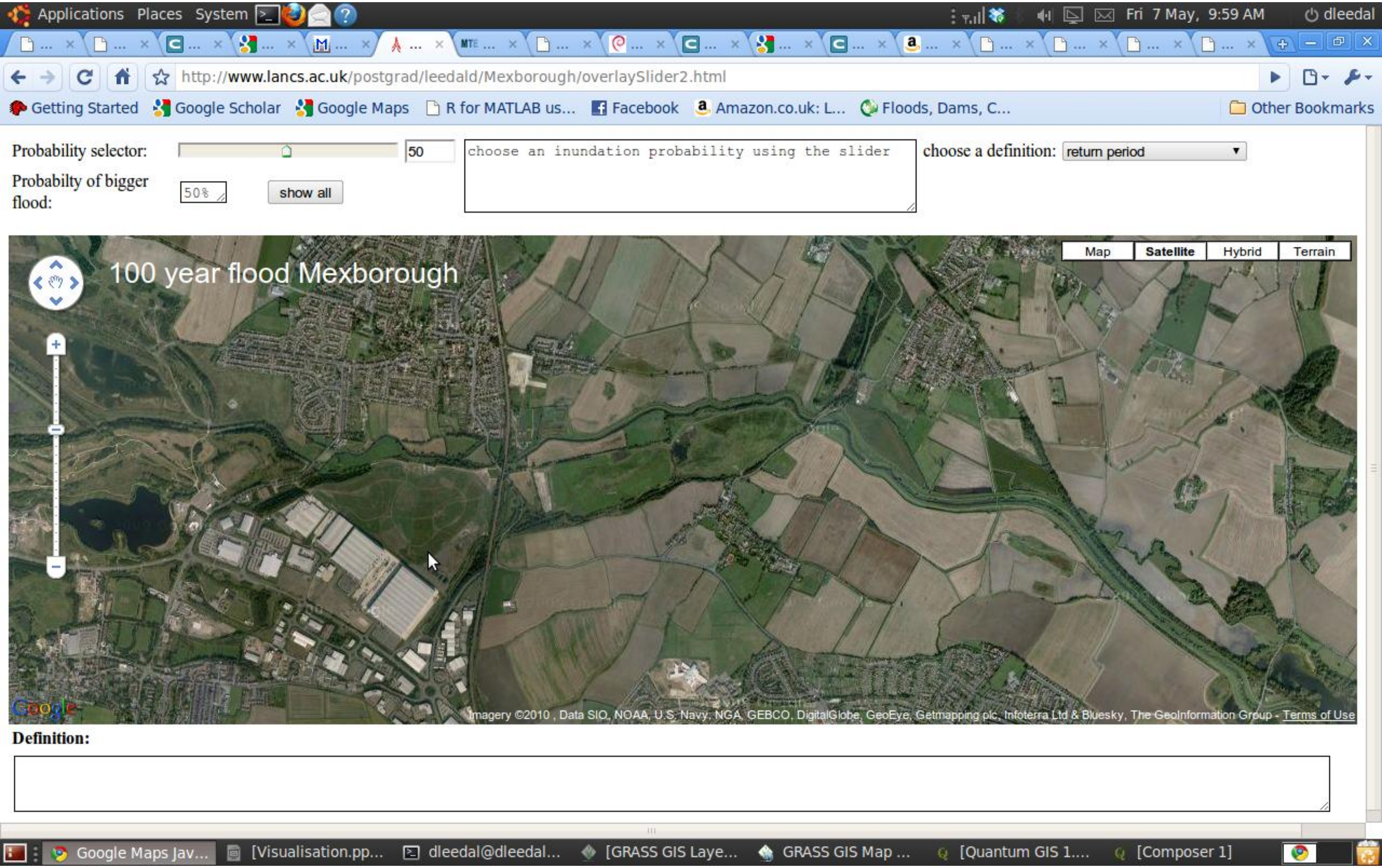
Google maps API



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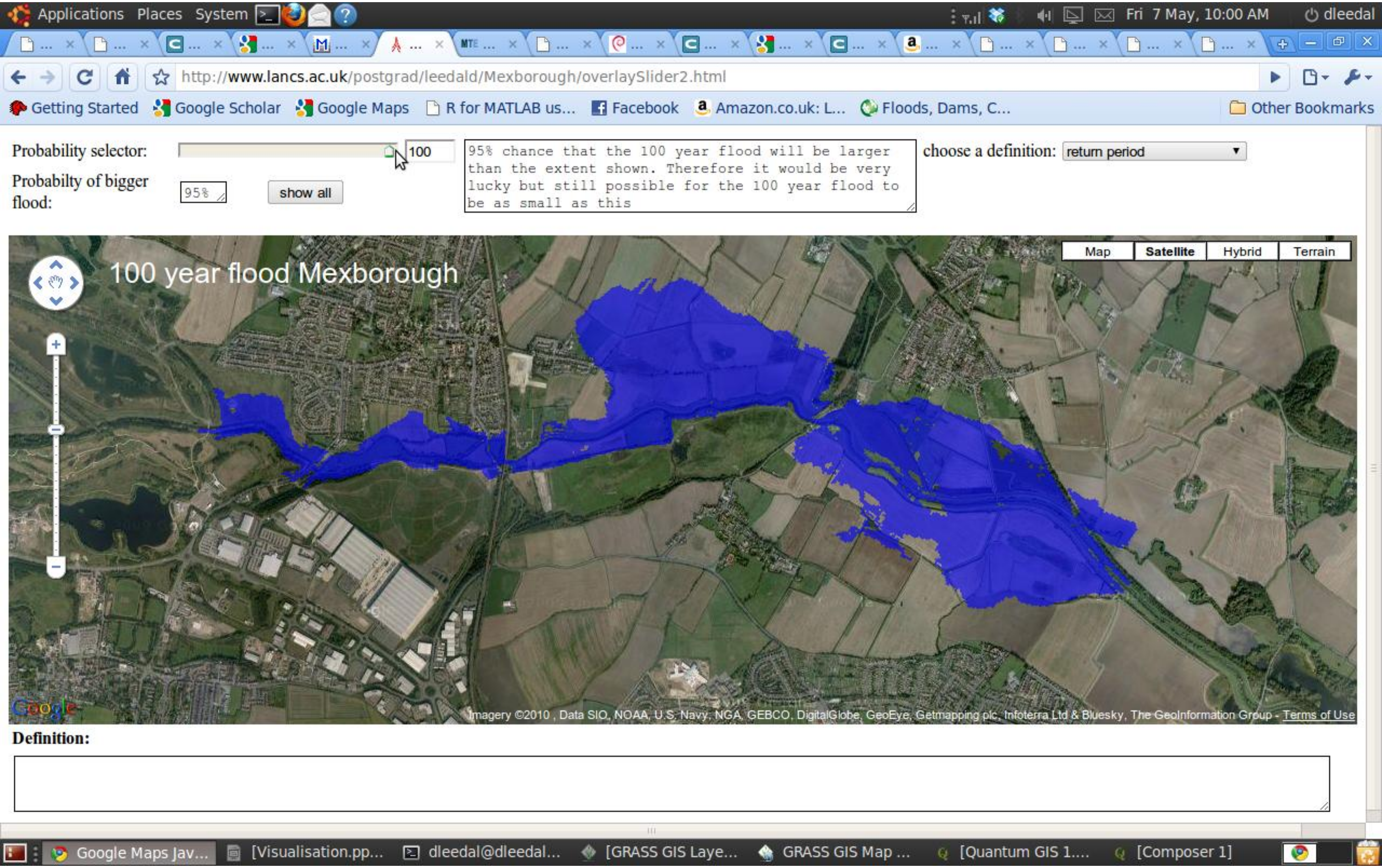

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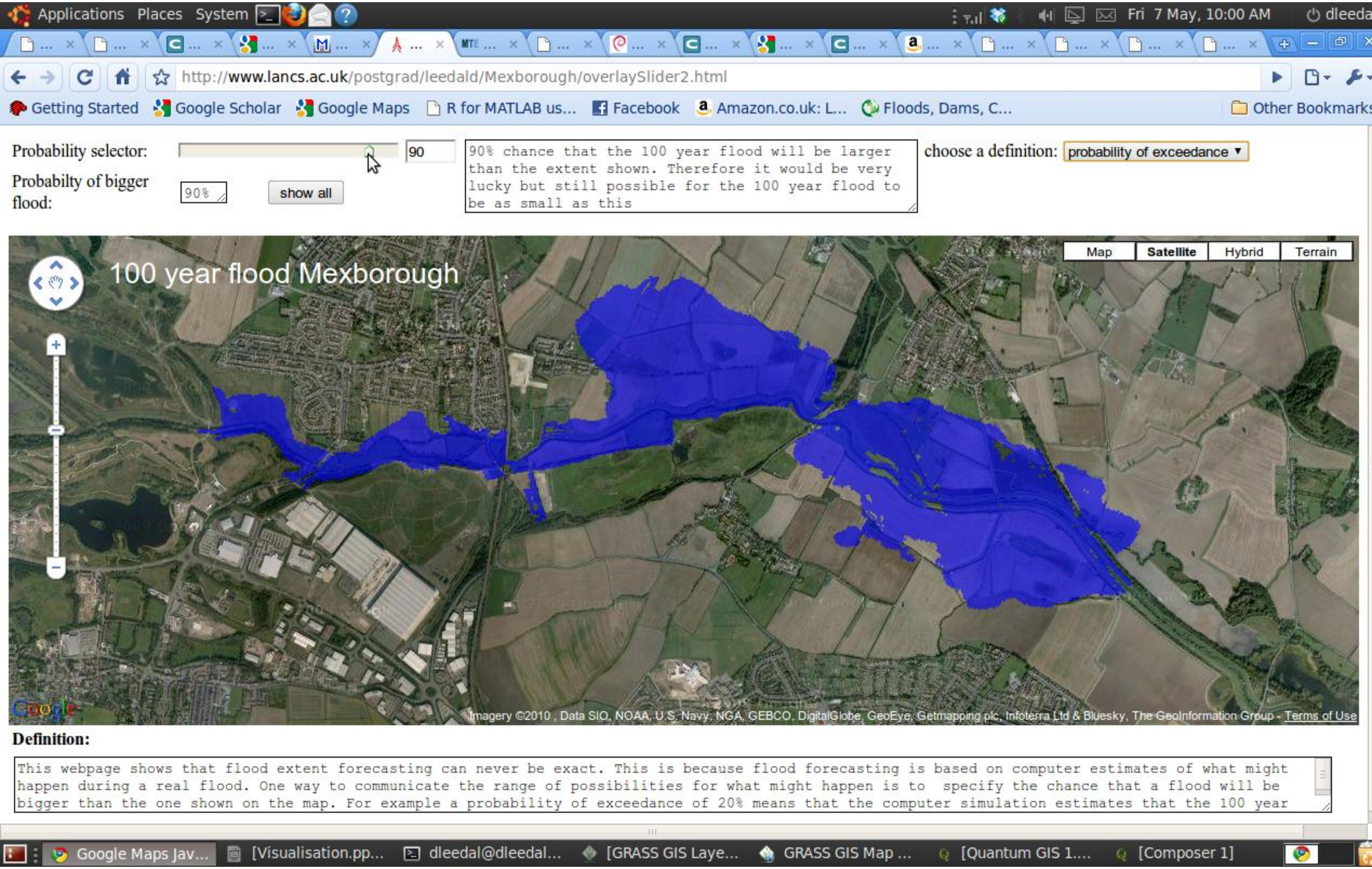

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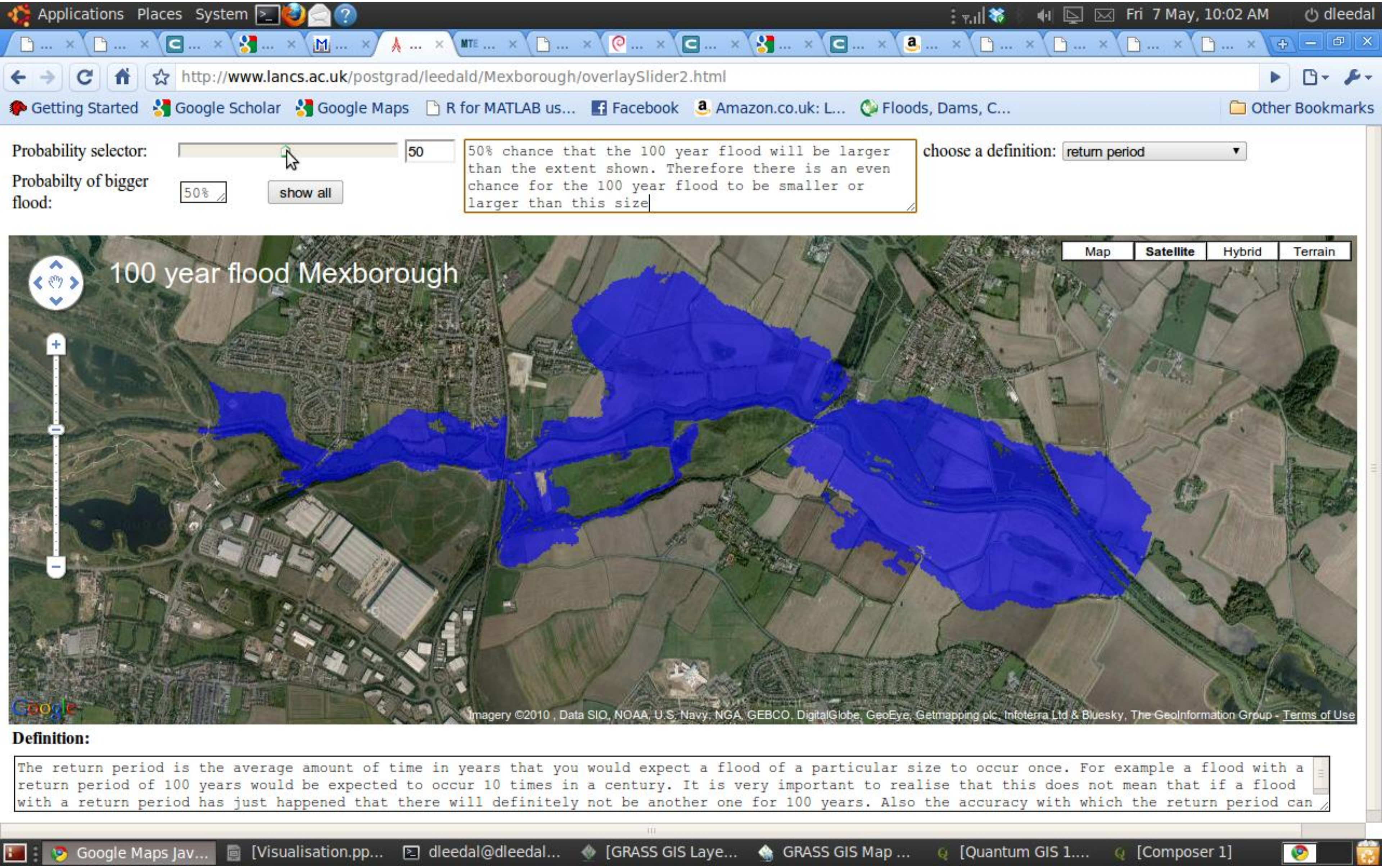

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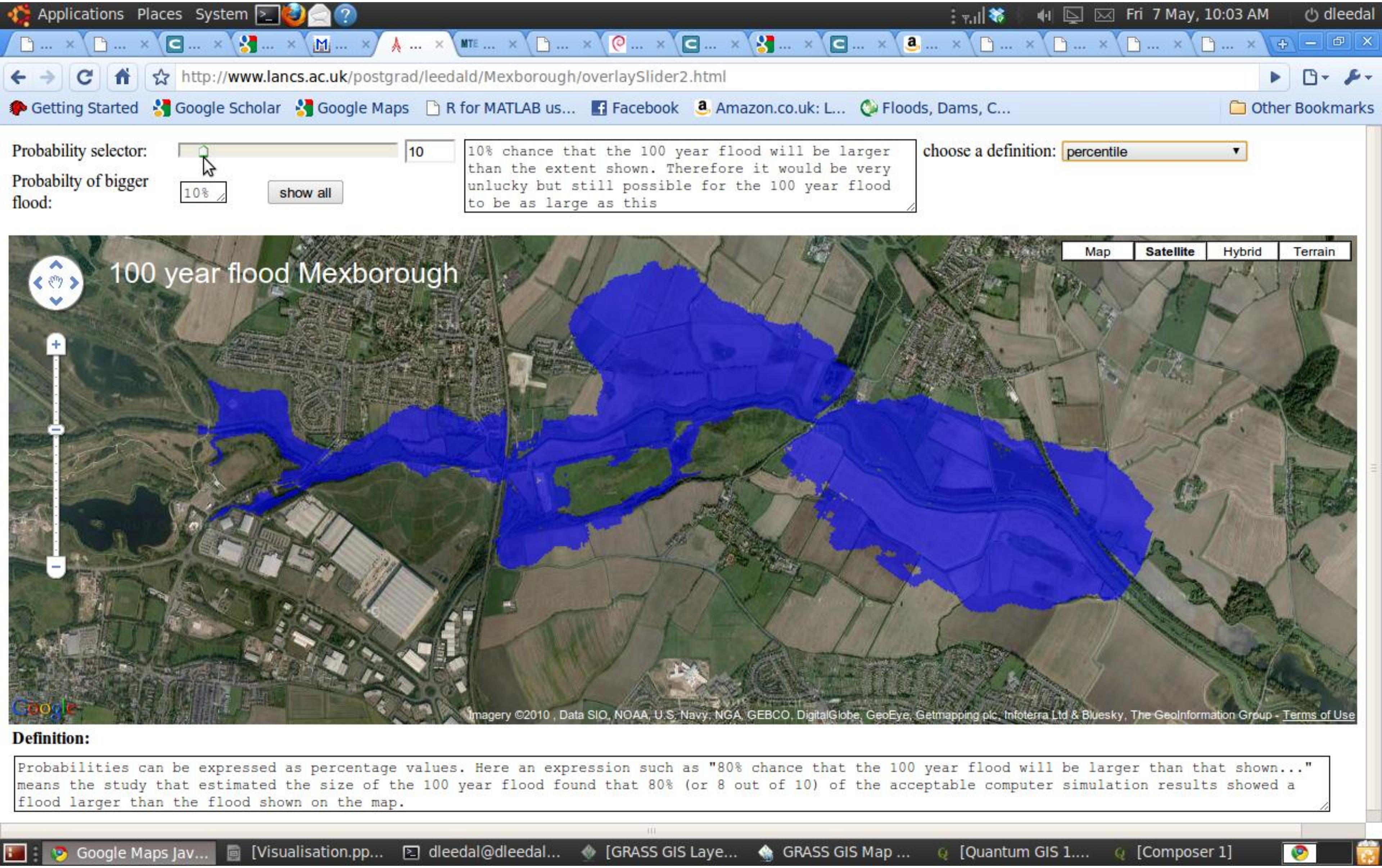

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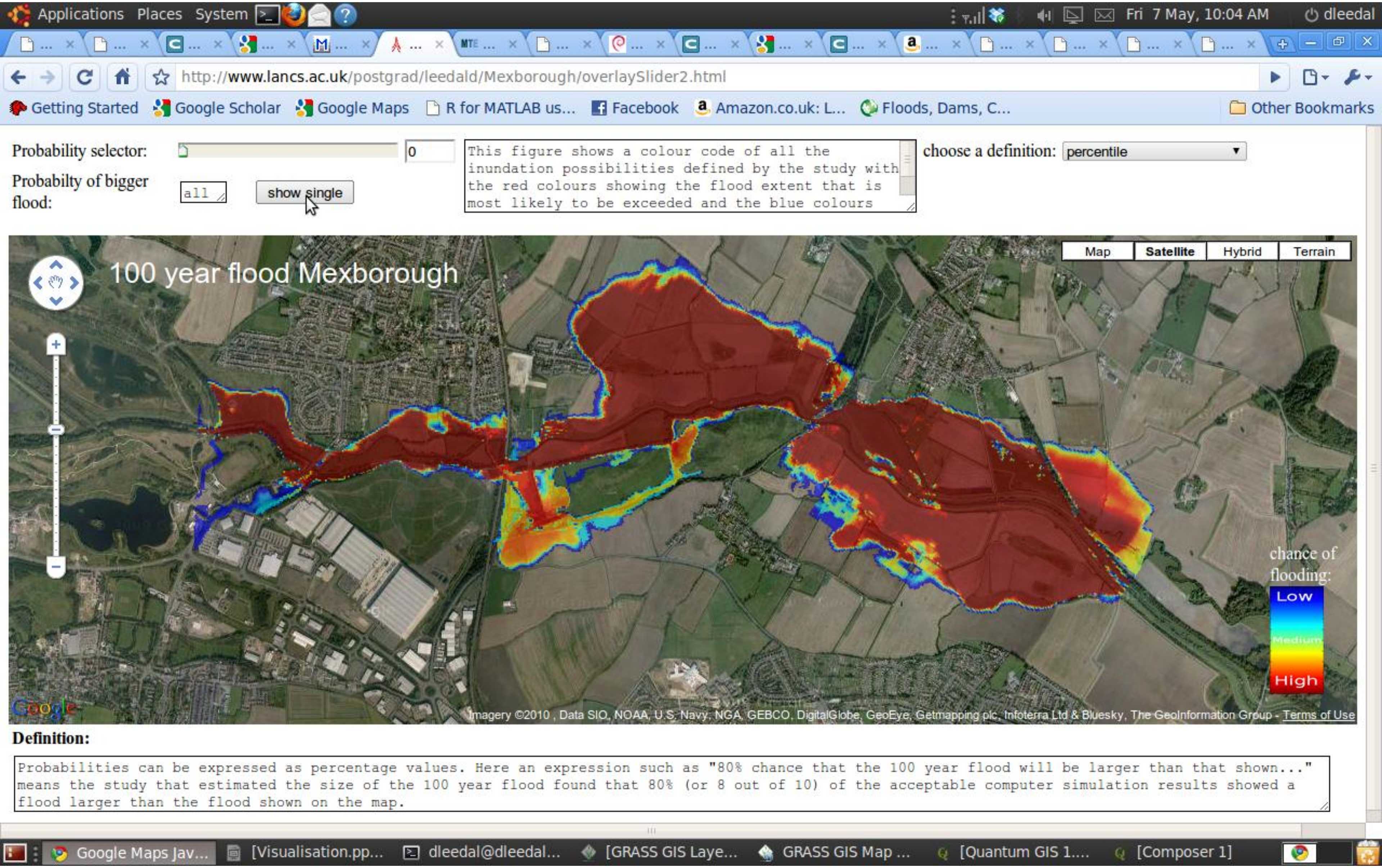

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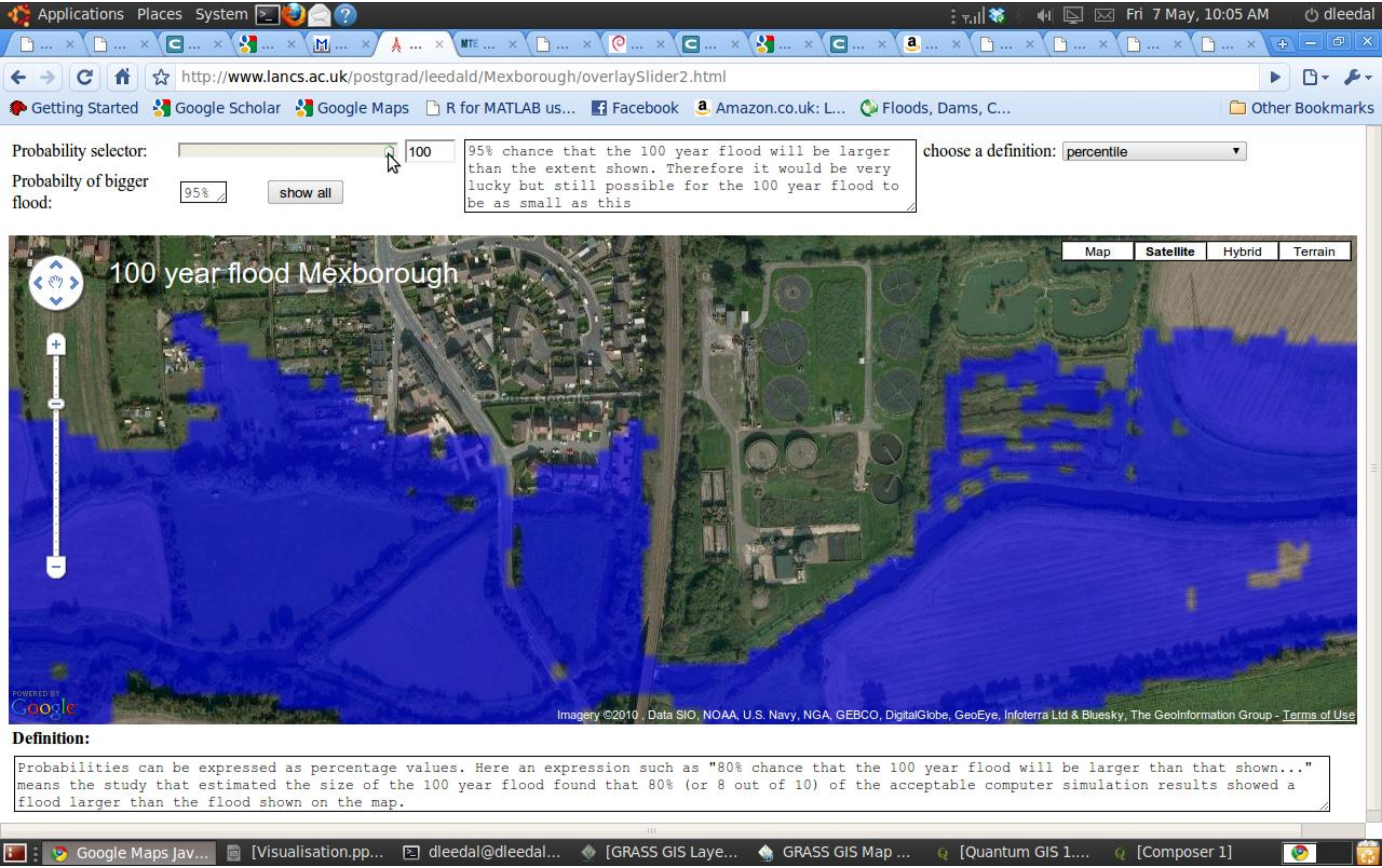

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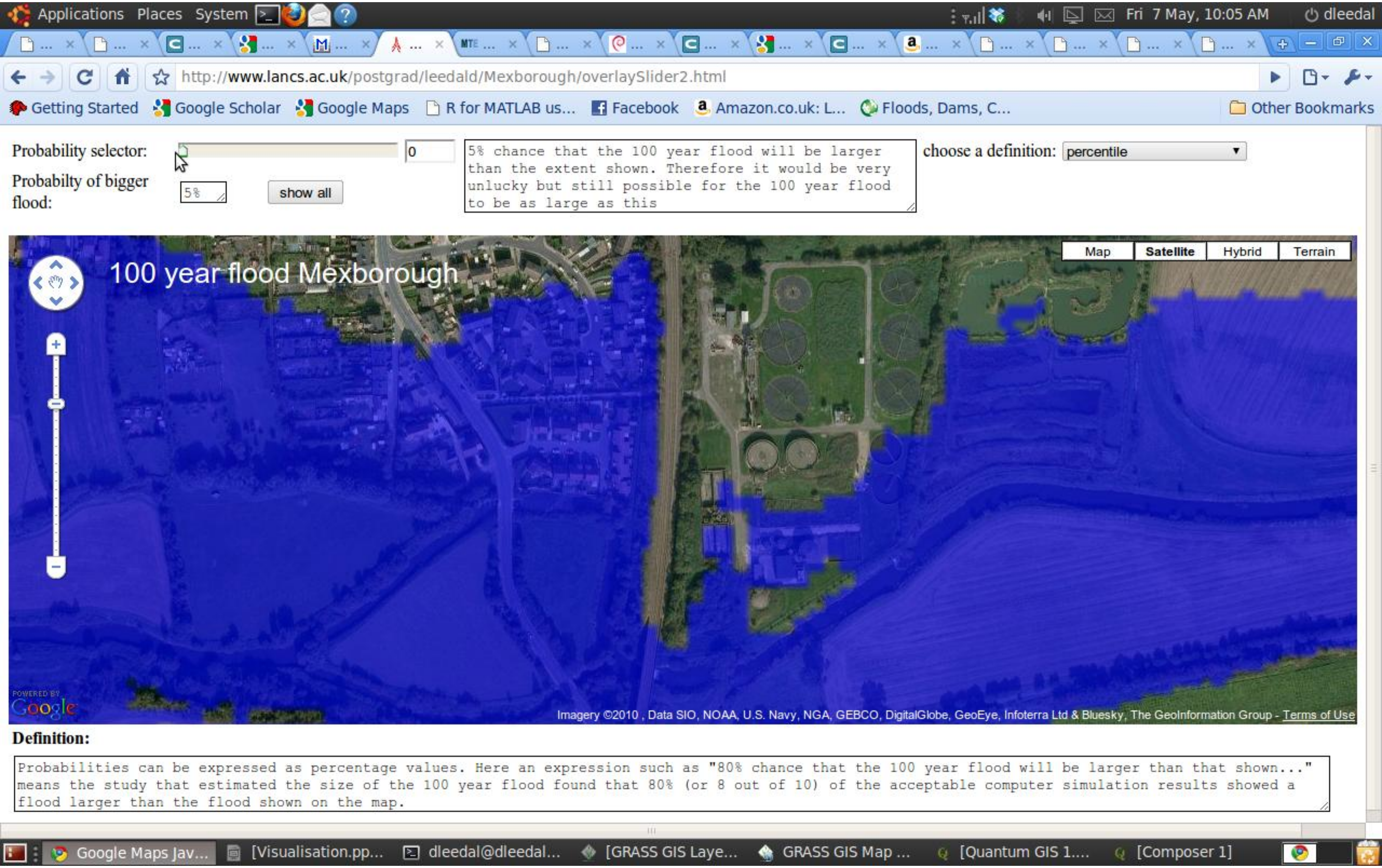
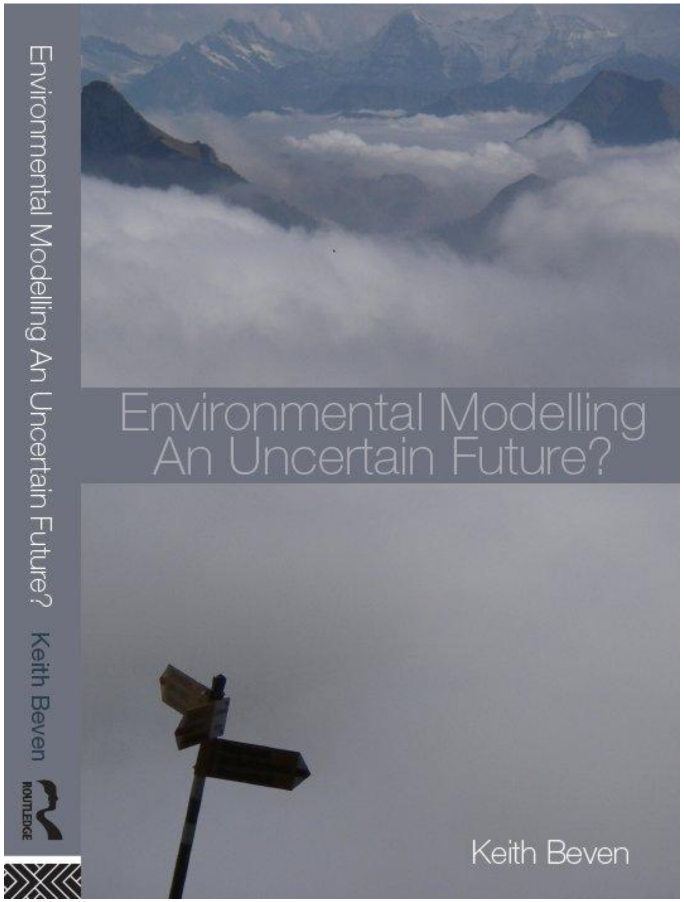


More on uncertainty estimation……



Environmental Modelling: An Uncertain Future?

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More information at www.uncertain-future.org.uk

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