Gresham College

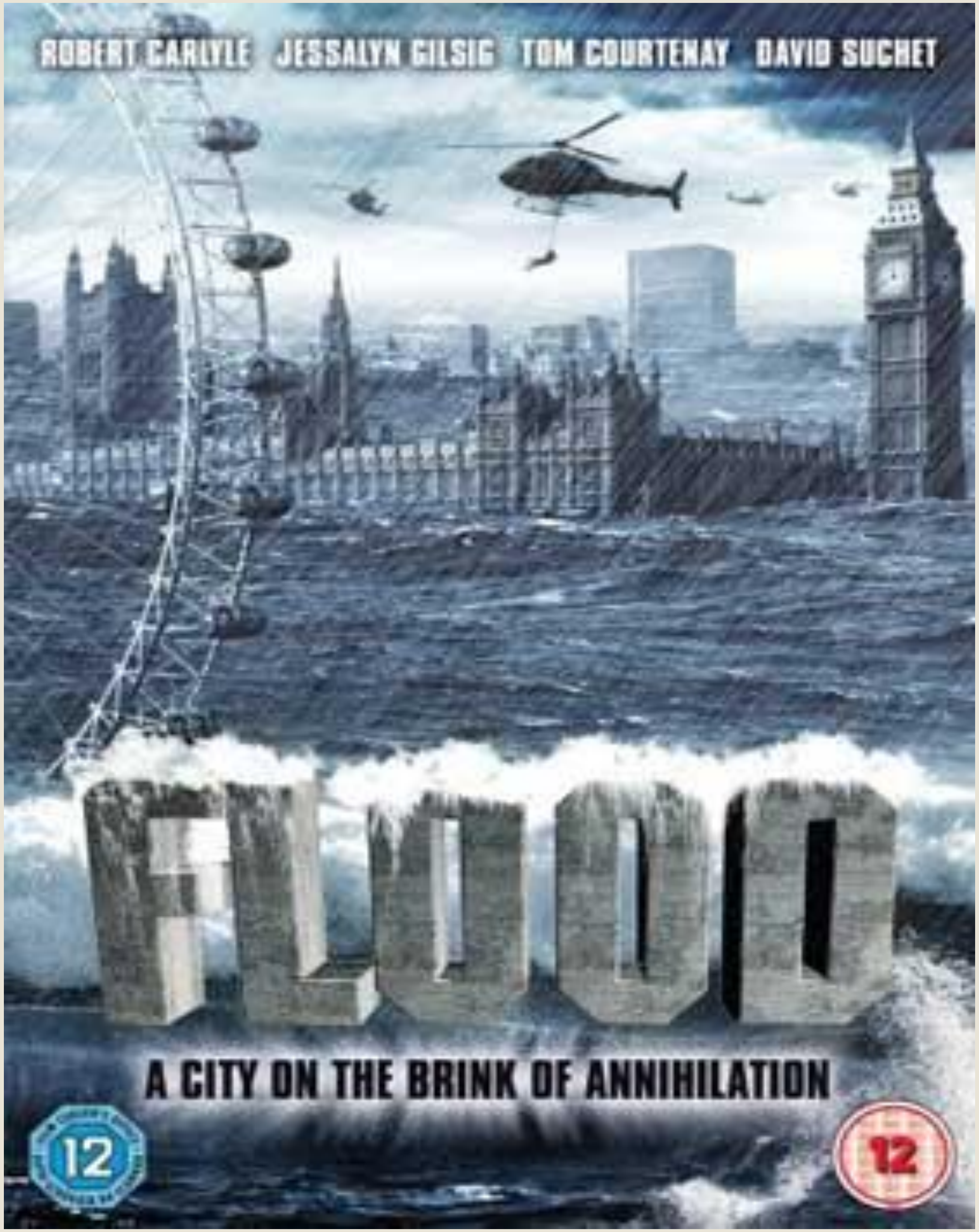
The Next Big UK Flood: Britain Under Water

Carolyn Roberts

Frank Jackson Foundation Professor of Environment

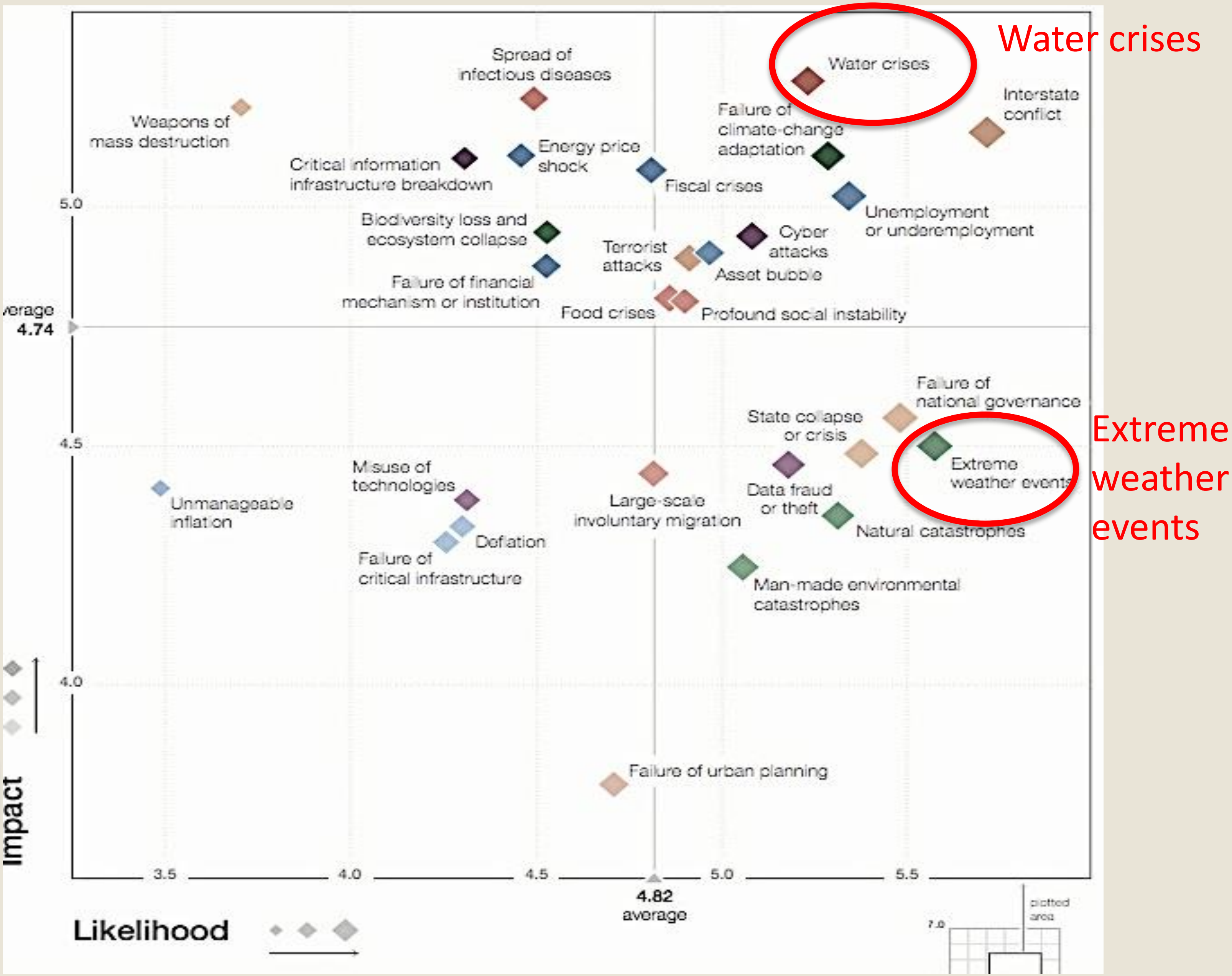
The Knowledge Transfer Network

Visiting Researcher, University of Oxford


ROBERT CARLYLE
JESSALYN GILSIG
TOM COURTENAY
DAVID SUCHET
FLOOD
A CITY ON THE BRINK OF ANNIHILATION
12
12

London

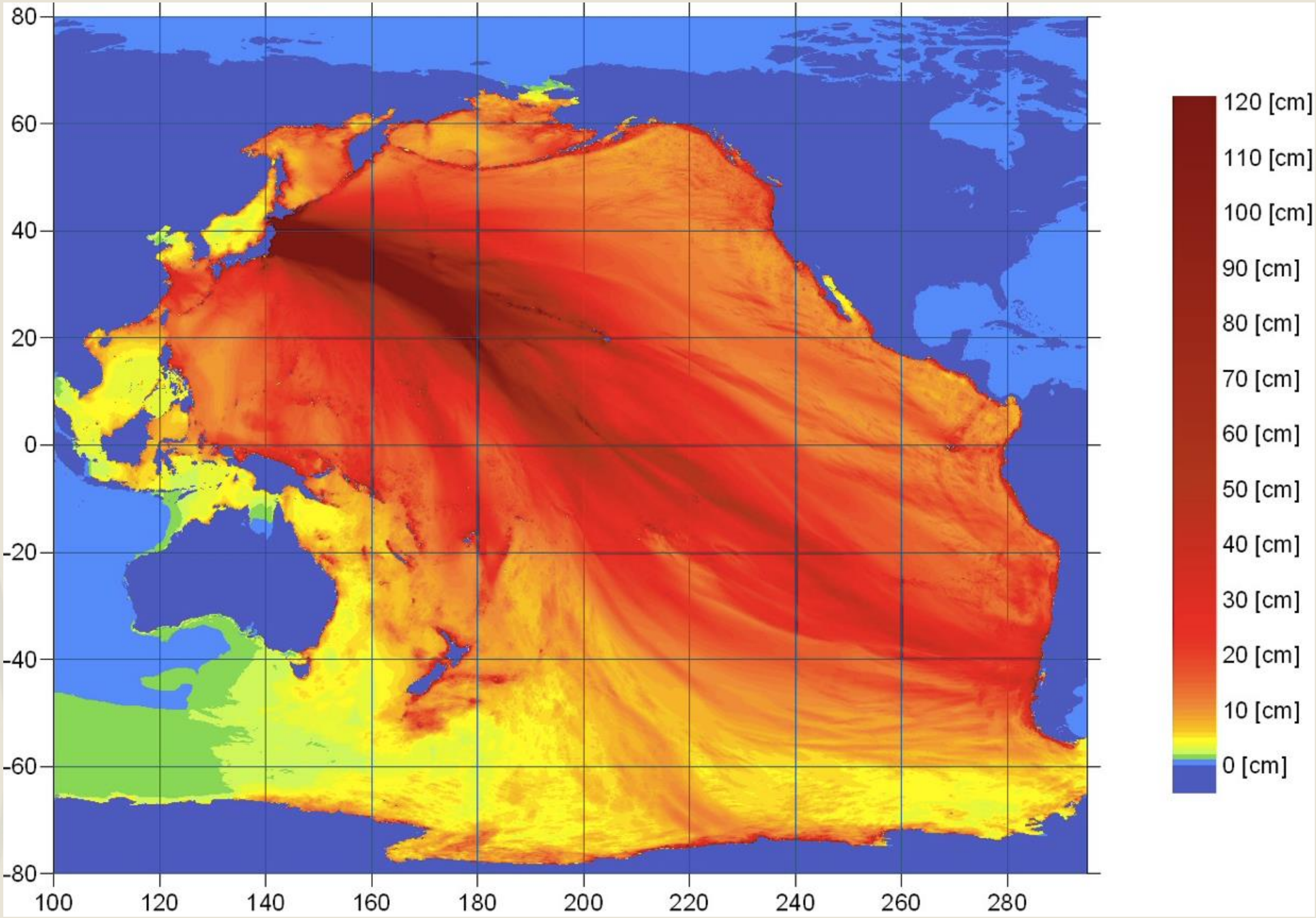
World Economic Forum's Global Risks Report 2015.



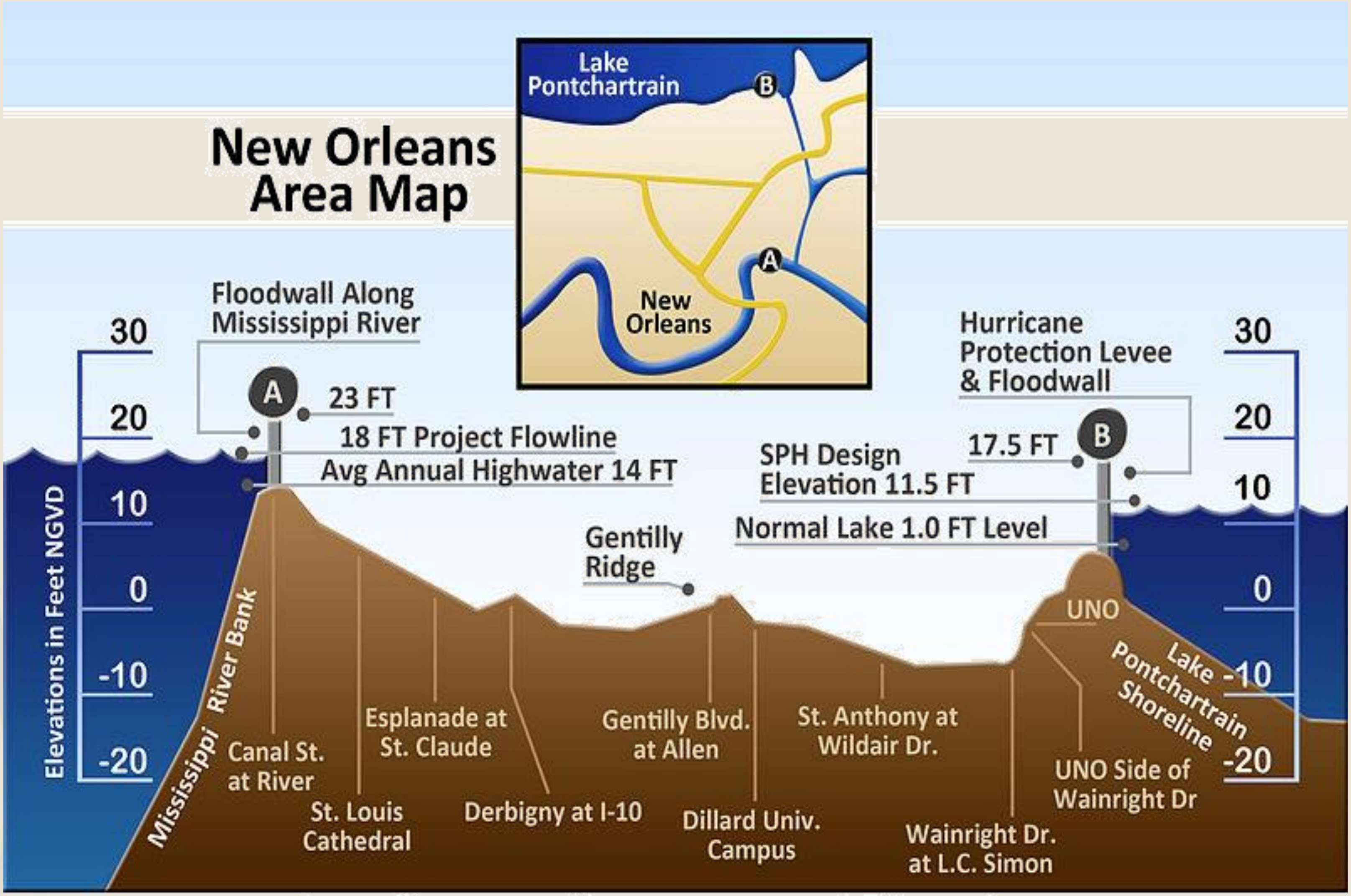
The earthquake hit at 7.58am local time on 26 December 2004. The magnitude 9.1 earthquake struck 30km below the surface around 160km off the western coast of northern Sumatra.

The 2011 Tōhoku, Japan tsunami

Ocean energy distribution forecast map for the 2011 Sendai earthquake from the U.S. NOAA



Hurricane Katrina flooding, August 2005



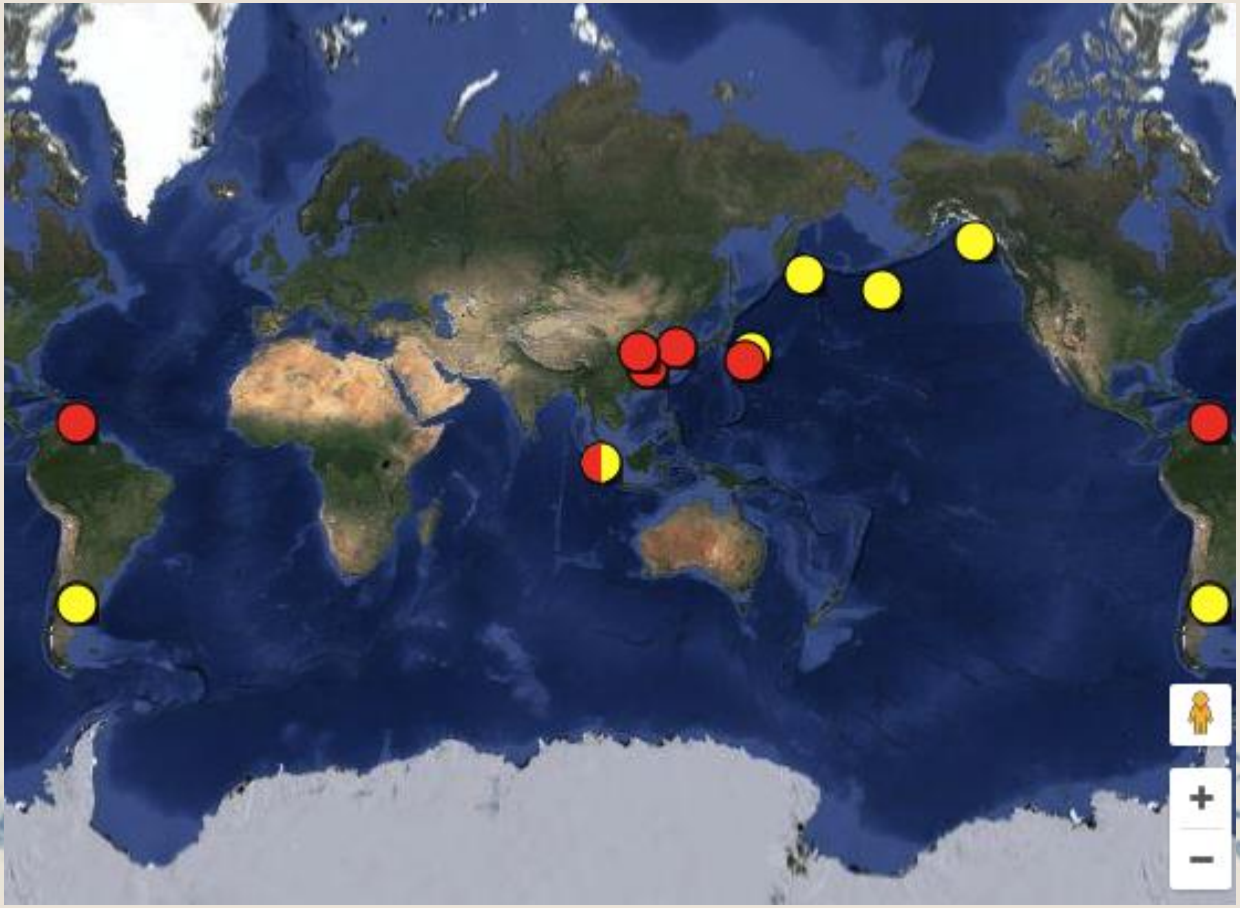
City of New Orleans Ground Elevations

From Canal St. at the Mississippi River to the Lakefront at U.N.O.

Hurricane Katrina flooding, August 2005

Flooded interchange in New Orleans, USA

British Geological Survey's 'largest and deadliest' earthquakes



Yellow pin is biggest earthquakes ever recorded, and red are the deadliest. Red and yellow pins are particularly deadly and big.

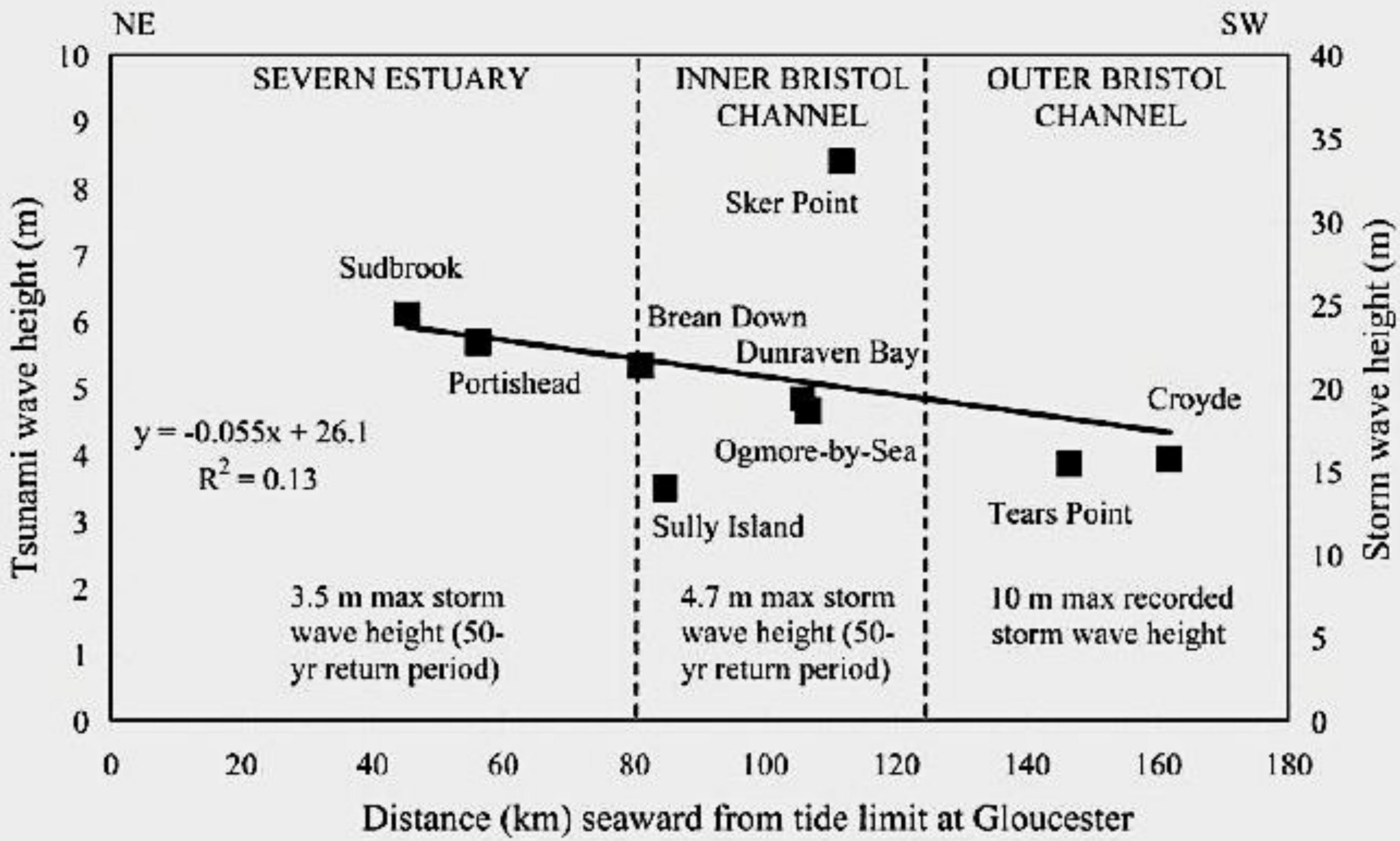
30th January 1607 about 9.00am in the morning in Somerset. 2000 deaths and great economic loss. High Water at Burnham was 8.28am. Bryant and Haslett, 2007

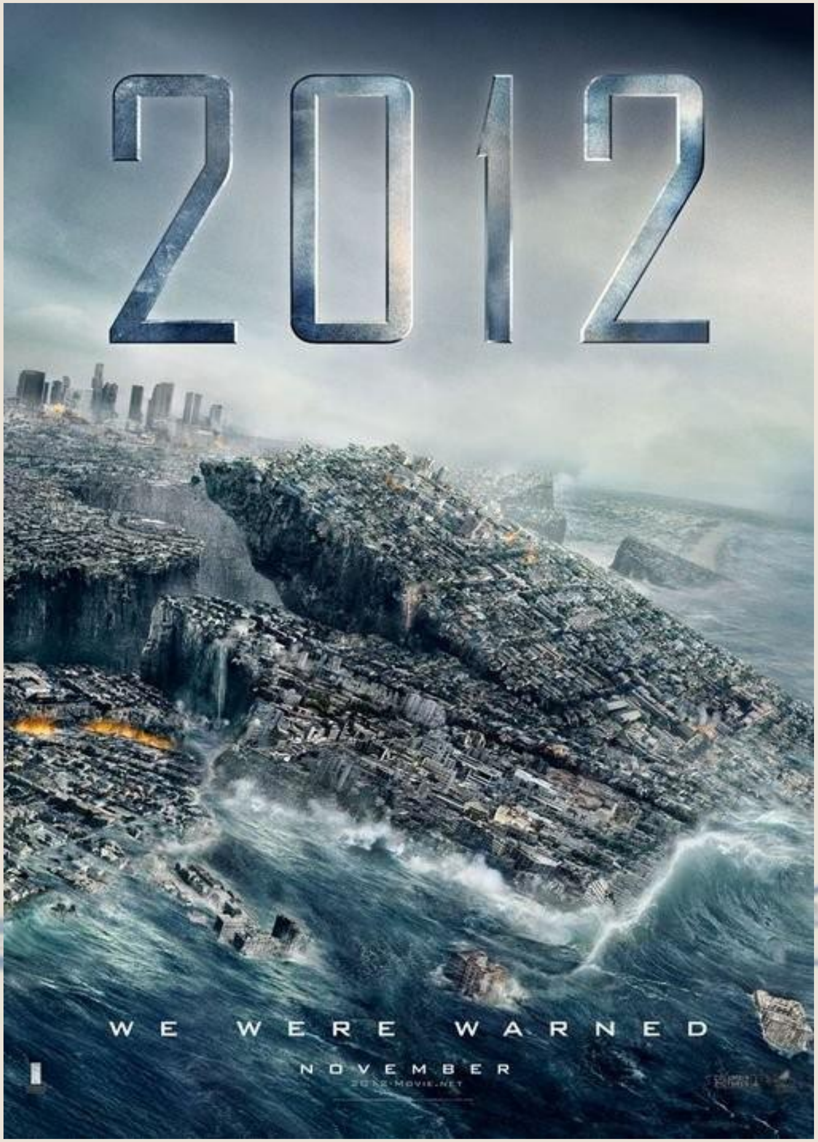
Lamentable newes out of Monmouthshire, 1607

‘The aforesaid waters, having gathered over their wonted limits are affirmed to have run…with a swiftness so incredible that no gray-hounde could have escaped by running before them..and they yet cover twenty four miles in length..’

‘Mistress Vann, a gentlewoman of good sort …is vouched before she could get uppe into the higher rooms of her house, having marked the approach of the waters…..to have been surprised by them…her house being distant above four miles from the sea’

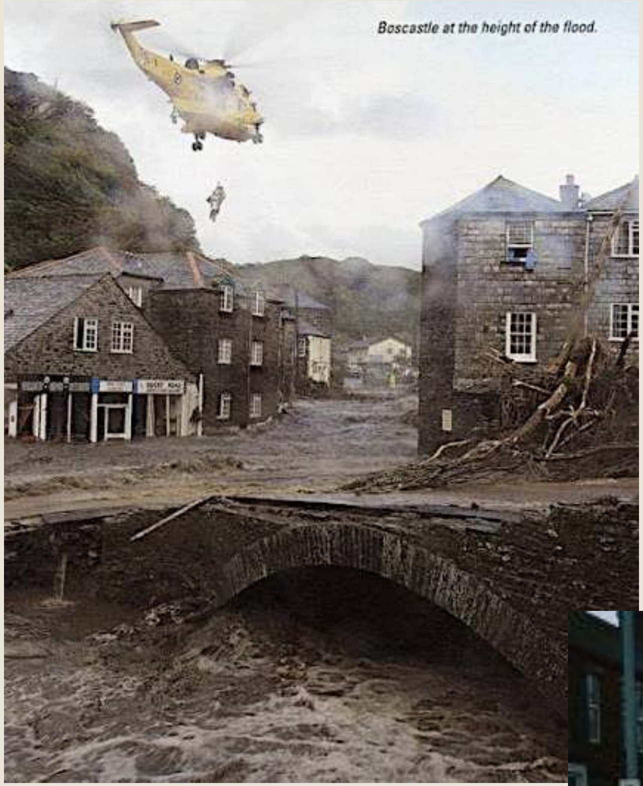
Hypothesised tsunami and storm wave heights throughout Bristol Channel. Some of the largest boulders are being moved at the mouth of the Severn Estuary. They require storm wave heights up to 7 times the 50-yr return period of maximum storm waves (from Bryant & Haslett, 2007, *J. Geol.*).




2012
WE WERE WARNED
NOVEMBER

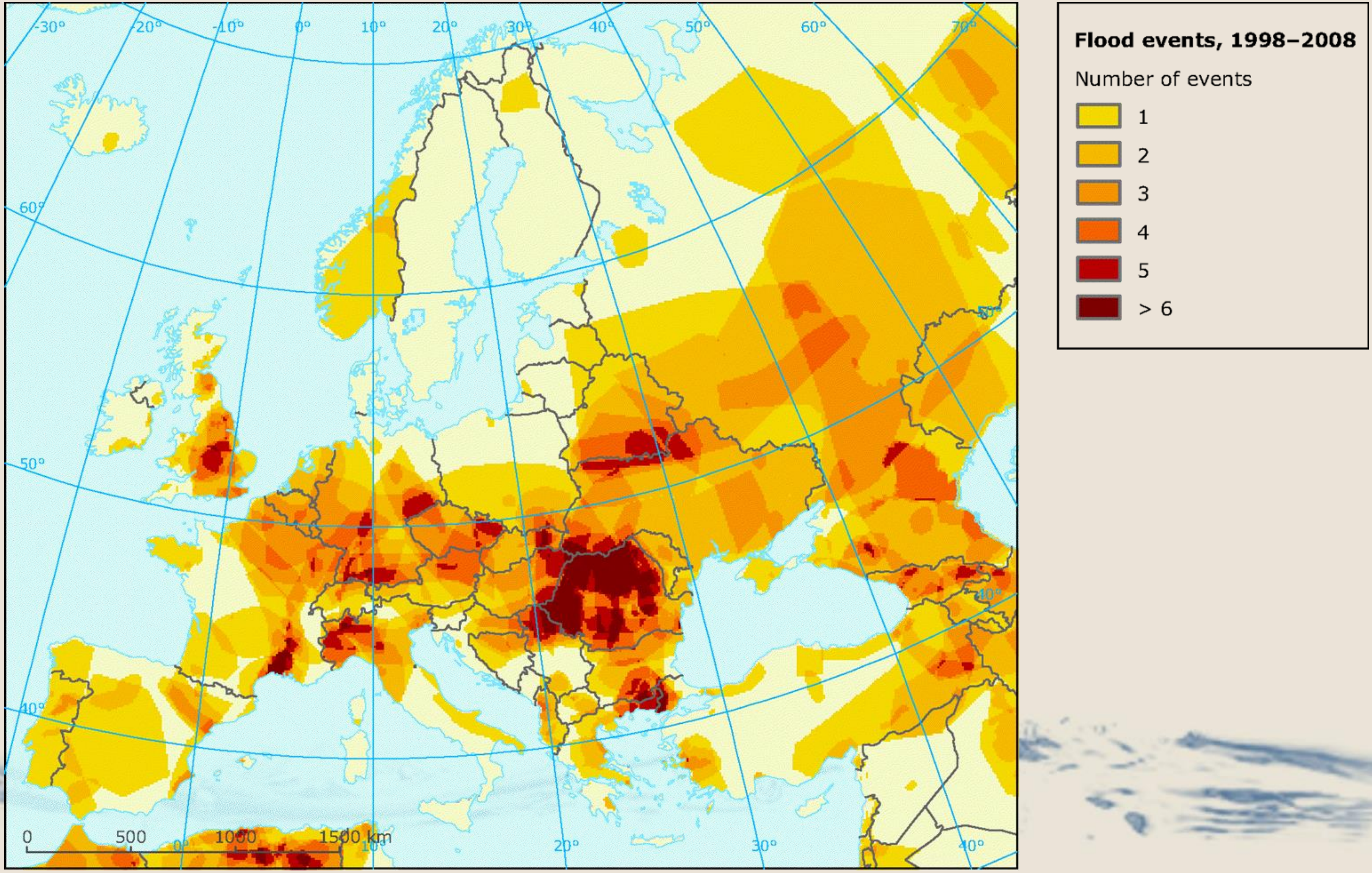
Lynmouth, 15th August 1952

Boscastle, Cornwall, August 2004



Carlisle, 2005

Cornwall, 17th November, 2010


Flood events, 1998–2008
Number of events
1
2
3
4
5
> 6
0
500
1000
1500 km
-30°
-20°
-10°
0°
10°
20°
30°
40°
50°
60°
70°
60°
50°
40°

Then we take decisions on what to do…

The main types of 'natural' flooding

- River flooding – high river flow, melting snow and ice (£0.5 Bn pa estimated currently)
- Coastal flooding – storm surges, tsunami (£0.32 Bn pa)
- Surface water flooding – impermeable surfaces, compacted farm land, intense rainfall (£ Bn pa)
- Groundwater flooding – prolonged heavy rainfall (£0.21 Bn pa)


Funded by NERC Knowledge Exchange Grant NE/HOO1786/1
Project FOSTER
Flood Organisation Science and Technology Exchange Research
NATURAL ENVIRONMENT RESEARCH COUNCIL
UNIVERSITY OF GLOUCESTERSHIRE
at Cheltenham and Gloucester
UNIVERSITY OF OXFORD

Flooding exceeded 1947 extent, especially further South in Severn catchment

July 2007, approximately 4,000 houses and 500 businesses flooded in Gloucestershire alone

Flooding included old and new properties in towns and villages, some on ‘non-floodplain’ areas

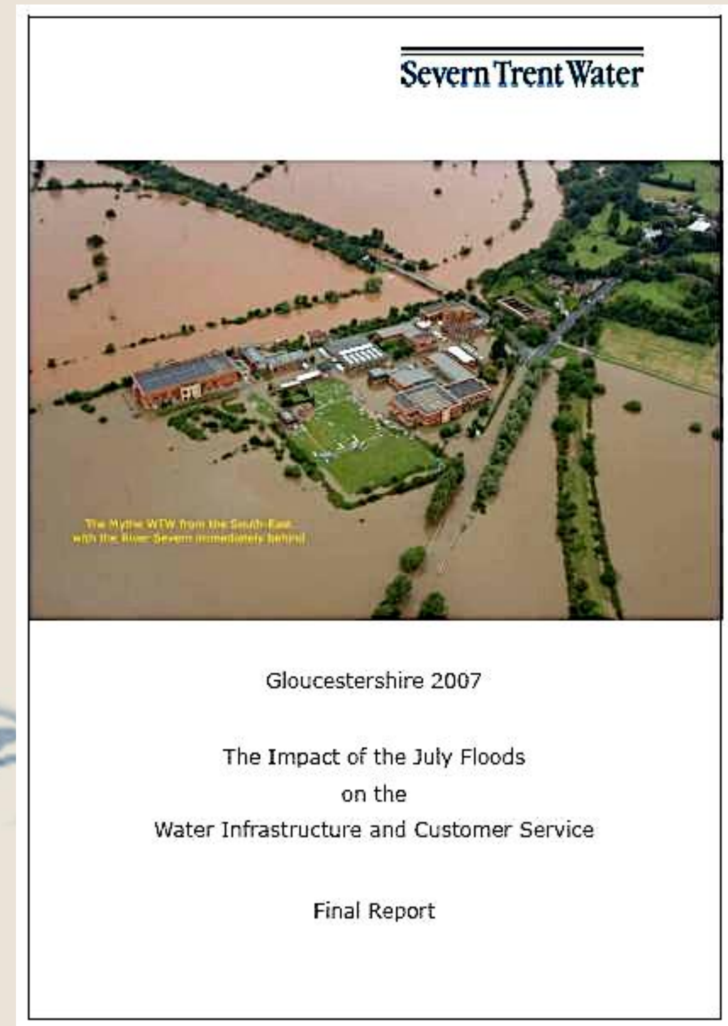

Tourist
Information
Tewkesbury


PROMENADE




‘In terms of scale, complexity and duration, this is simply the largest <UK> peacetime emergency we’ve seen’ Chief Constable, Dr. Tim Brain

- Relatively few direct deaths, unlike the 1947 event
- Serious economic consequences for UK businesses, local authorities and emergency services
- Single critical points of failure such as water treatment plants, electricity stations and transport infrastructure
- c. 400,000 people lacked safe piped water supply for up to 21 days
- c. 10,000 people trapped on flooded M5 motorway for up to 18 hours


Severn Trent Water

Gloucestershire 2007

The Impact of the July Floods
on the
Water Infrastructure and Customer Service

Final Report

UK responsibilities changed

The 'Pitt Review', 2008

Word cloud from Executive Summary of Pitt Review

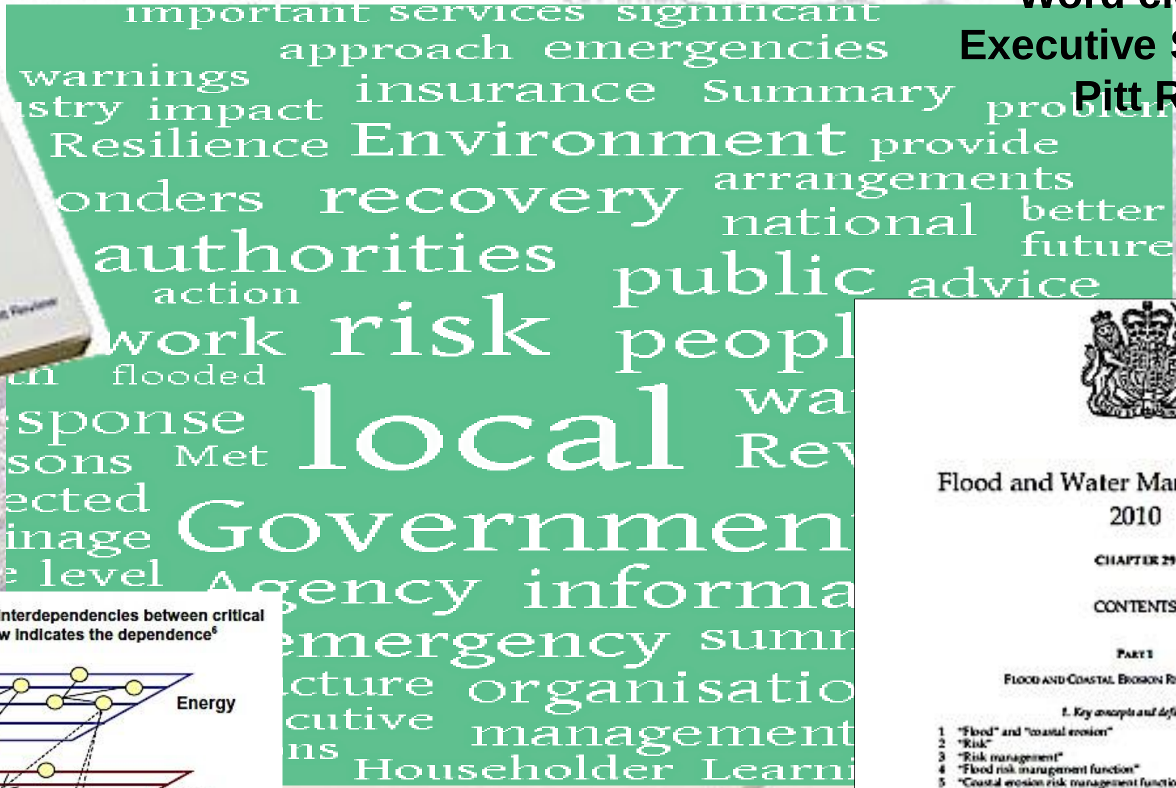
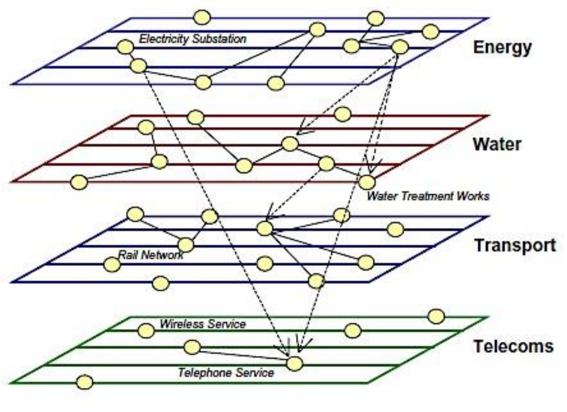
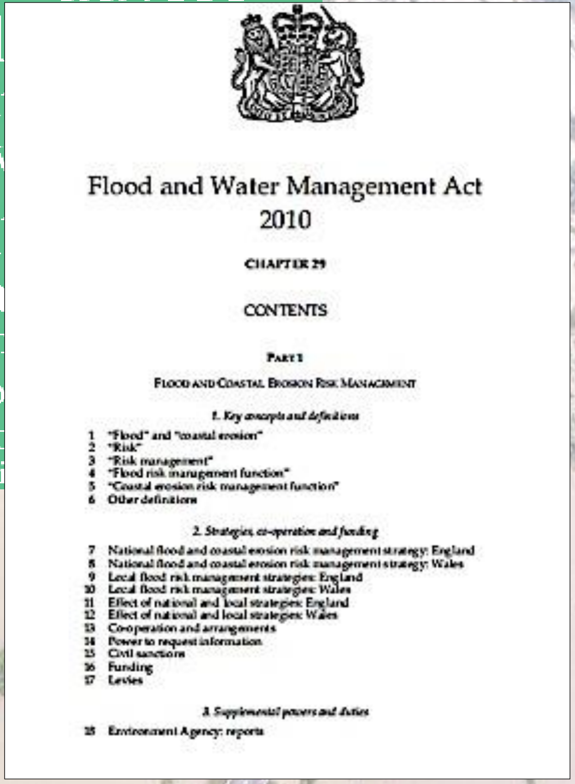


Figure 13 – A schematic outline of some of the interdependencies between critical infrastructure sectors. The direction of the arrow indicates the dependence[6]





Flood and Water Management Act 2010

CHAPTER 29

CONTENTS

PART 1

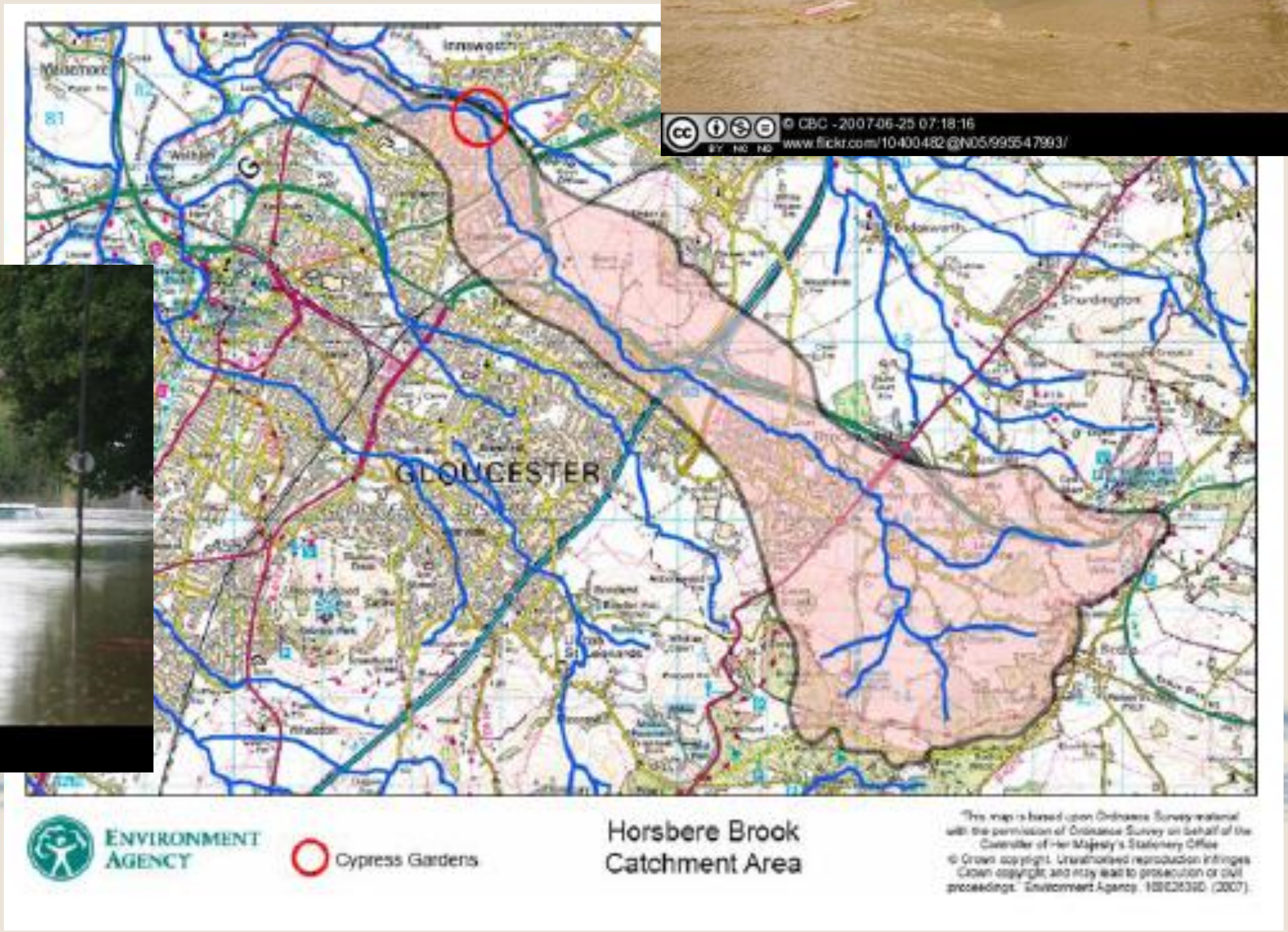
FLOOD AND COASTAL EROSION RISK MANAGEMENT

1. Key concepts and definitions

2. Strategies, co-operation and funding

3. Supplemental powers and duties

What happened in Horsbere Brook, Gloucester?

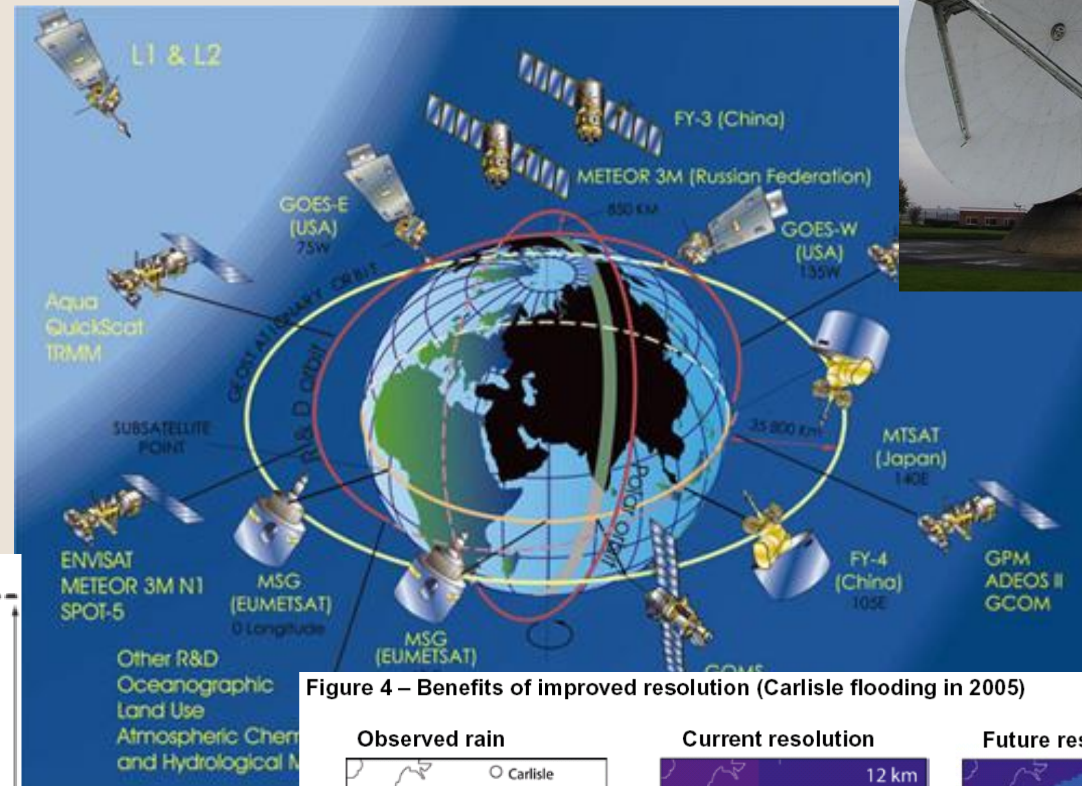


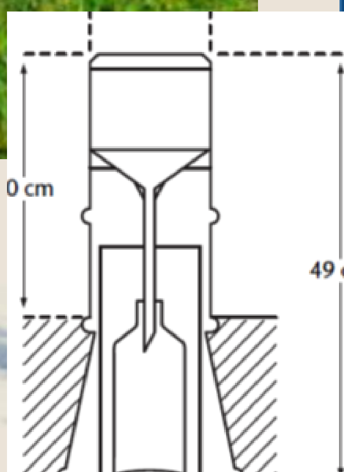
Source: Gloucestershire County Council (2007) *Scrutiny Inquiry into the Summer Emergency 2007*. GCC, 148pp. Image reproduced with permission © Gloucestershire County Council.

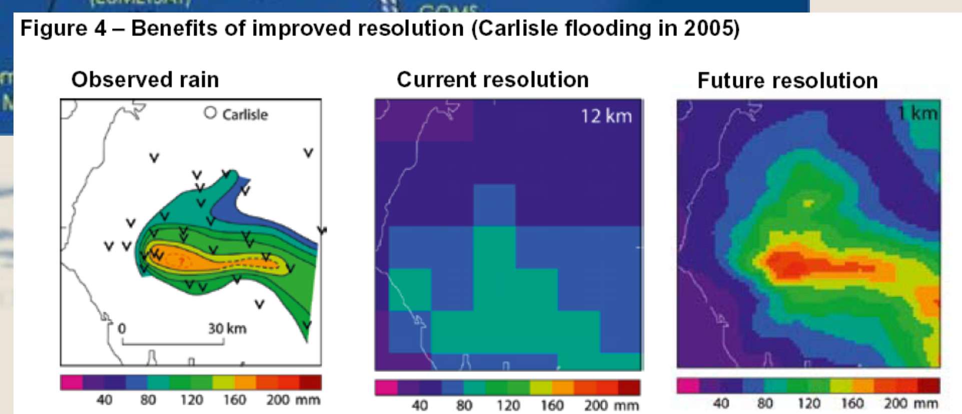
Where's the uncertainty?

- What actually happened this time, where, and why?
- How can we generalise about the physical principles, and model floods, at different spatial resolutions and timescales?
- How can we forecast future floods at different scales?
- How can we forecast future floods in changing environmental conditions?
- What will we do about it (adaptation and mitigation)?
- What effect will that have on what happens?

Uncertainties in rainfall data



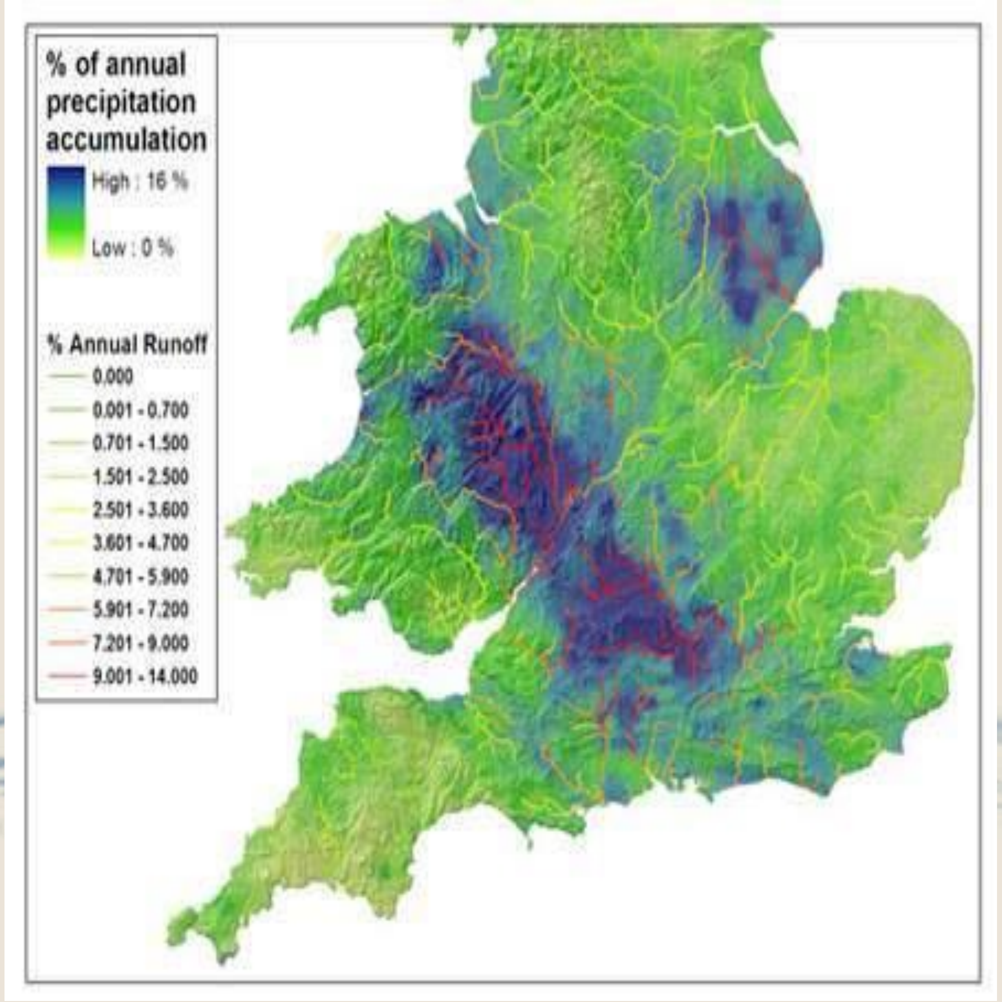


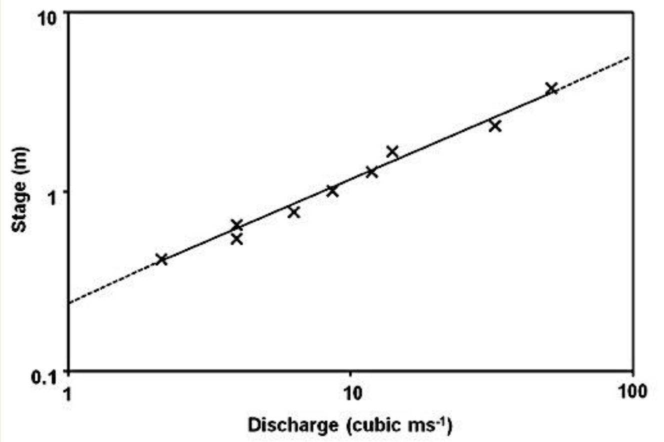


Source: CEOS (2011) *The Earth Observation Handbook* (http://www.eohandbook.com/eohb05/ceos/part2_6.html)

A ‘1 in 400+ year’ event?

- 1st June to 31st August: 200-250% long term average rainfall across most of the catchment. Four main ‘episodes’
- July 2007: 400-450% long term average rainfall
- 20th July: 78mm in 12 hours widely, peaking at 110mm in 2 hrs locally (1 in 443 yrs estim).
- 2 months’ rainfall in 12 hours.





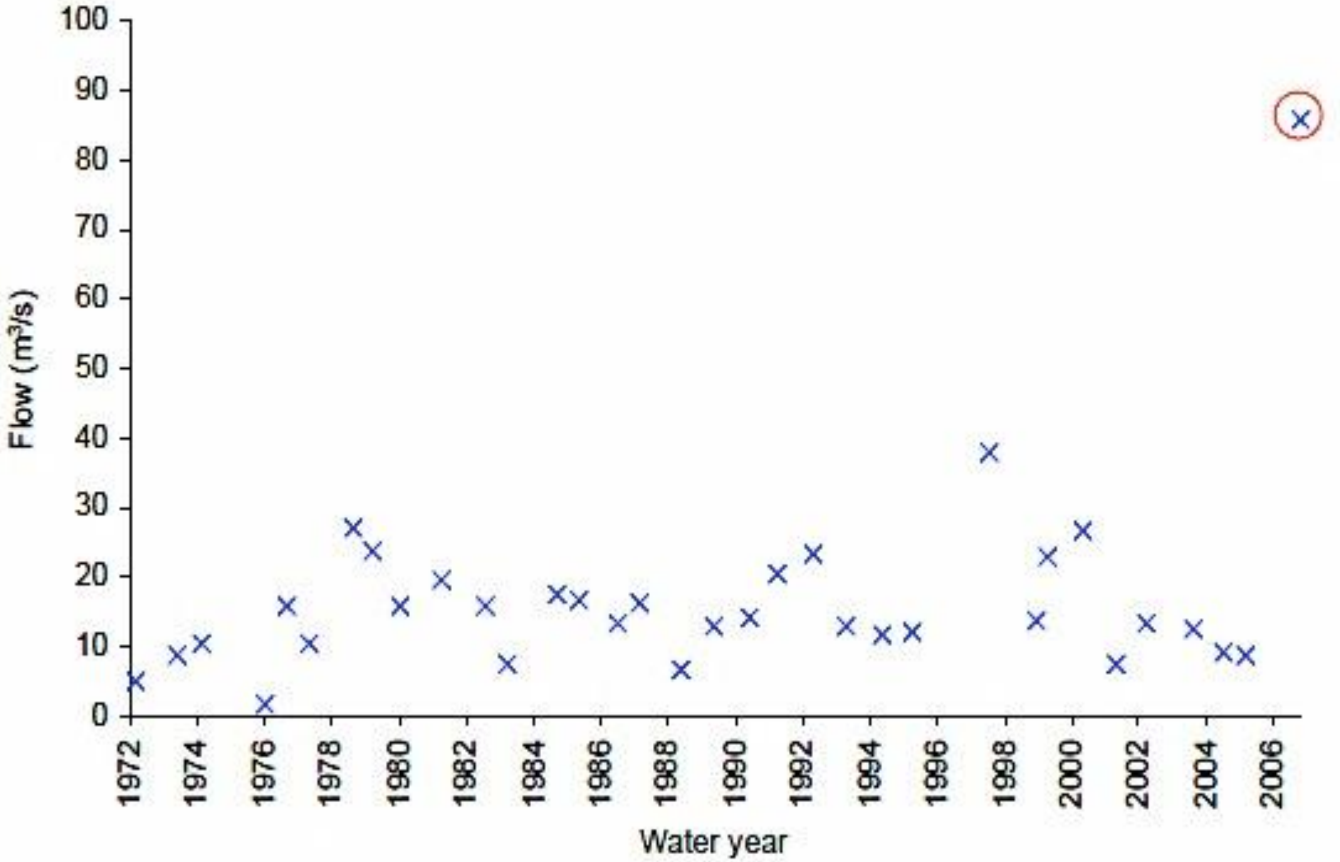
Uncertainties in level and flow (discharge)

Source: Richard Croft [CC-BY-SA-2.0 (www.creativecommons.org/licenses/by-sa/2.0)], via Wikimedia Commons.
http://commons.wikimedia.org/wiki/File%3ABrant_Broughton_Gauging_Station_-_geograph.org.uk_-_166904.jpg

Short records and extreme events

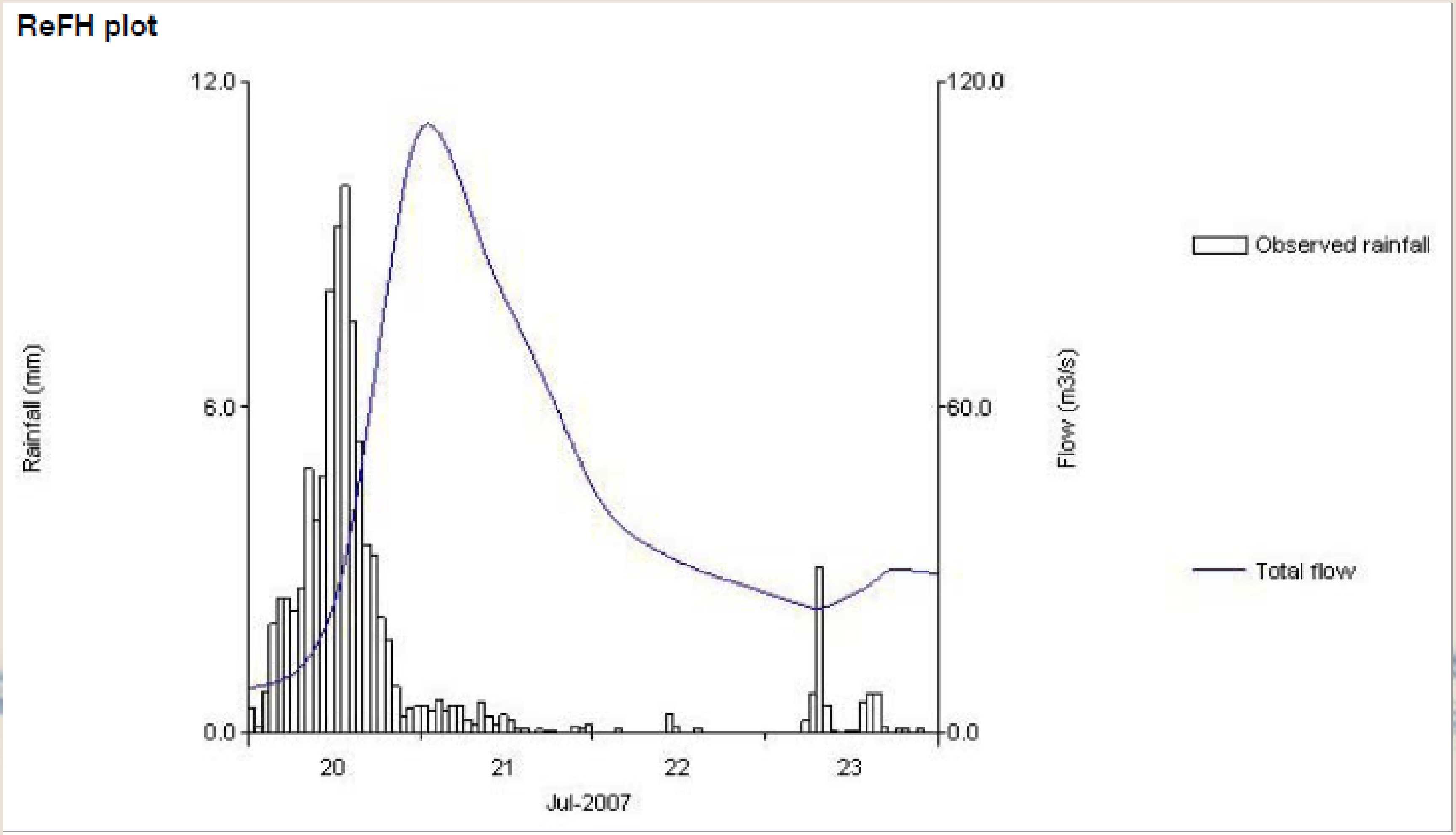
4.22 Isbourne at Hinton

Annual maximum time series plot (flow)



July	
Return Period	>1000 years
Peak stage	4.93m
Peak flow (m^3/s)	124 (NFFS) 86 (ReFH and extrapolated EA rating) 170 (hydraulic model)
Confidence in flow	Very low (rating exceeded by >1m and ReFH estimates uncertain)
POT rank	1
Years of data	35

Rainfall (and Runoff) at River Leadon at Wedderburn Bridge (500 year event?)



Source: Environment Agency Midlands Region (2007) *Summer 2007 Flood Hydrology Support: Final Report.* JBA Consulting, Skipton, 145pp. Contains Environment Agency information © Environment Agency and database right.

Estimated Return Periods

River	At Station	July 2007 event, Estimated Return Period of flow in years
Severn	Diglis	50
Severn	Saxon's Lode	200
Severn	Mythe	200
Severn	Haw Bridge	200
Severn	Gloucester	200
Isbourne	Hinton	Over 1000
Avon	Warwick	25
Avon	Stratford	75
Avon	Bidford	200
Avon	Evesham	400
Arrow	Studley	200
Arrow	Broom	200
Leadon	Wedderburn Bridge	500

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- What effect will that have on what happens?

UK research on hydrological ‘uncertainty’

Flood mapping examples
Prof. Robert Gurney, Reading University

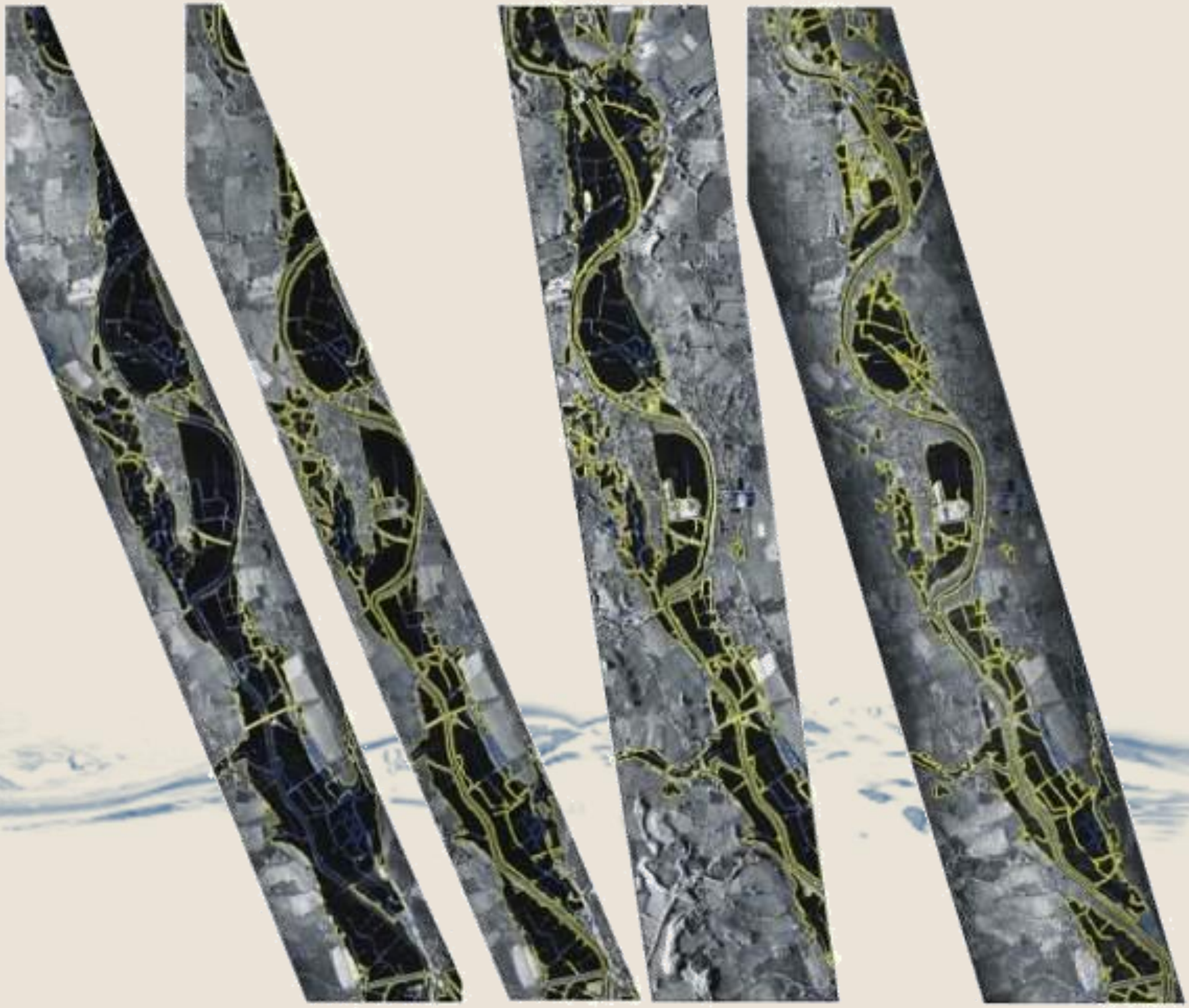
Aerial photo of
Tewkesbury flooding

TerraSAR-X image of
Tewkesbury flood (3m
resolution)

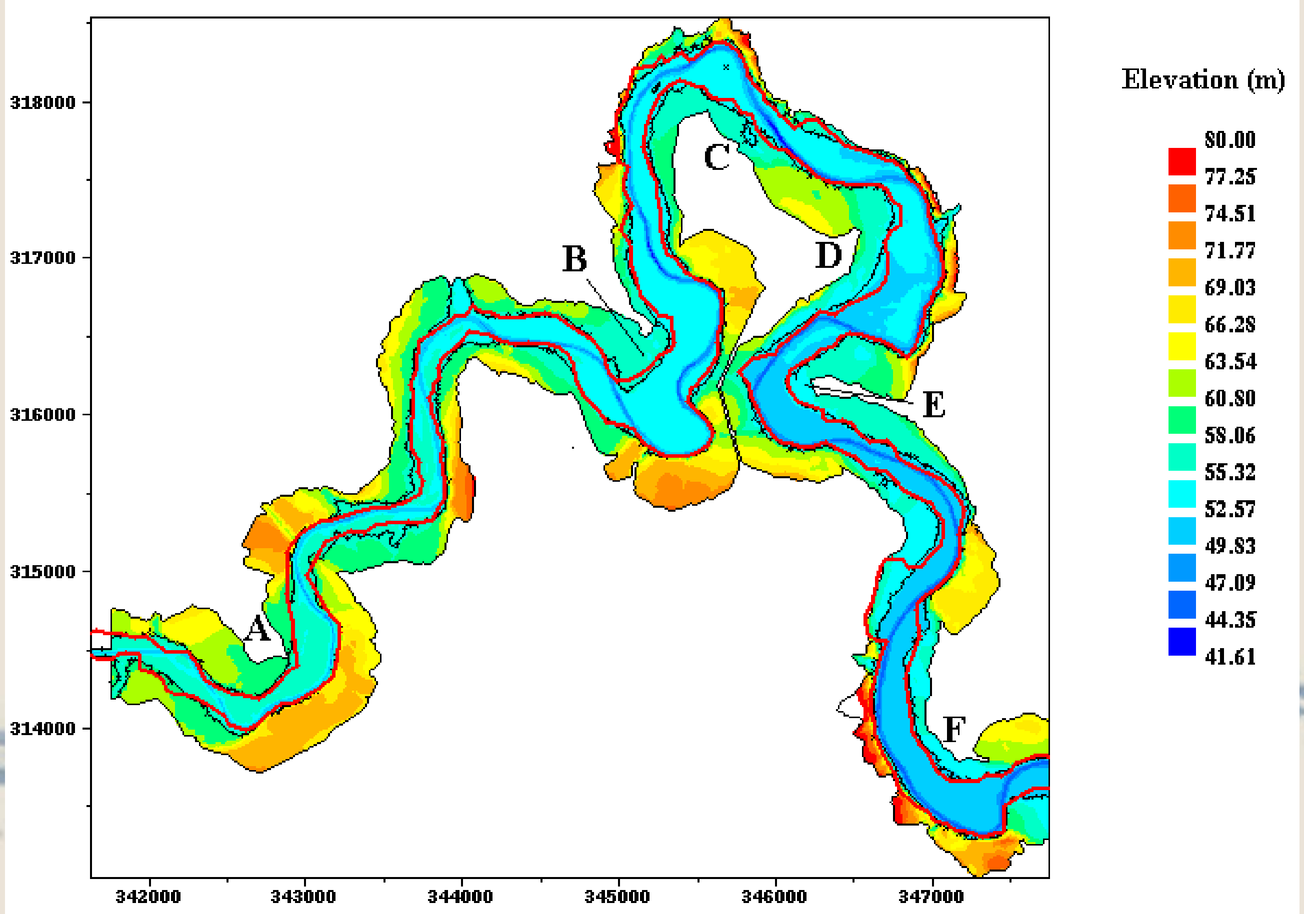
Attempts to predict flood extent

ASAR image sequence of falling flood levels (1m resolution) acquired on (a) 8th (b) 14th (c) 15th (d) 17th Nov. 2000.

The drainage network is shown in blue and predicted flood extent using the 'Snake algorithm' is in yellow.

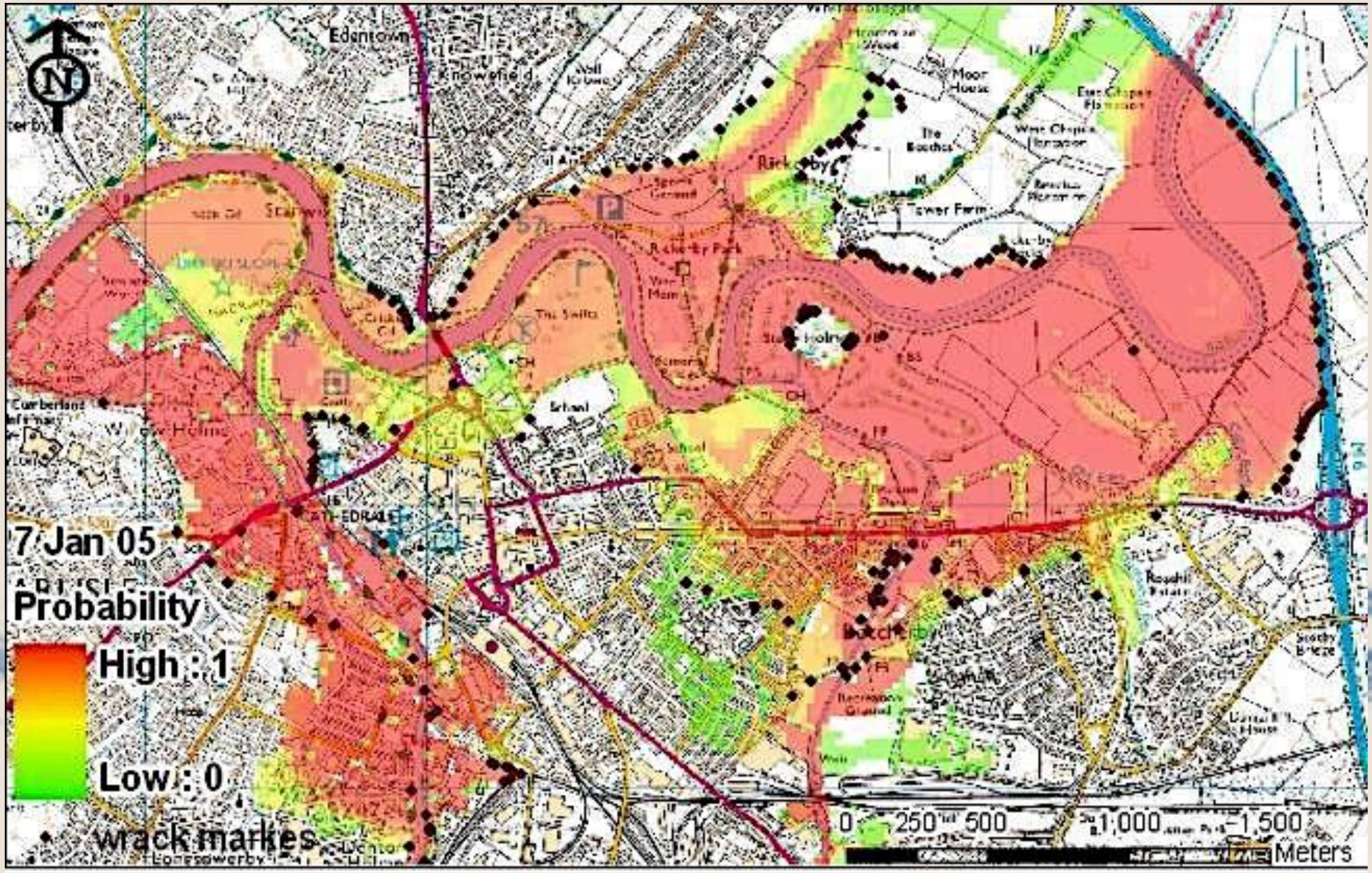


Mapping and modelling flood extent

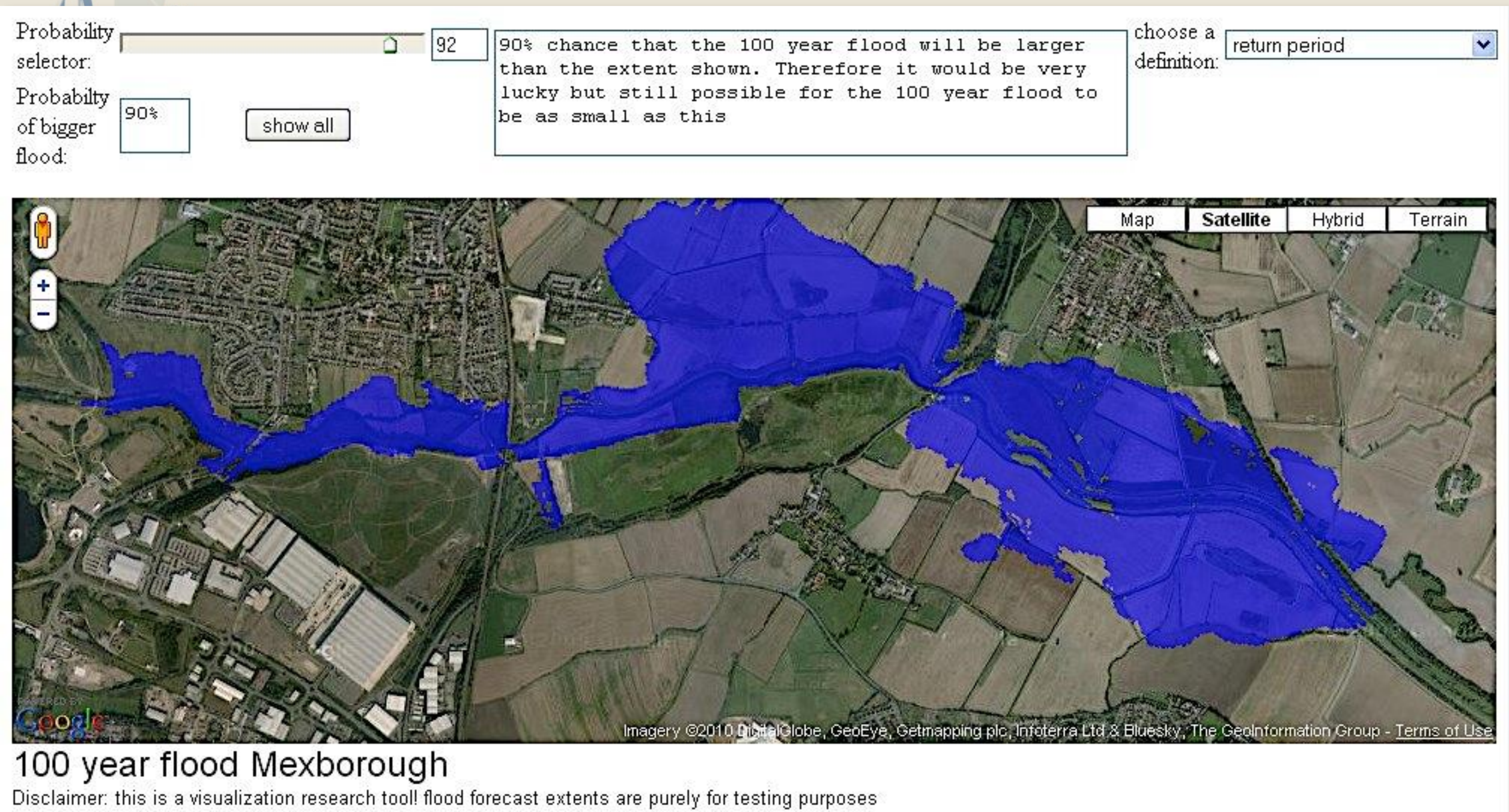


Fine mesh waterline (black) and SAR waterline (red) on bathymetry

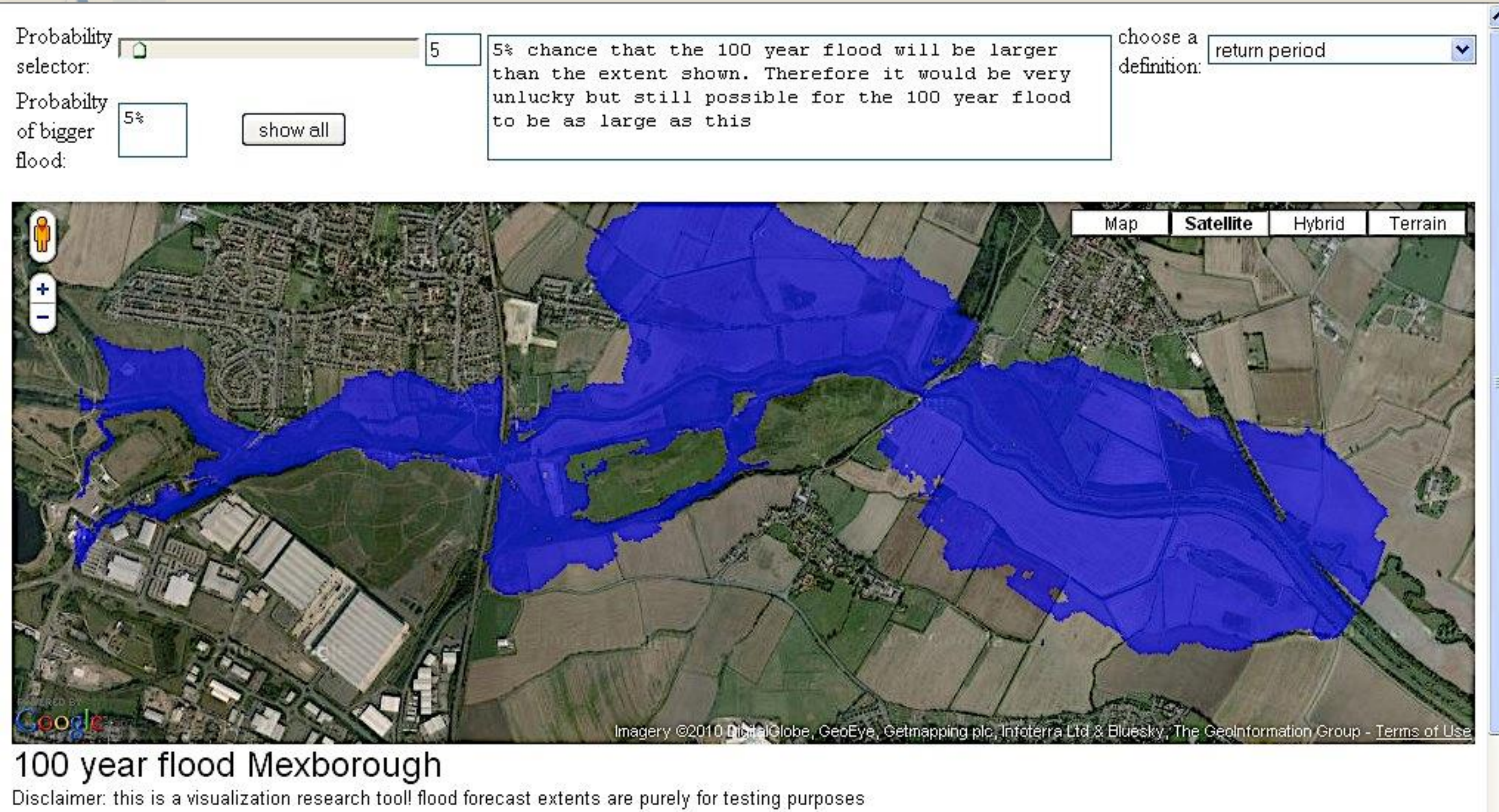
Creating multiple scenarios then matching them with actual rainfall to produce an estimation of what might happen. This was tested using data from the 2005 flood. Forecast maps show the probability of flooding (Green 0.005-0.1, Blue 0.1-0.9, Yellow 0.9-0.95, Red 0.95)



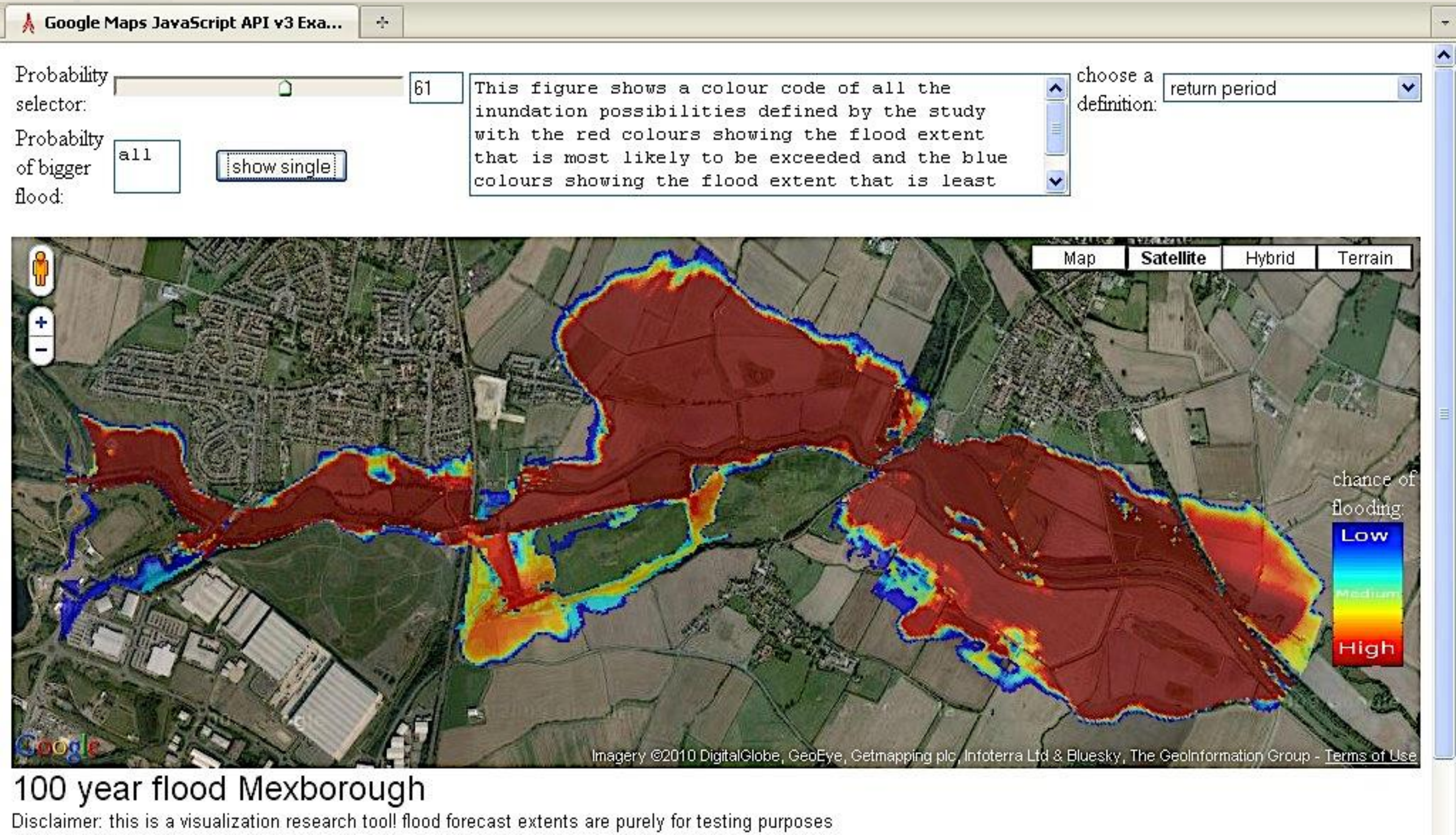
92 % chance 1 in 100 year flood will be larger than shown



5 % chance that 1 in 100 year flood will be larger than shown



Chance of flooding for 1 in 100 year flood



1km square and receptors

1 in 30 year return period

1 in 100 year return period

1 in 1000 year return period

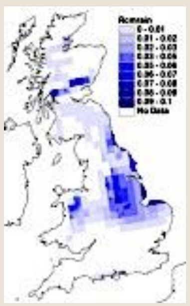
'Next generation' National Flood Risk Assessment, Dr. Hannah Cloke, King's College London

FRACAS

National-scale application

Catchment-scale applications (Eden and Kennet)

RCM rain and PE

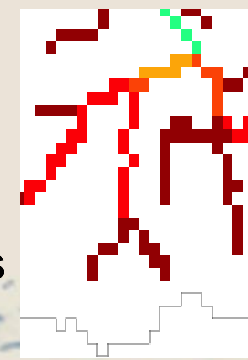


G2G flows and flood frequency

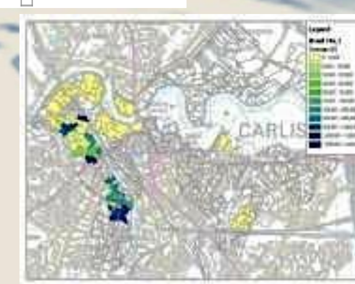
Flood risk estimation using RASP

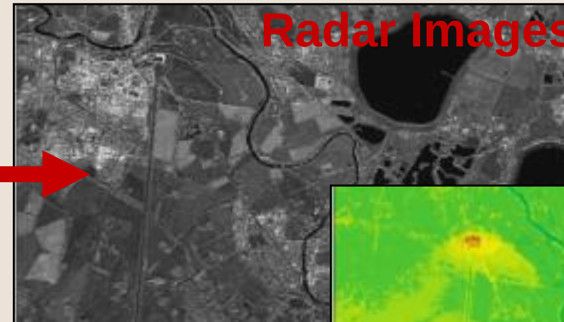
Weather generator rainfall

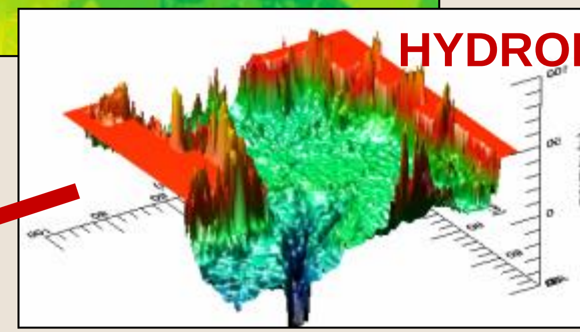
G2G Flows



Flood risk and inundation modelling using Infoworks RS







Environment Agency Online Flood Map

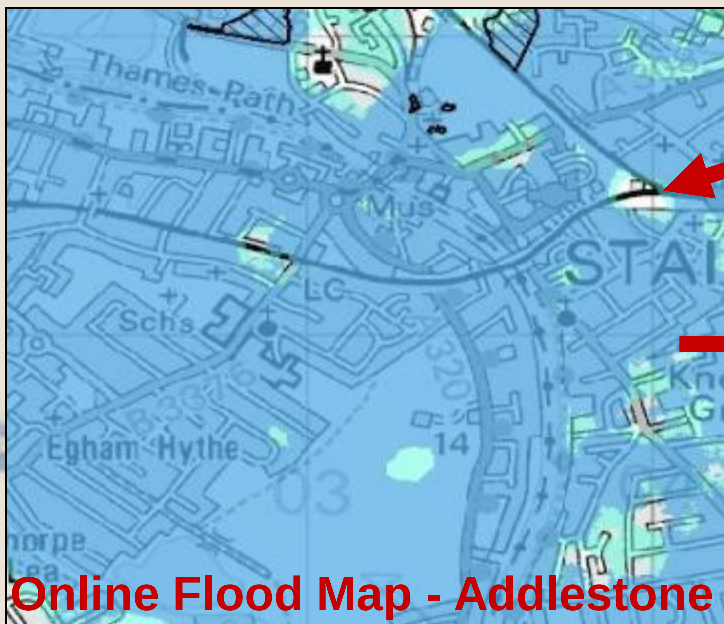
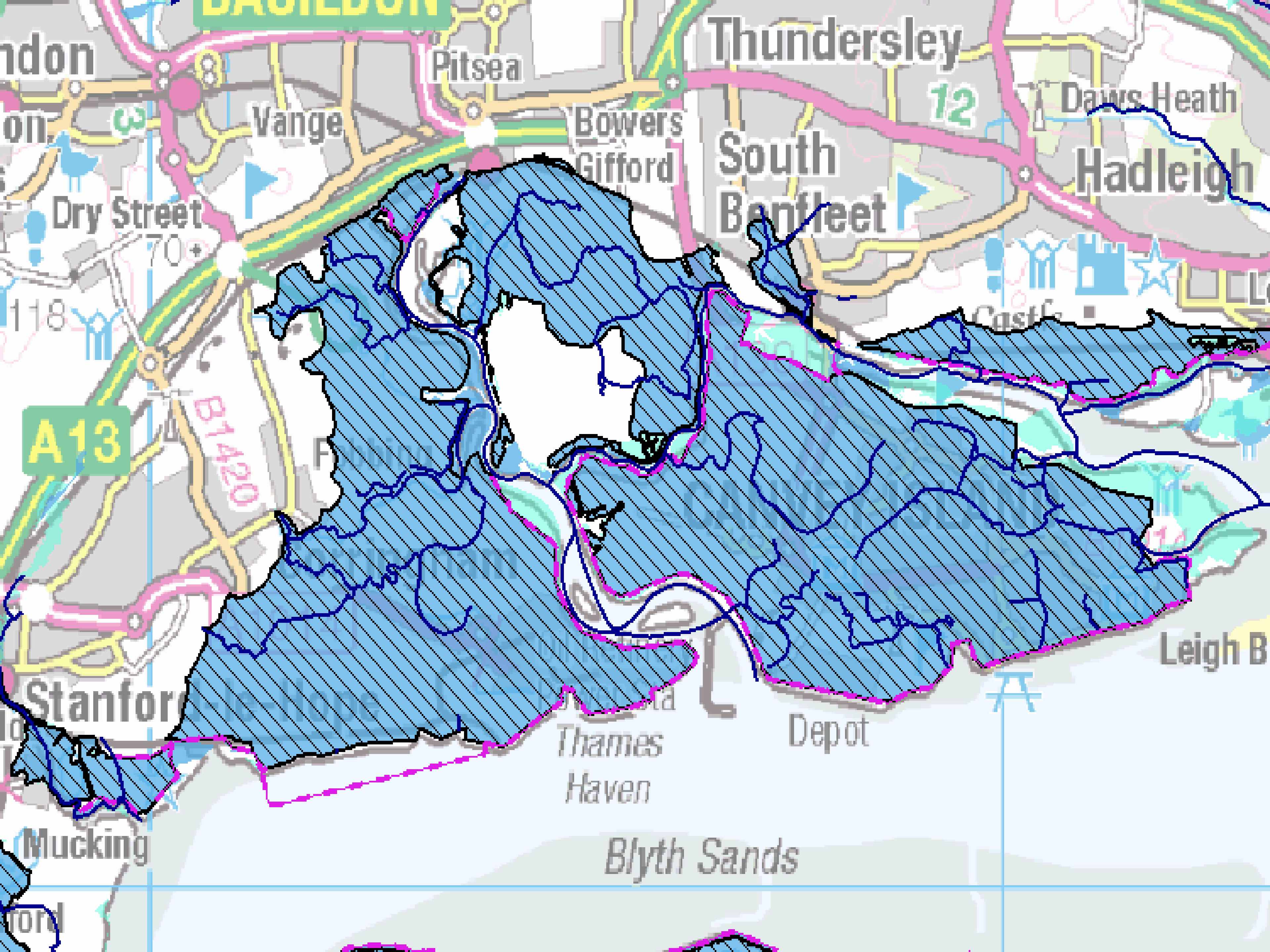


Image compiled by James Porter, Brunel University (2012). Contains Environment Agency information © Environment Agency and database right

The Environment Agency map of the ‘25 year’ and the ‘50 year’ flood event


Thundersley
Pitsea
Vange
Bowers
Gifford
South
Benfleet
Daws Heath
Hadleigh
12
Dry Street
118
A13
B1420
Thames
Haven
Depot
Mucking
Blyth Sands

Flood extent at 12 noon

Flood extent at 5pm

Where's the uncertainty?

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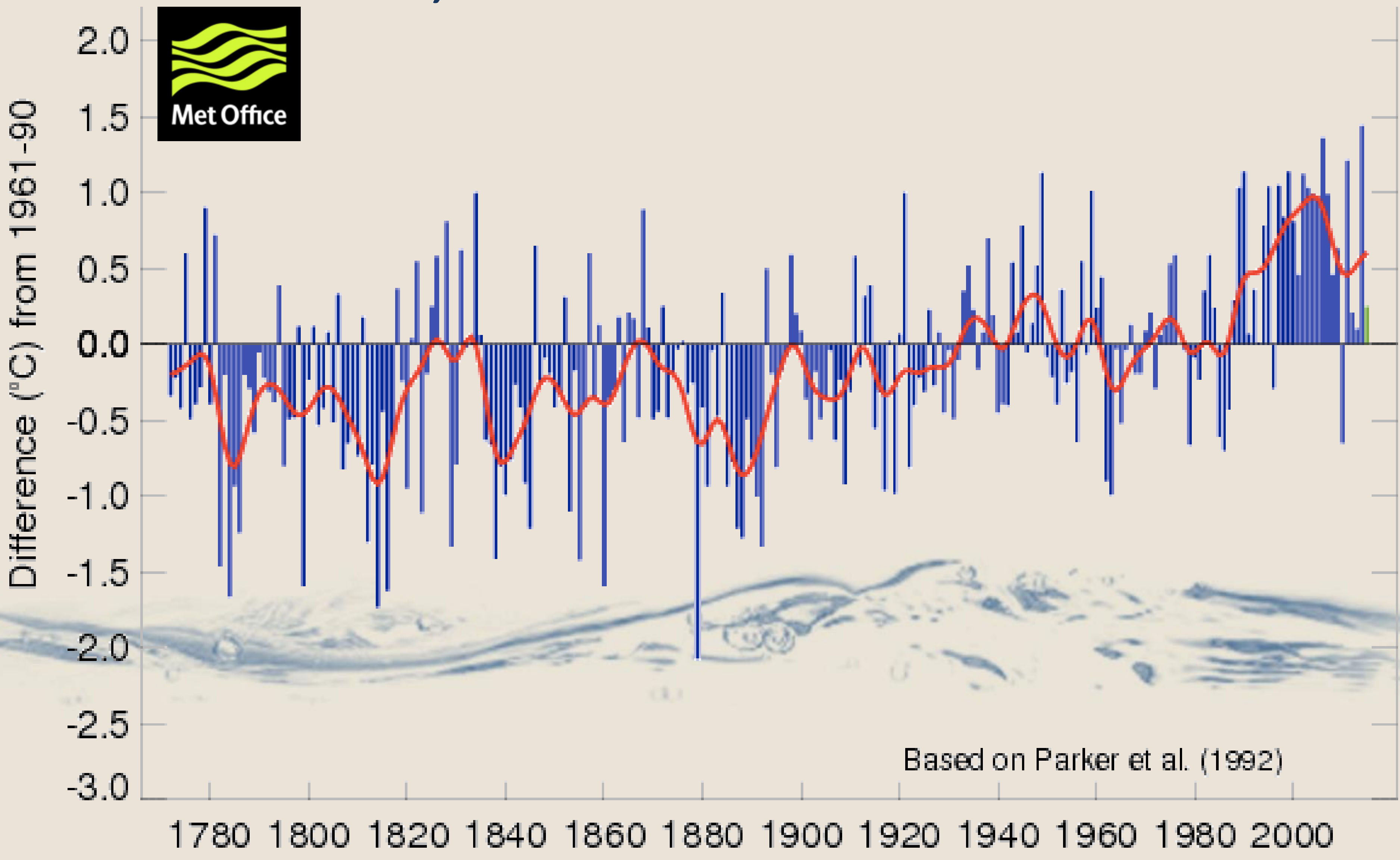
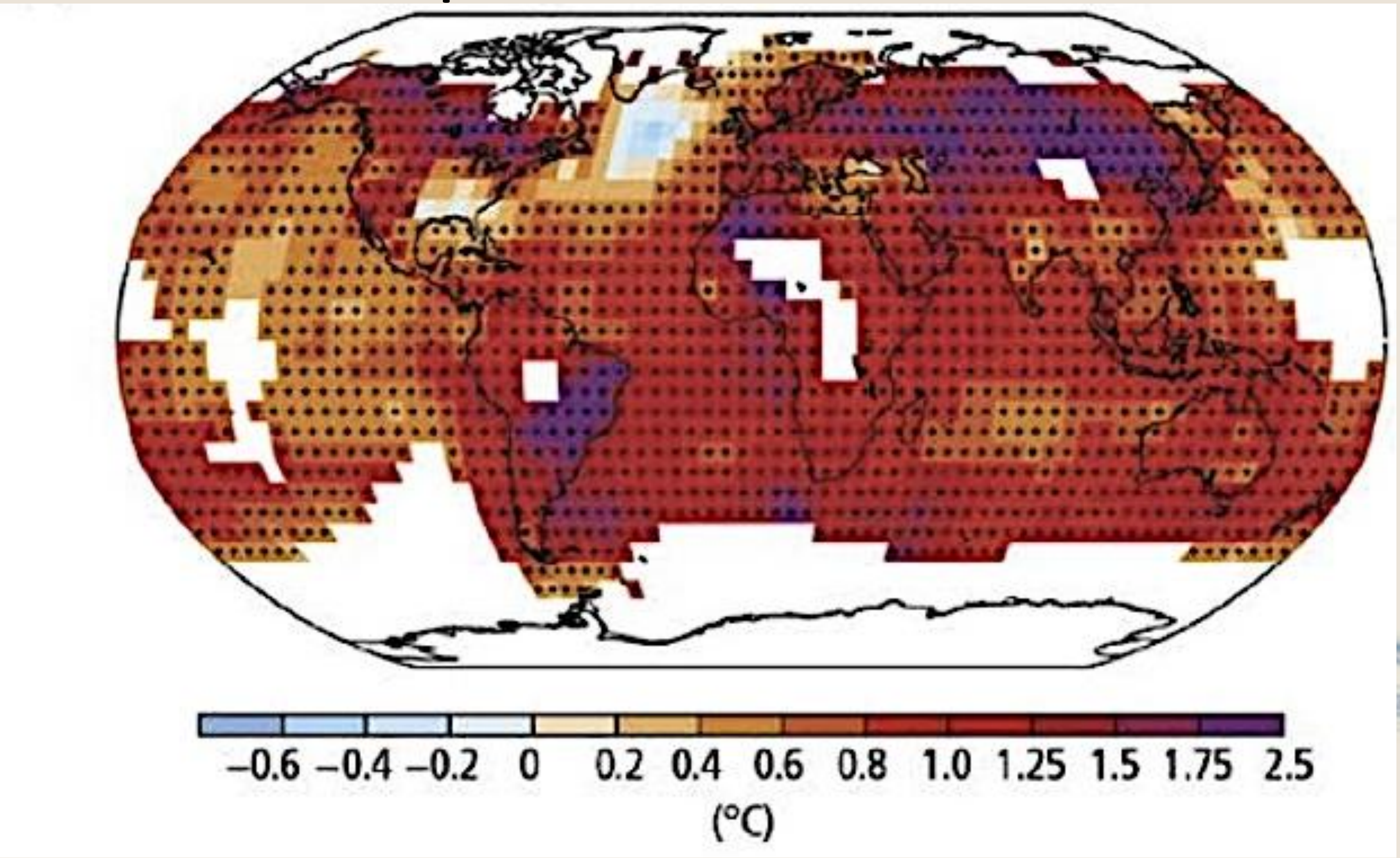
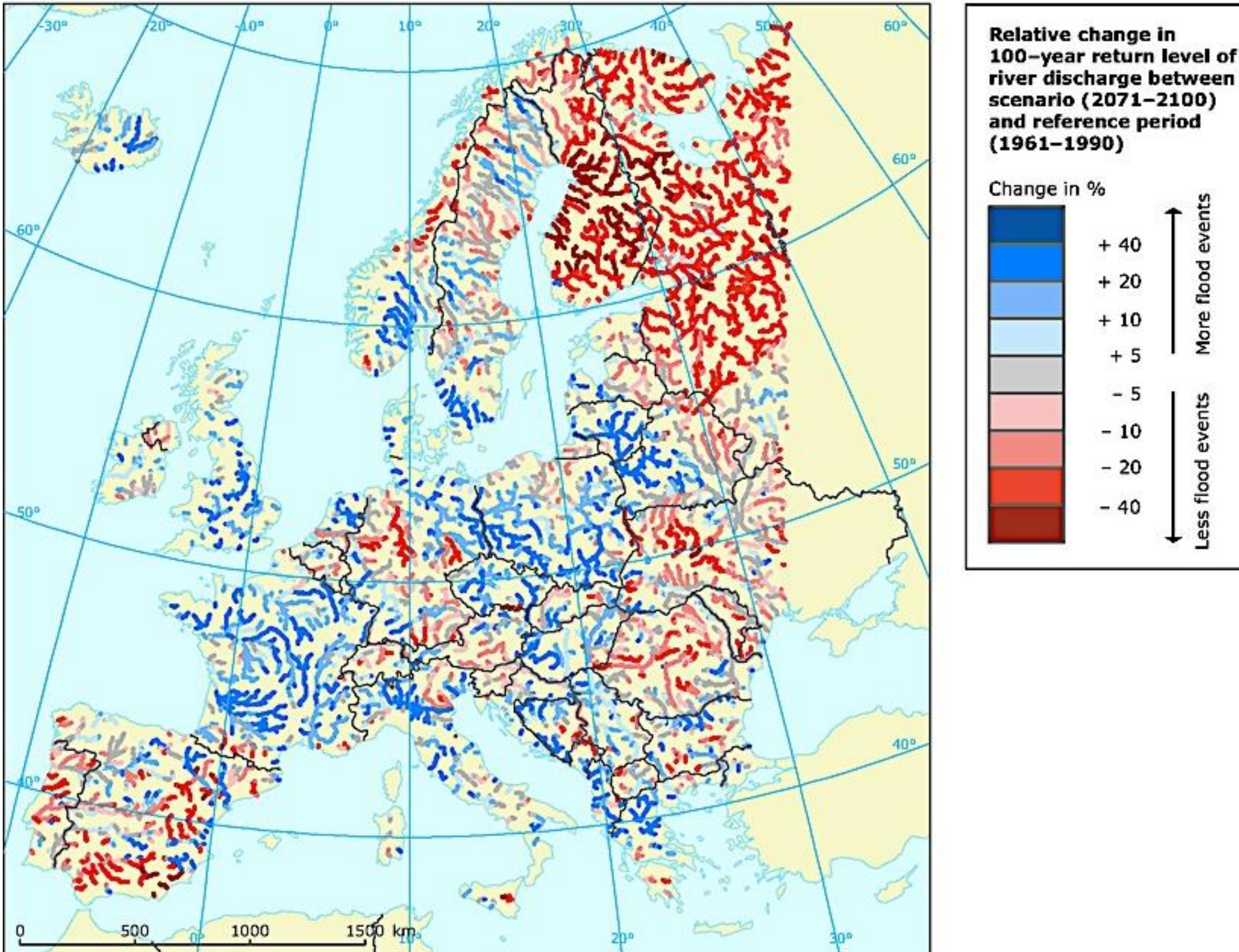
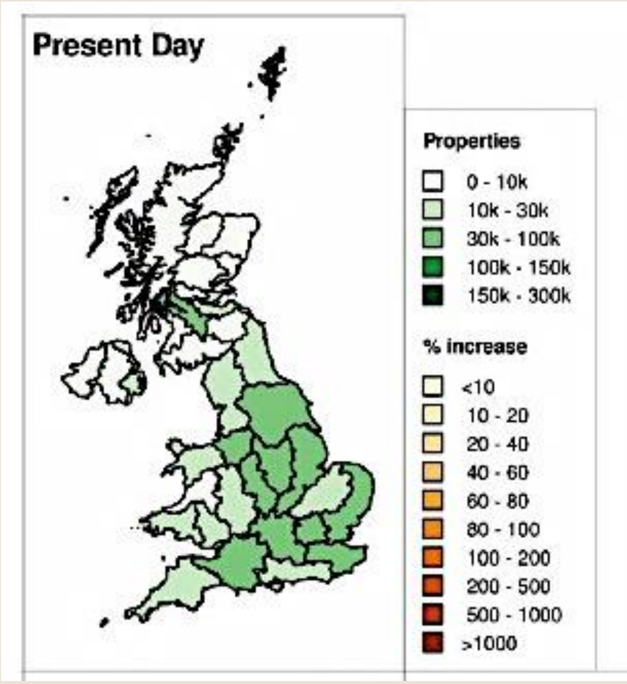
Mean Central England Temperature Anomalies, 1772 - 9th November 2015

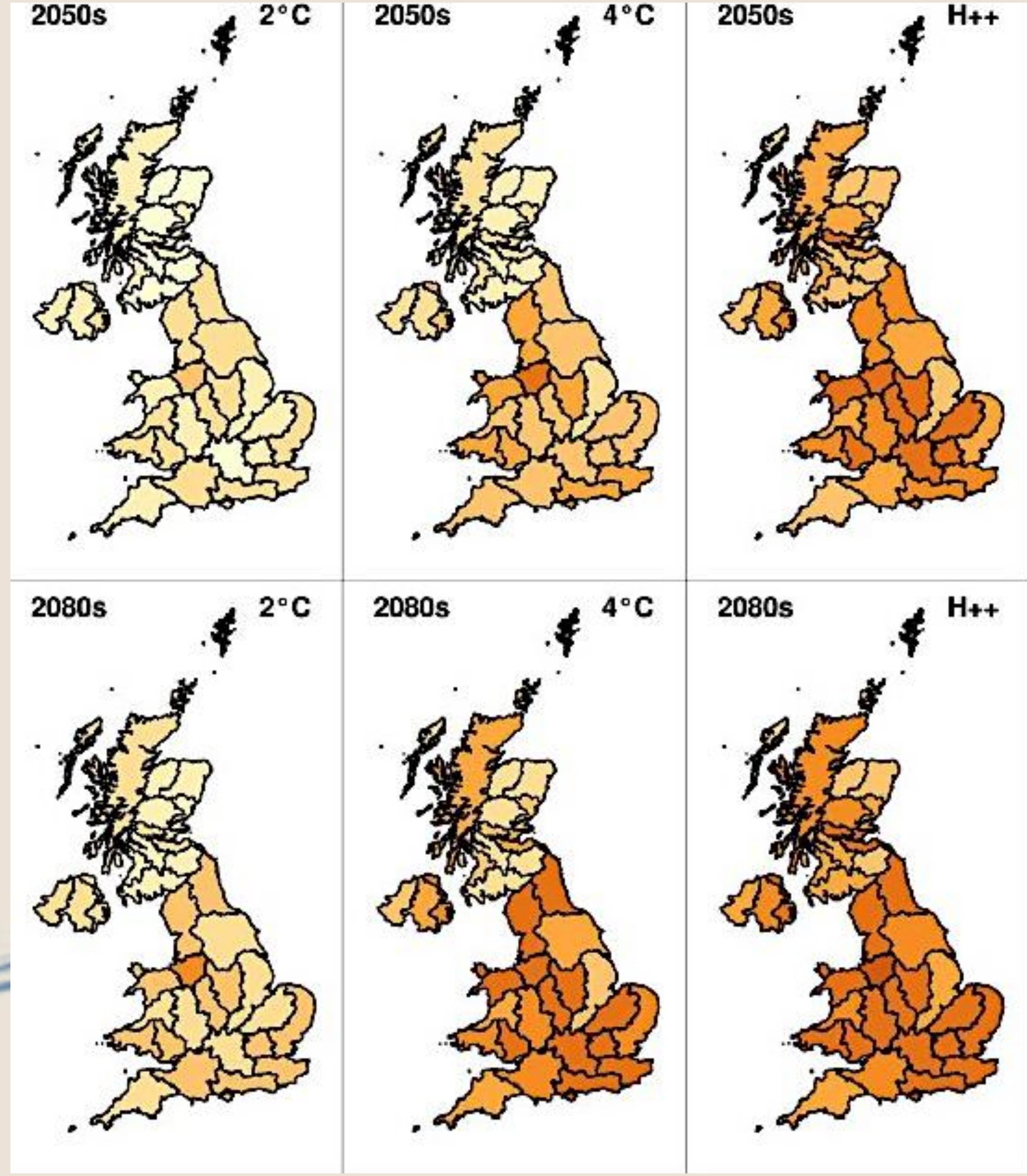


Observed change in surface temperature 1901-2012

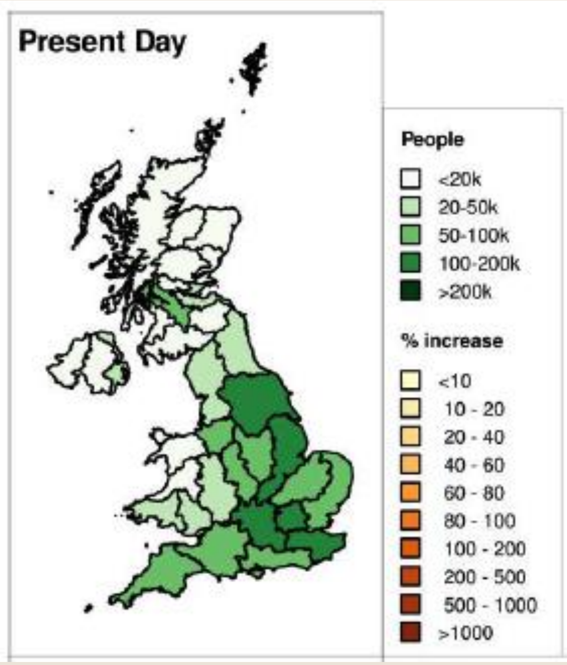



Relative change in 100–year return level of river discharge between scenario (2071–2100) and reference period (1961–1990)
Change in %
+ 40
+ 20
+ 10
+ 5
− 5
− 10
− 20
− 40
More flood events
Less flood events
0
500
1000
1500 km

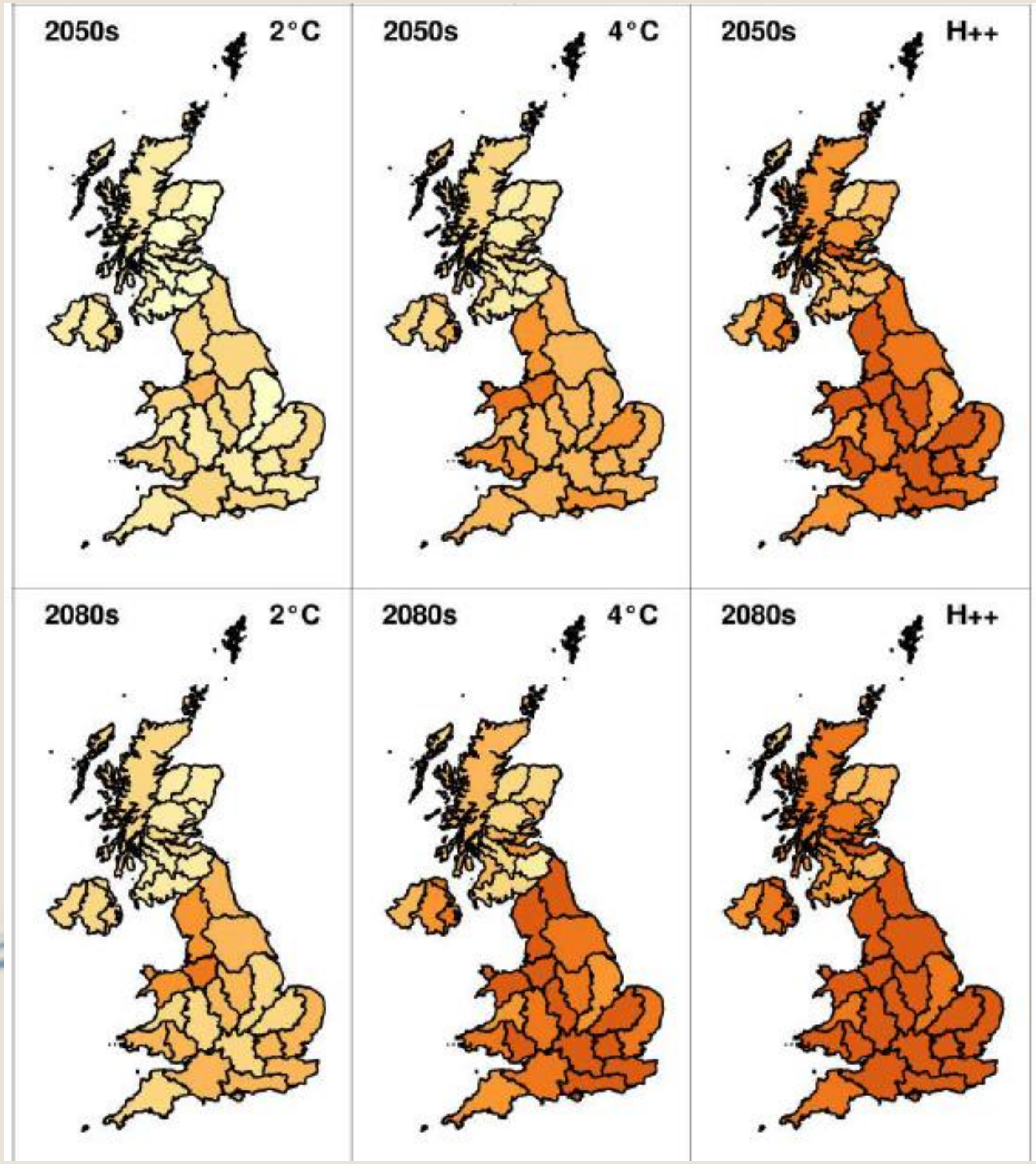


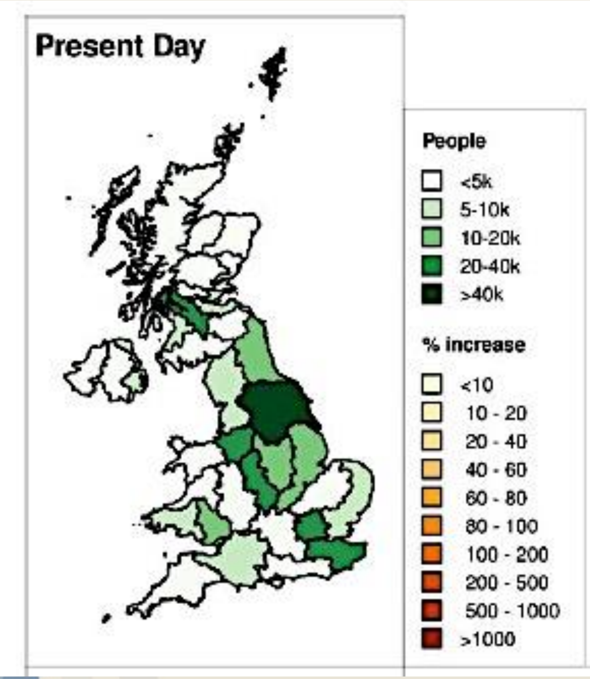


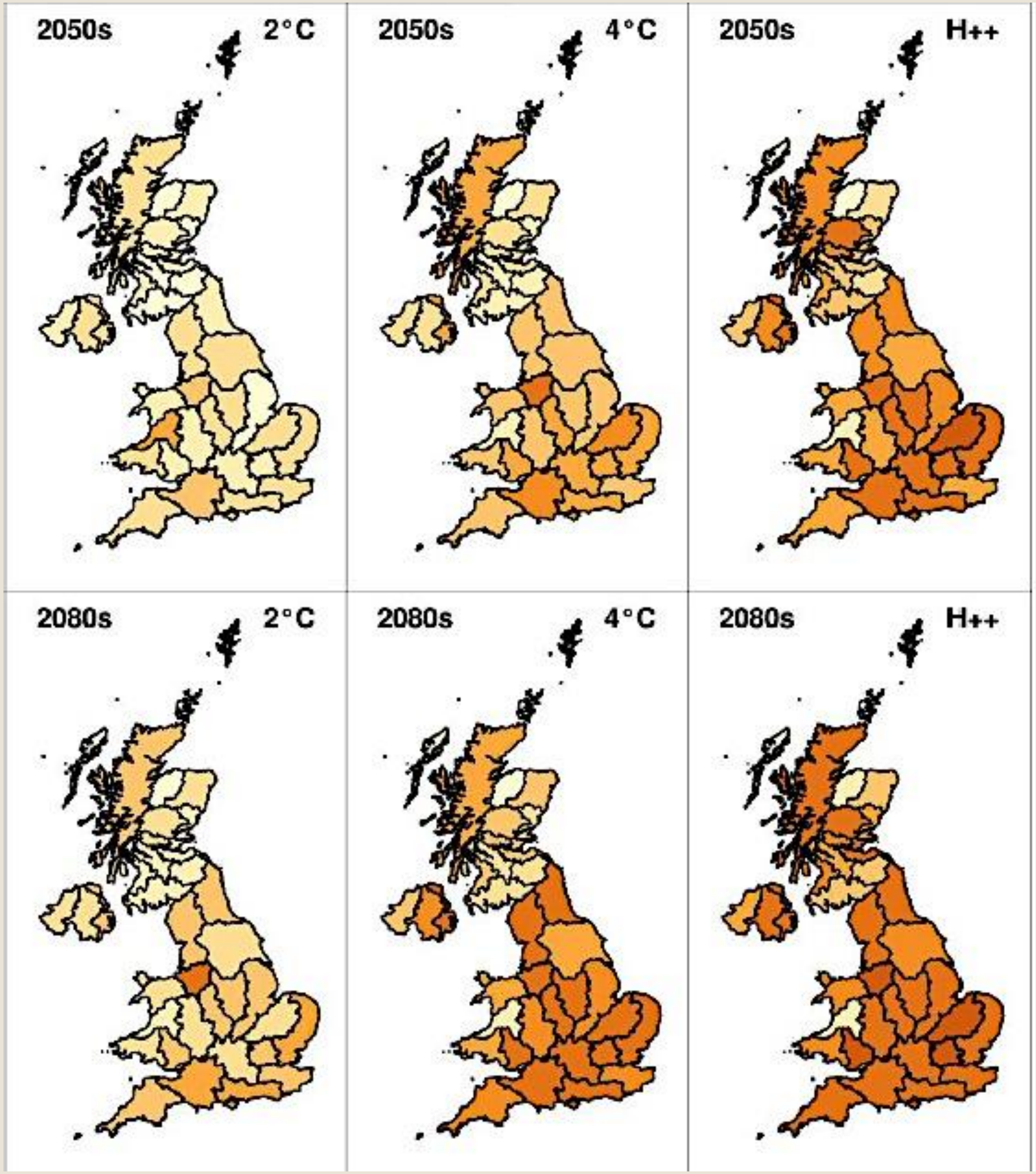
Change in residential properties at risk of flooding 1 in 75 years, assuming no population growth and current adaptation scenario



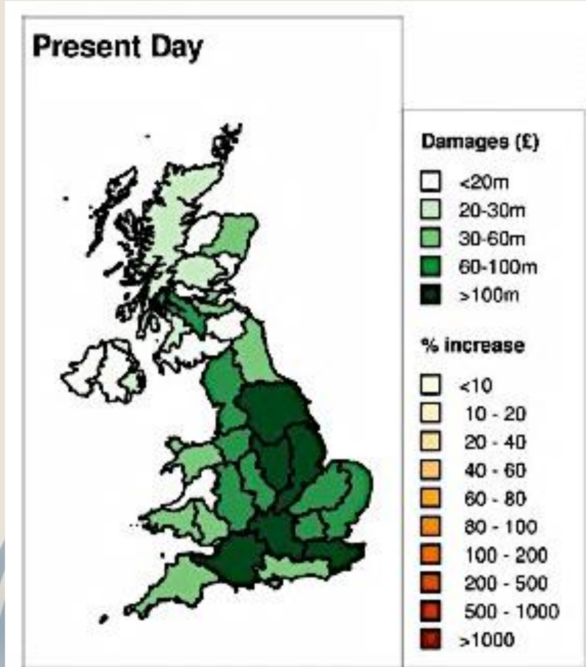
Change in people at risk of flooding 1 in 75 years, assuming no population growth and current adaptation scenario

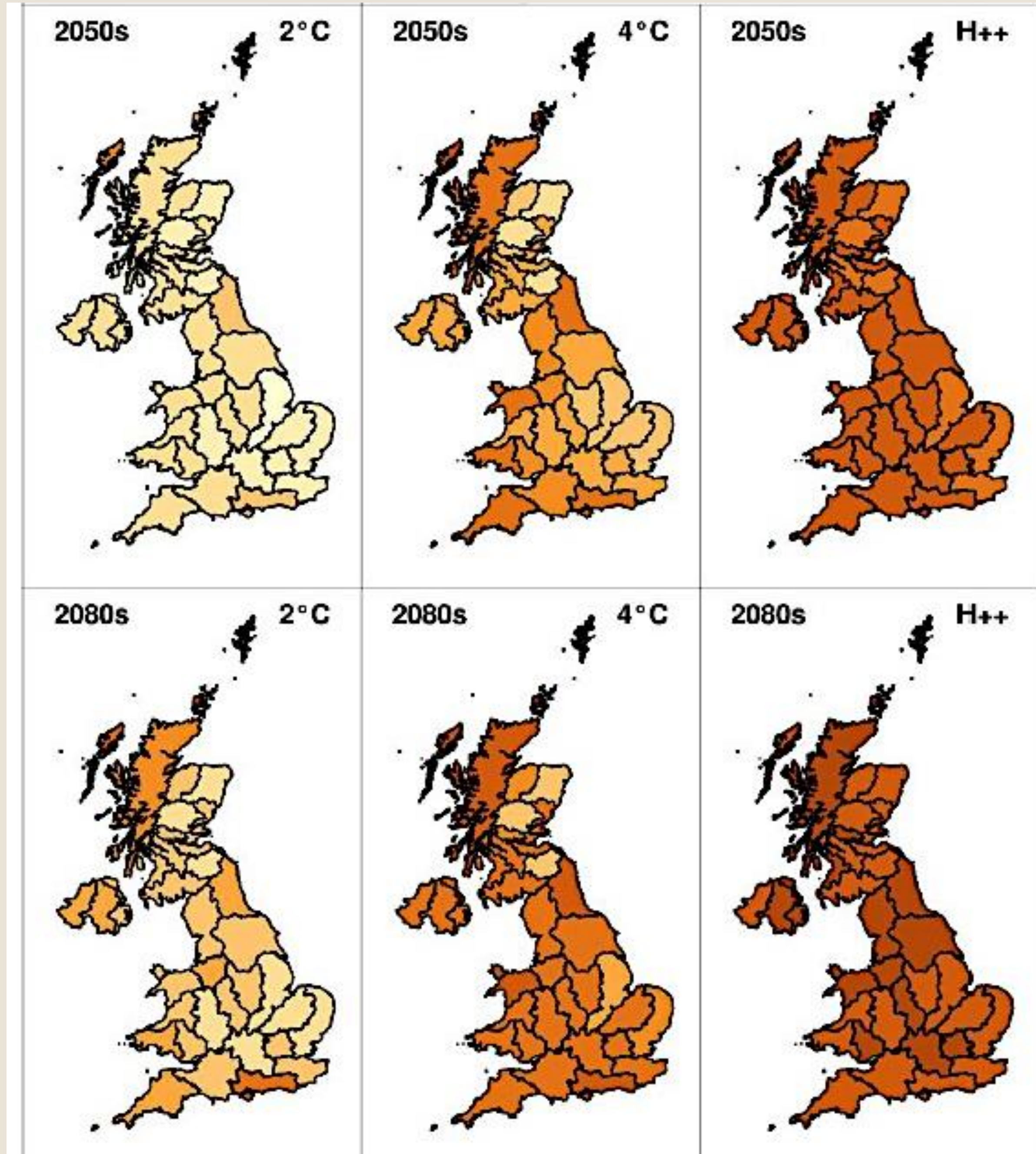




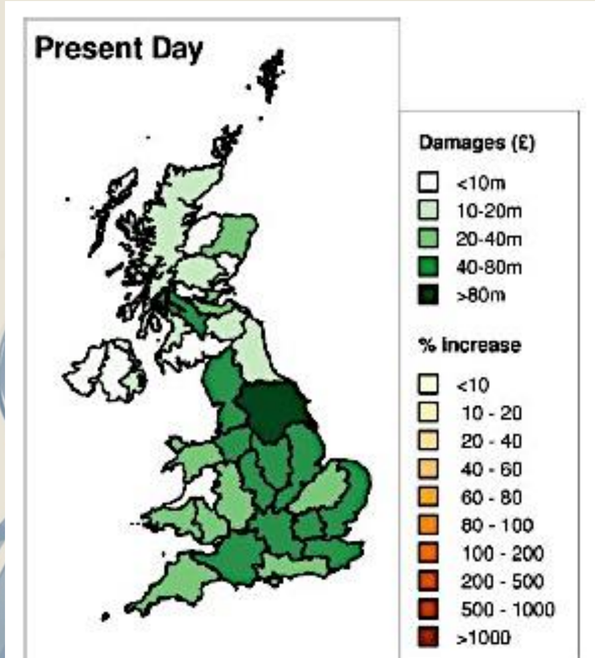


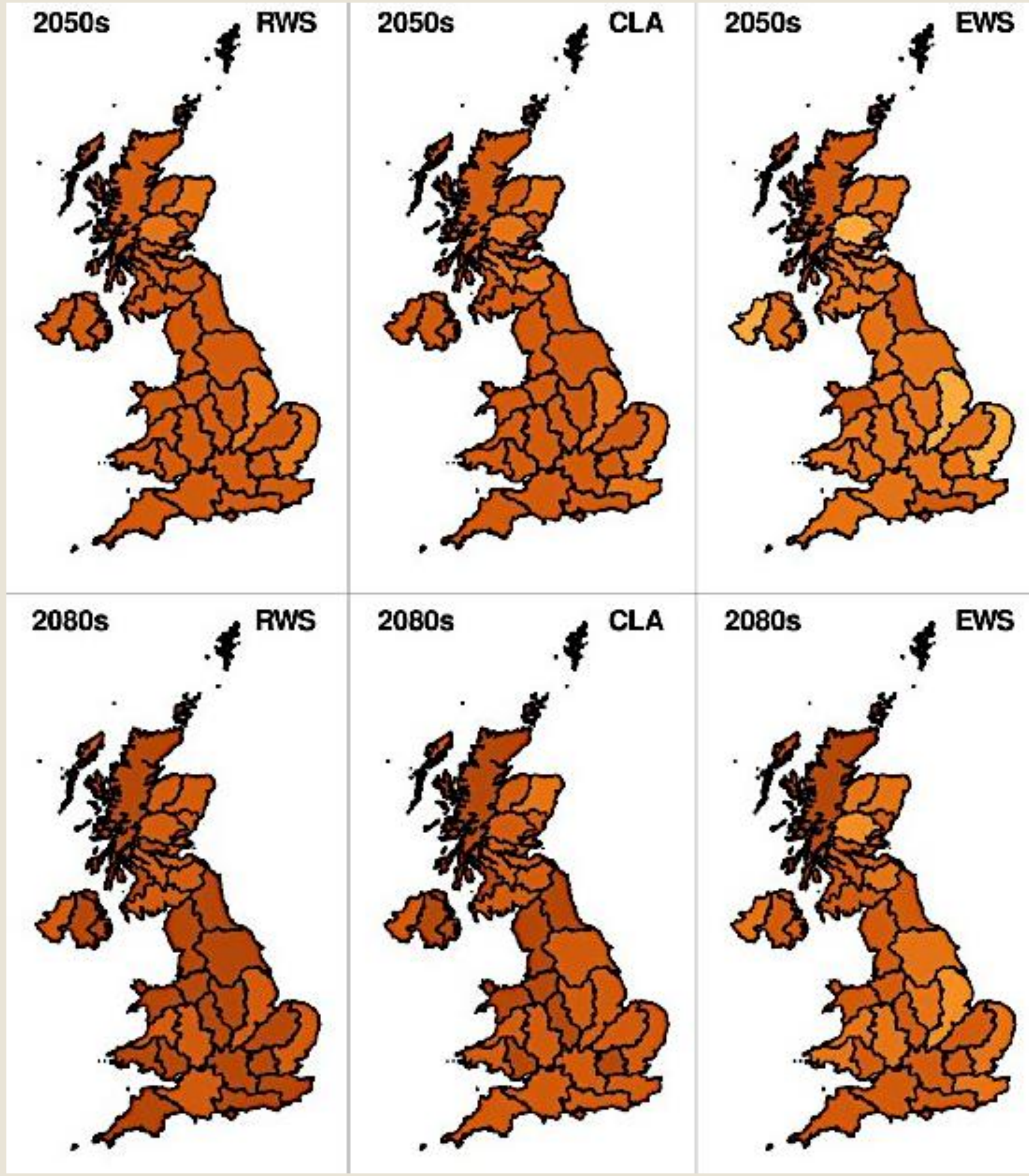
Change in deprived people at risk of flooding 1 in 75 years, assuming no population growth and current adaptation scenario



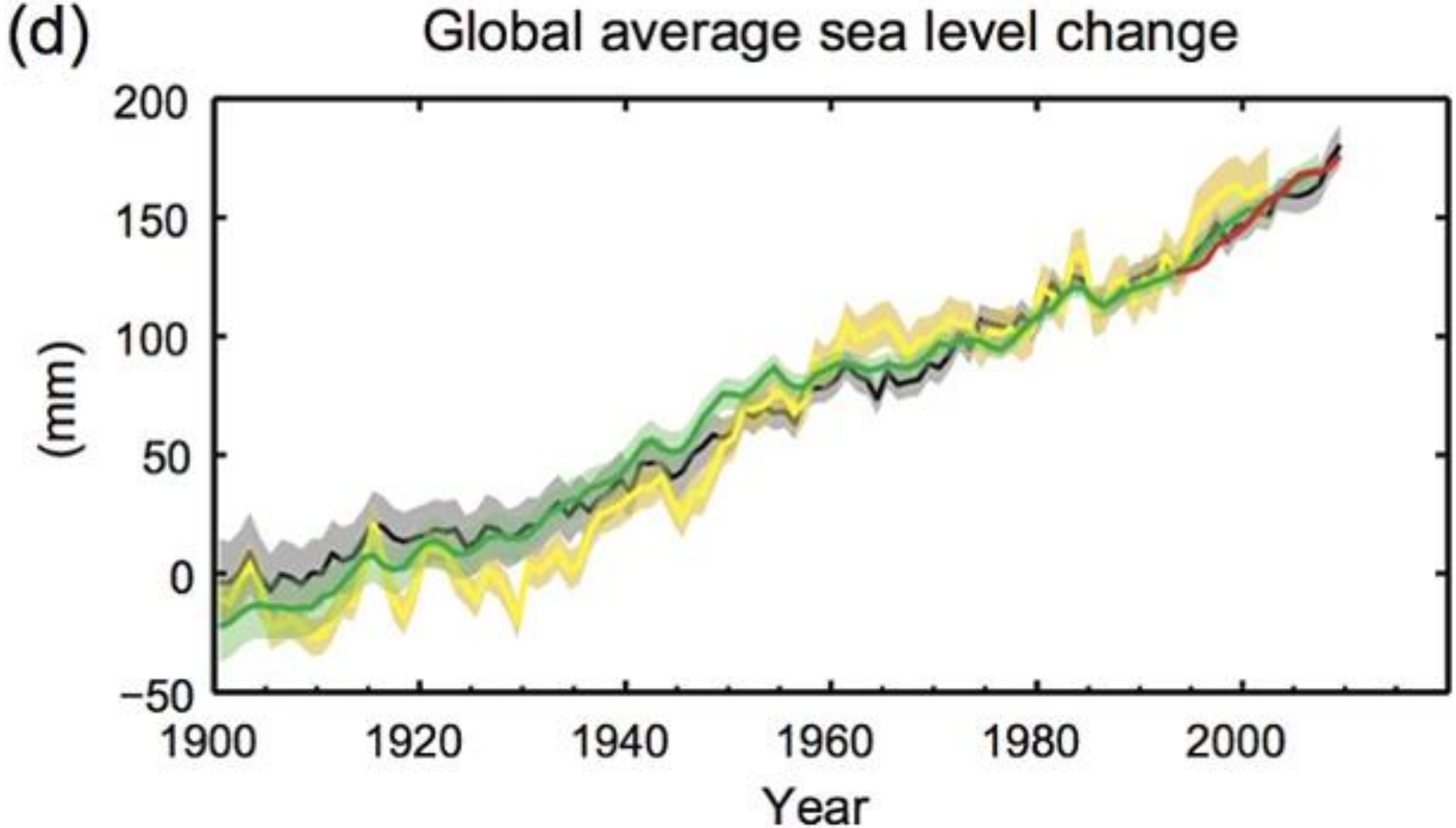


Change in expected damages (direct and indirect) from flooding 1 in 75 years, assuming no population growth and current adaptation scenario



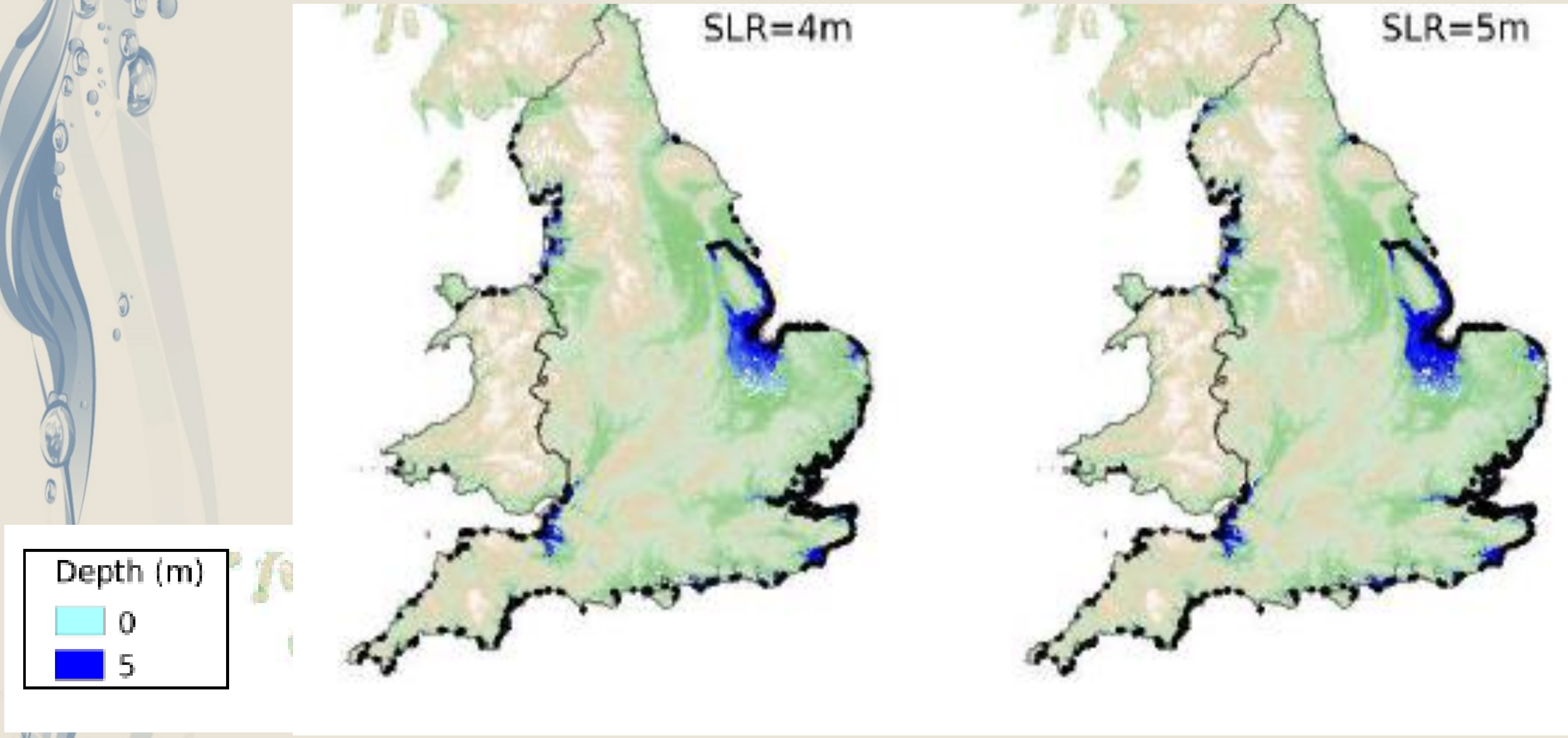


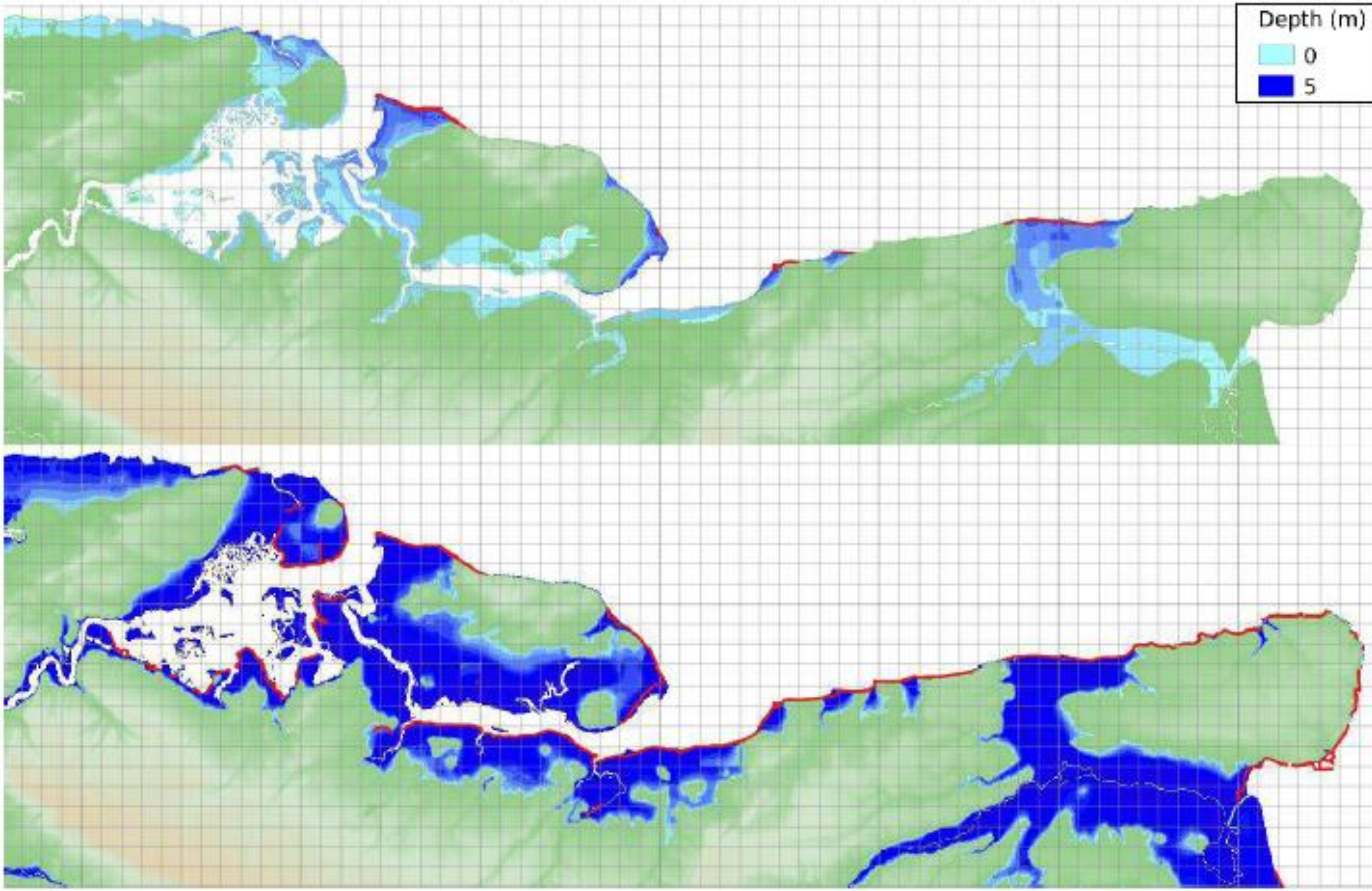
The influence of alternative adaptation strategies on expected annual damages (H++ scenario and high population growth)



(d)
Global average sea level change
200
150
100
50
0
−50
(mm)
1900
1920
1940
1960
1980
2000
Year

Temporary inundation extent under a 1:200 year return period tidal surge and two example sea level rises

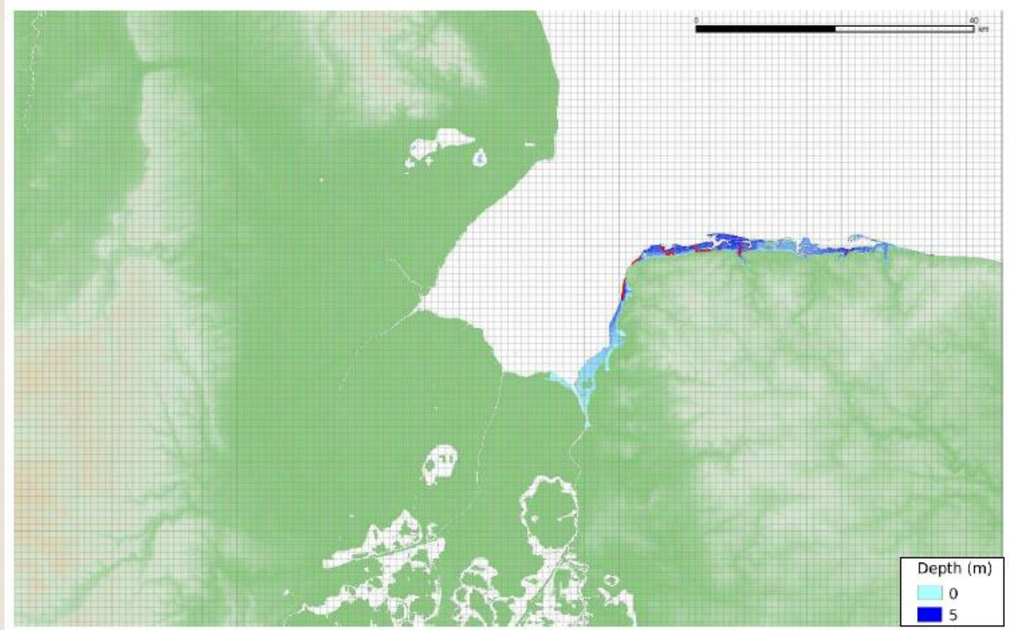


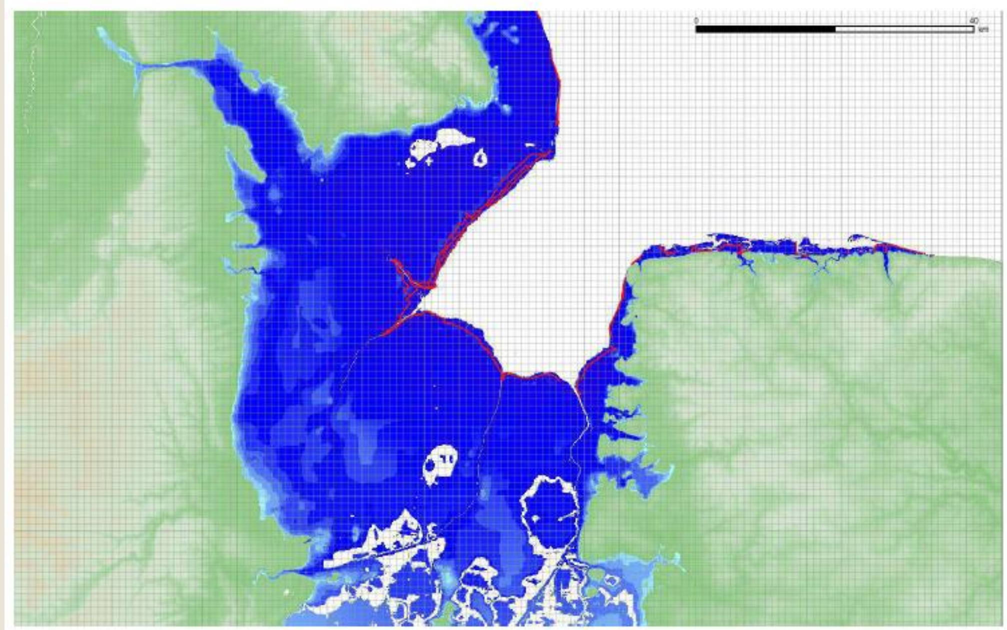


Defences at risk are shown in red. The 1km grid used by the model is also shown.

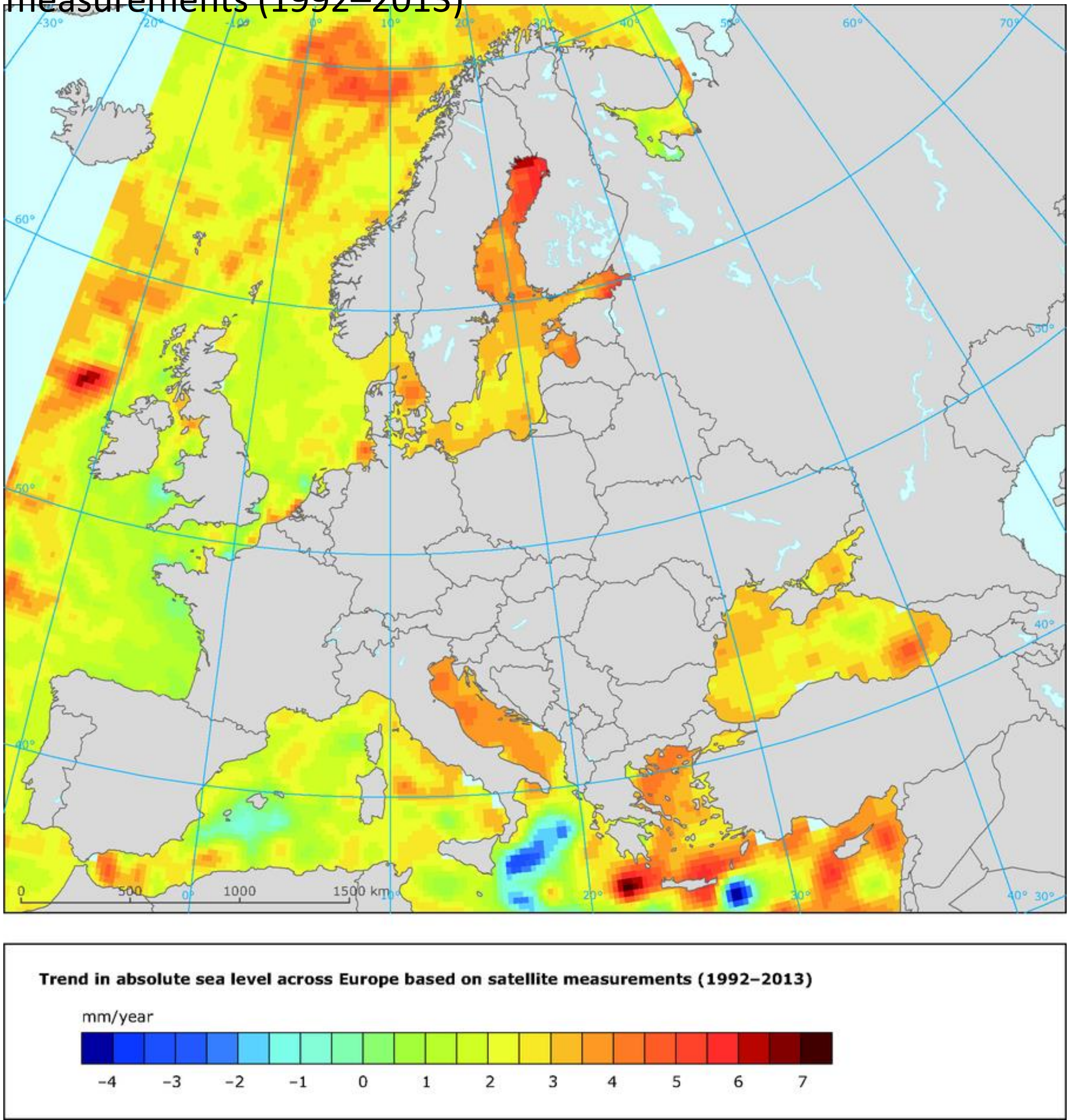
Top: Present day sea levels. Bottom: 5m of sea level rise

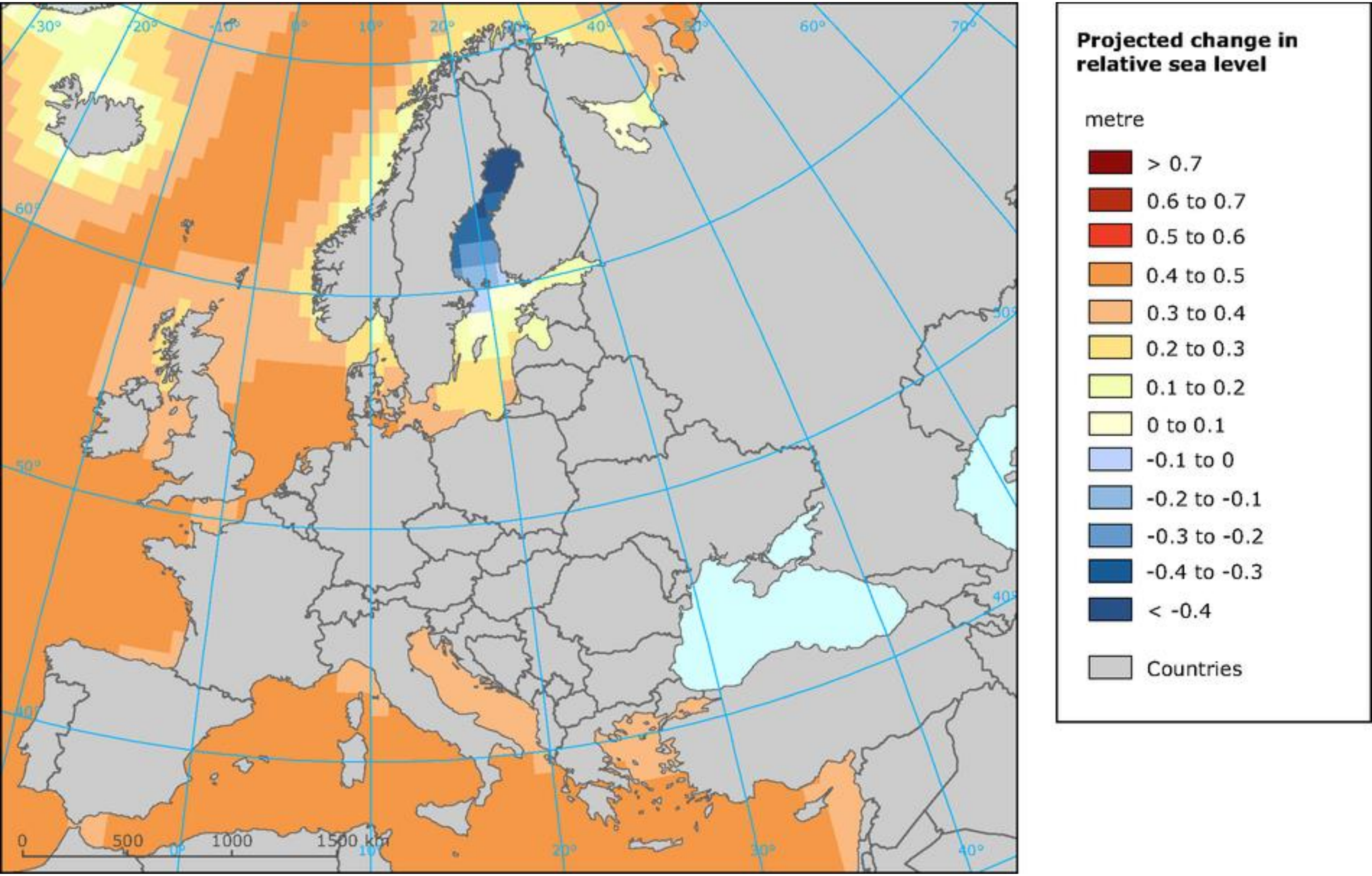
Figure 7-6 North Kent coast: Temporary inundation extent under a 1:200 year return period tidal surge


Depth (m)
0
5

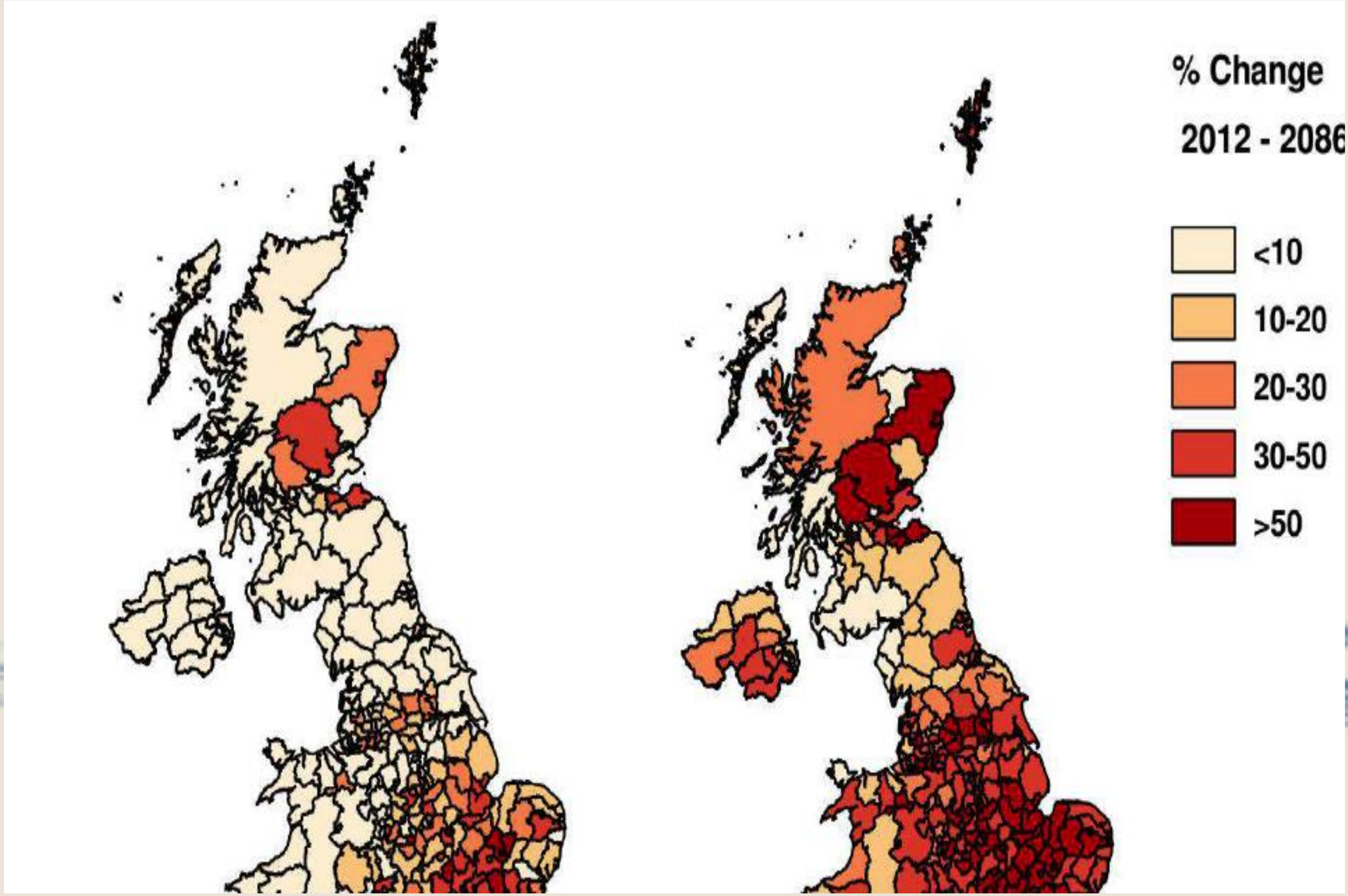


Trend in absolute sea level in European Seas
based on satellite measurements (1992–2013)



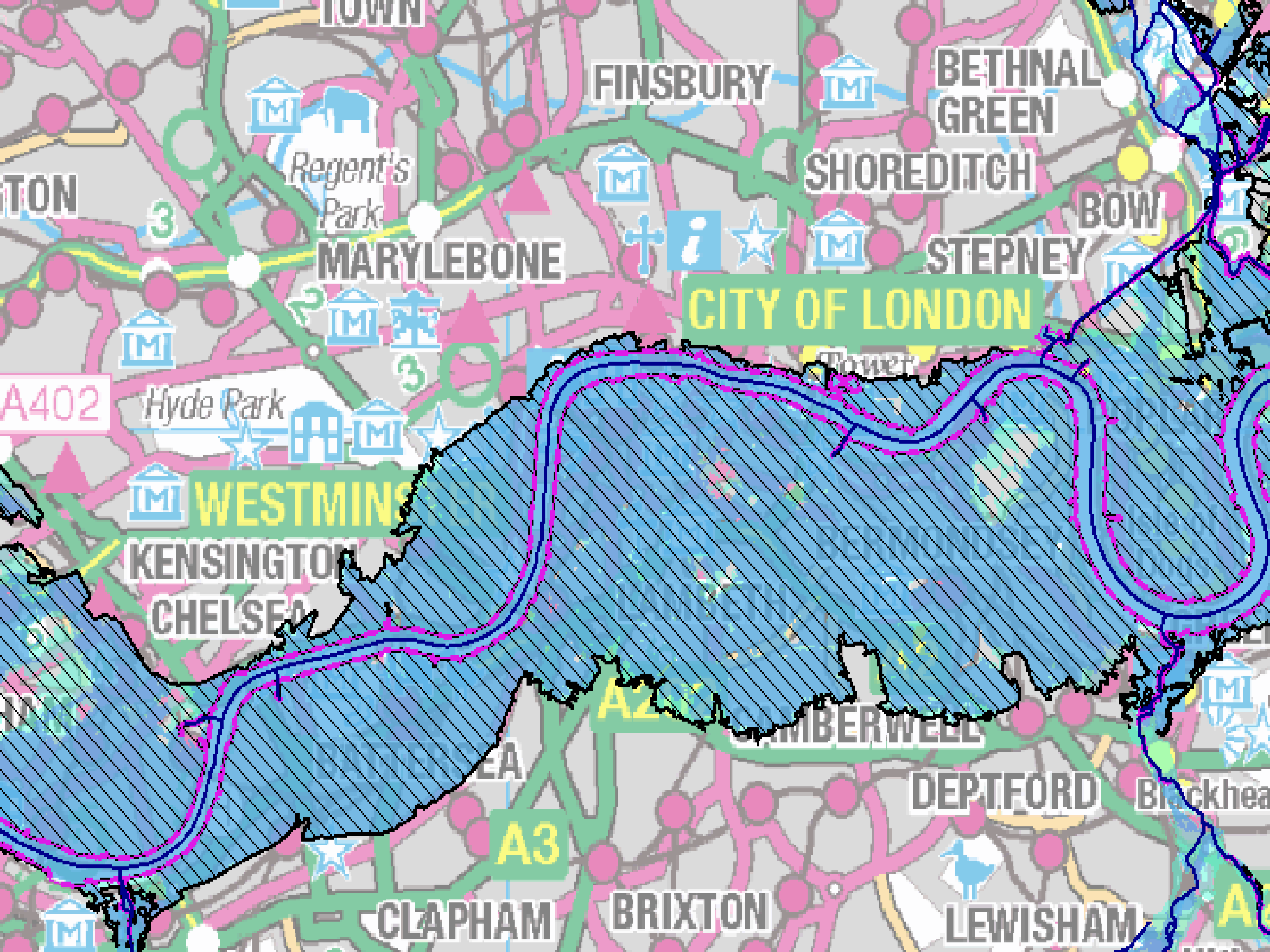

Projected change in relative sea level
metre
> 0.7
0.6 to 0.7
0.5 to 0.6
0.4 to 0.5
0.3 to 0.4
0.2 to 0.3
0.1 to 0.2
0 to 0.1
-0.1 to 0
-0.2 to -0.1
-0.3 to -0.2
-0.4 to -0.3
< -0.4
Countries
0
500
1000
1500 km

Projected population increases to 2086 (low and high scenarios) for local authorities



Flooding ‘rubbish’

- It’s the wettest winter on record (so unusual that we don’t need to do anything)…
- The Environment Agency is a bloated quango, just a wasteful, inefficient and poorly managed talking shop
- Leaders of government departments and agencies should resign
- If we dredged the rivers everything would be sorted out
- Dredging the rivers would not have made any difference
- If we spent an extra £x M everything would be sorted out
- Politicians are being held to ransom by the ‘green’ lobbyists
- All the money went on creating new bird habitats; wildlife is being protected at the expense of humans
- Scientists are talking rubbish, and just want (‘to trouser’) more research money
- It’s Brussels’ fault, green idealogues infest the EU
- Lessons will or won’t be learned

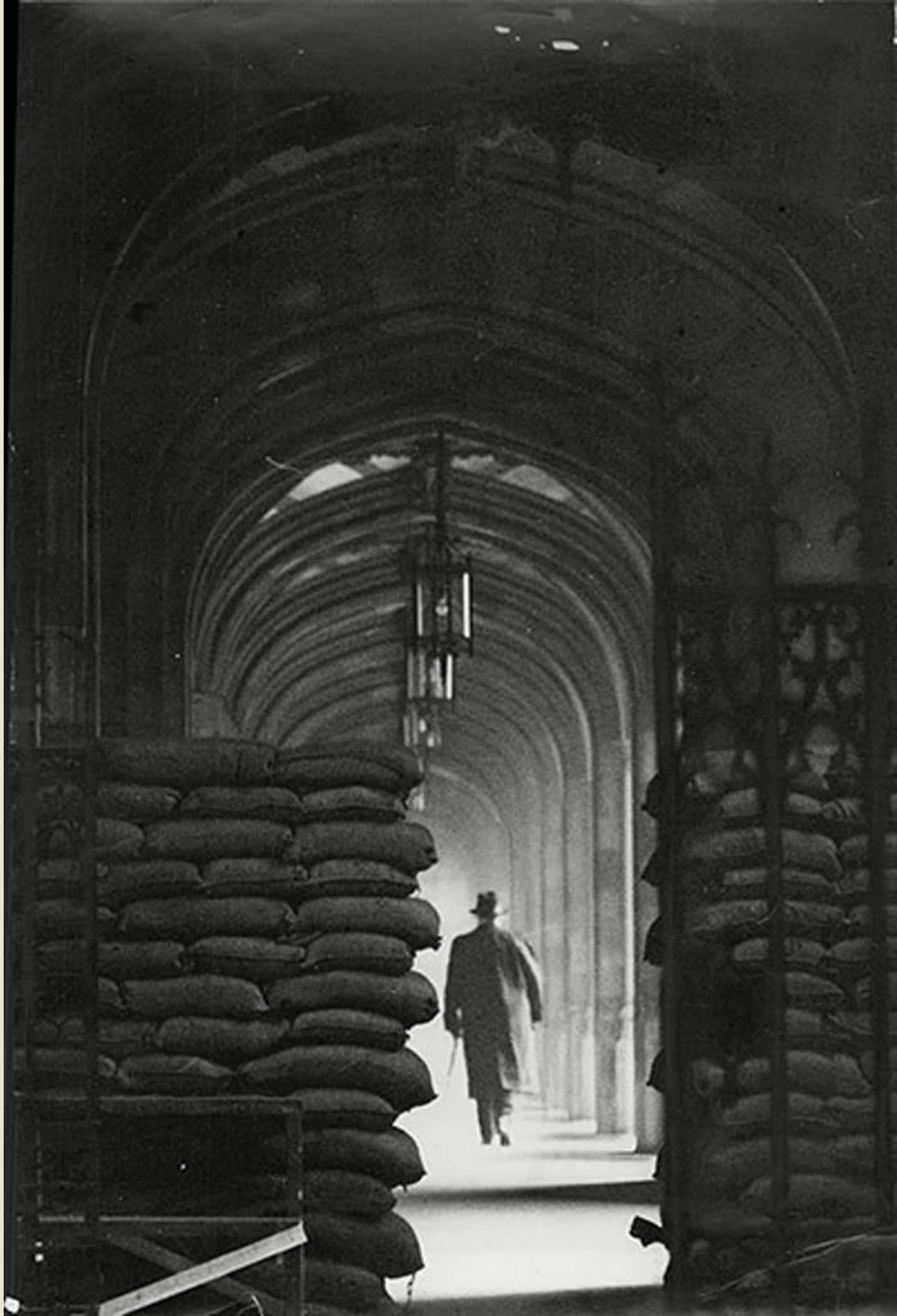


FINSBURY
BETHNAL GREEN
SHOREDITCH
BOW
Regent's Park
MARYLEBONE
STEPNEY
CITY OF LONDON
Hyde Park
A402
WESTMINS
KENSINGTON
CHELSEA
A2
CAMBERWELL
DEPTFORD
A3
CLAPHAM
BRIXTON
LEWISHAM

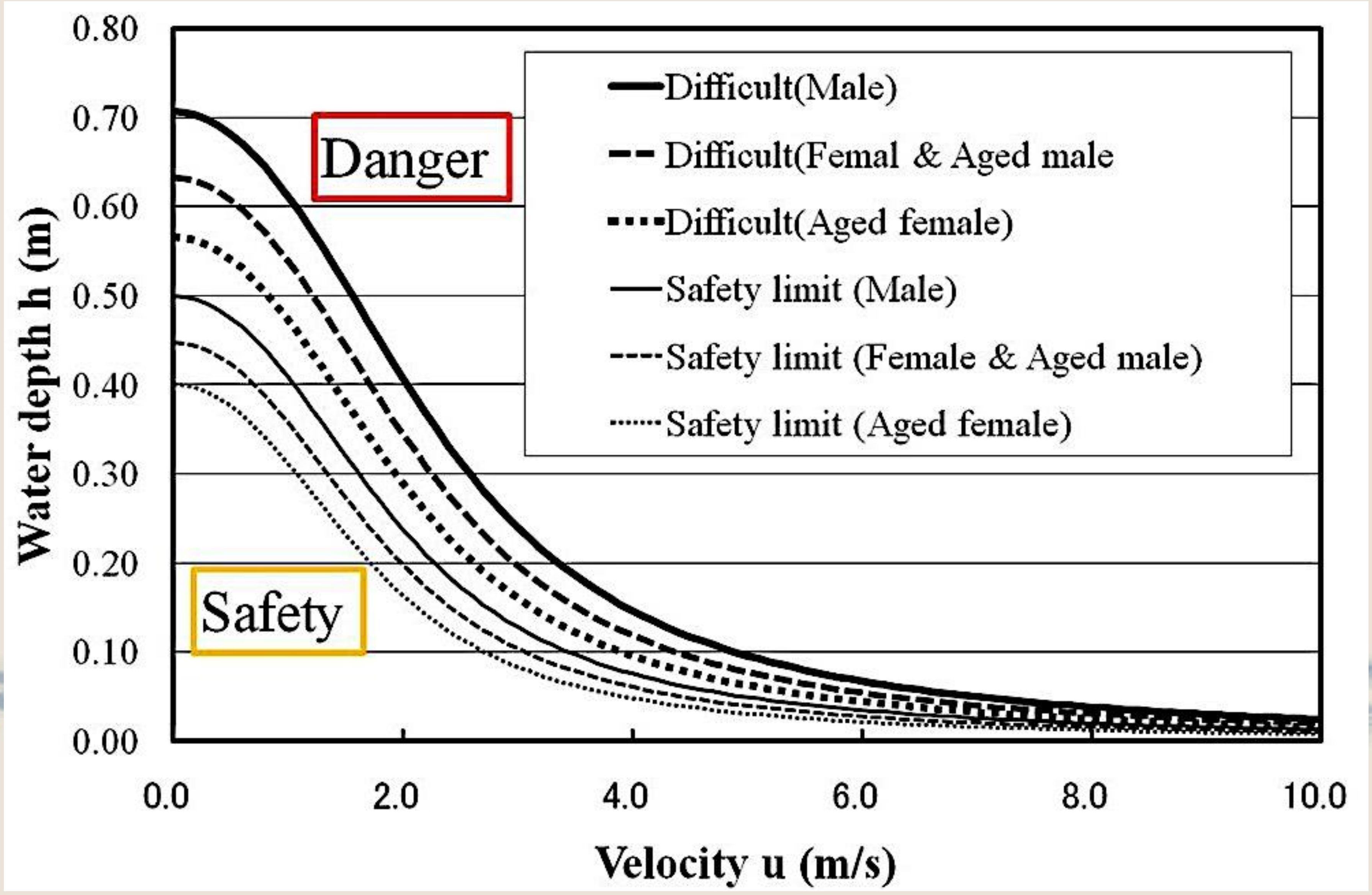
Changes in Expected Annual Damages and properties at risk by the 2080s

Region	Present day EAD	Present day properties at risk >1in75	$+2^{o}$ C and Low population growth EAD	$+2^{o}$ C and Low population growth Properties at risk	$+4^{o}$ C and Low population growth EAD	$+4^{o}$ C and Low population growth Properties at risk
Herts and North London	£19 Bn	71,000	£40 Bn	160,000	£62 Bn	240,000
Kent and South London	£33 Bn	86,000	£66 Bn	200,000	£92 Bn	270,000

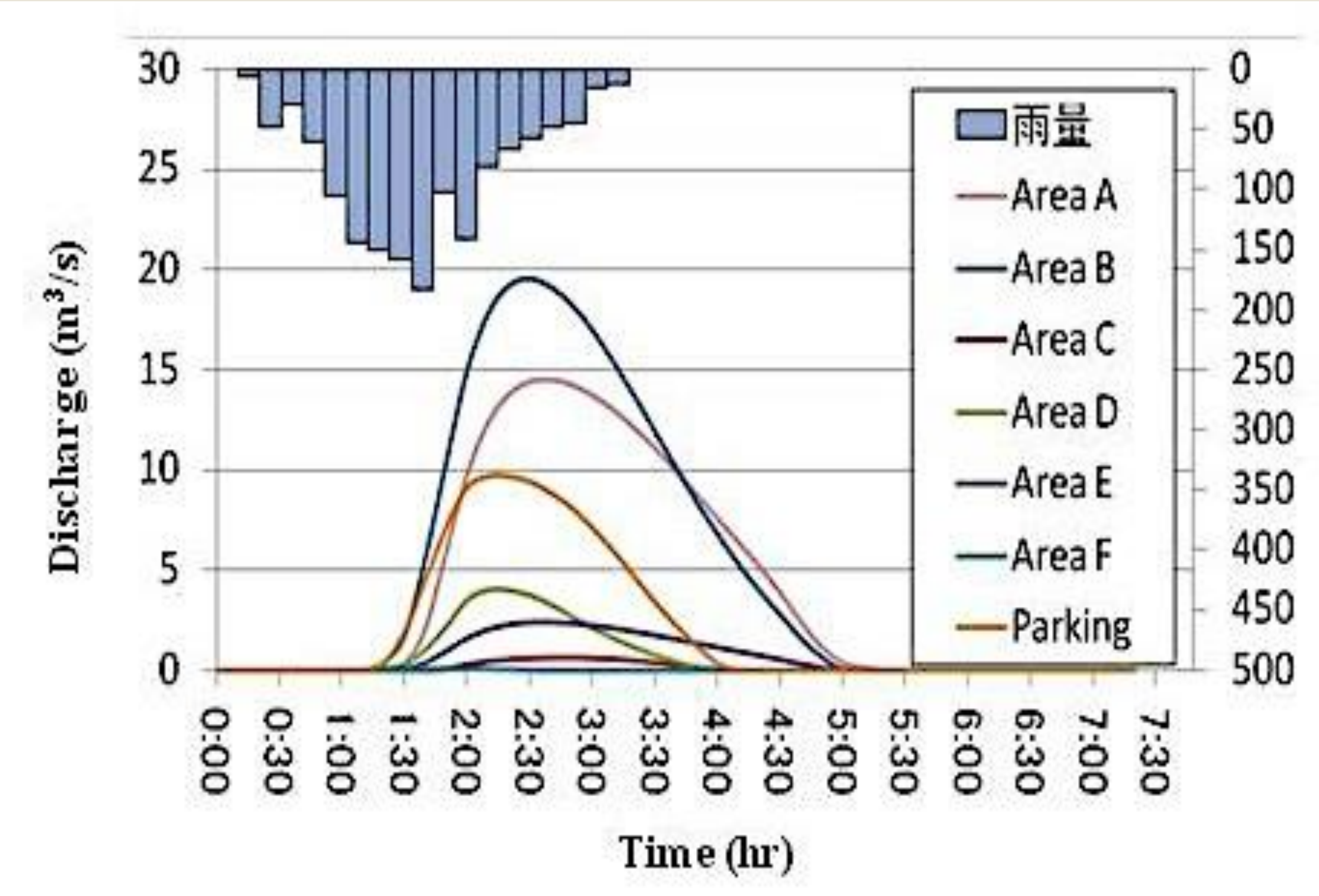
House of Commons, 1953



Evacuation of underground mega-malls in the event of flooding, by Ishigaki and colleagues, Osaka University, Japan



Calculated time between rainfall and flood hydrograph in underground mega-mall in Osaka, Japan



Timing of elderly womens' entrapment in an underground mega-mall in Osaka, in the event of flooding (Ishigaki, 2011)

Dark red = 30 minutes
Bright red = 40 minutes
Yellow = 90 minutes