



Science for the future management of floods and droughts

Prof. Alan Jenkins

Outline

- Floods
- Droughts
- The future

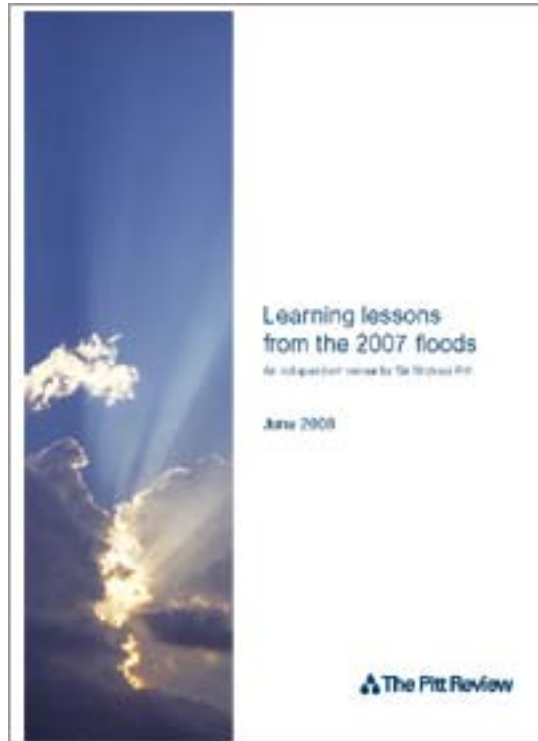


Types of flooding

- Fluvial
- Pluvial
- Coastal
- Groundwater
- Snowmelt



2007 Floods & the Pitt Review



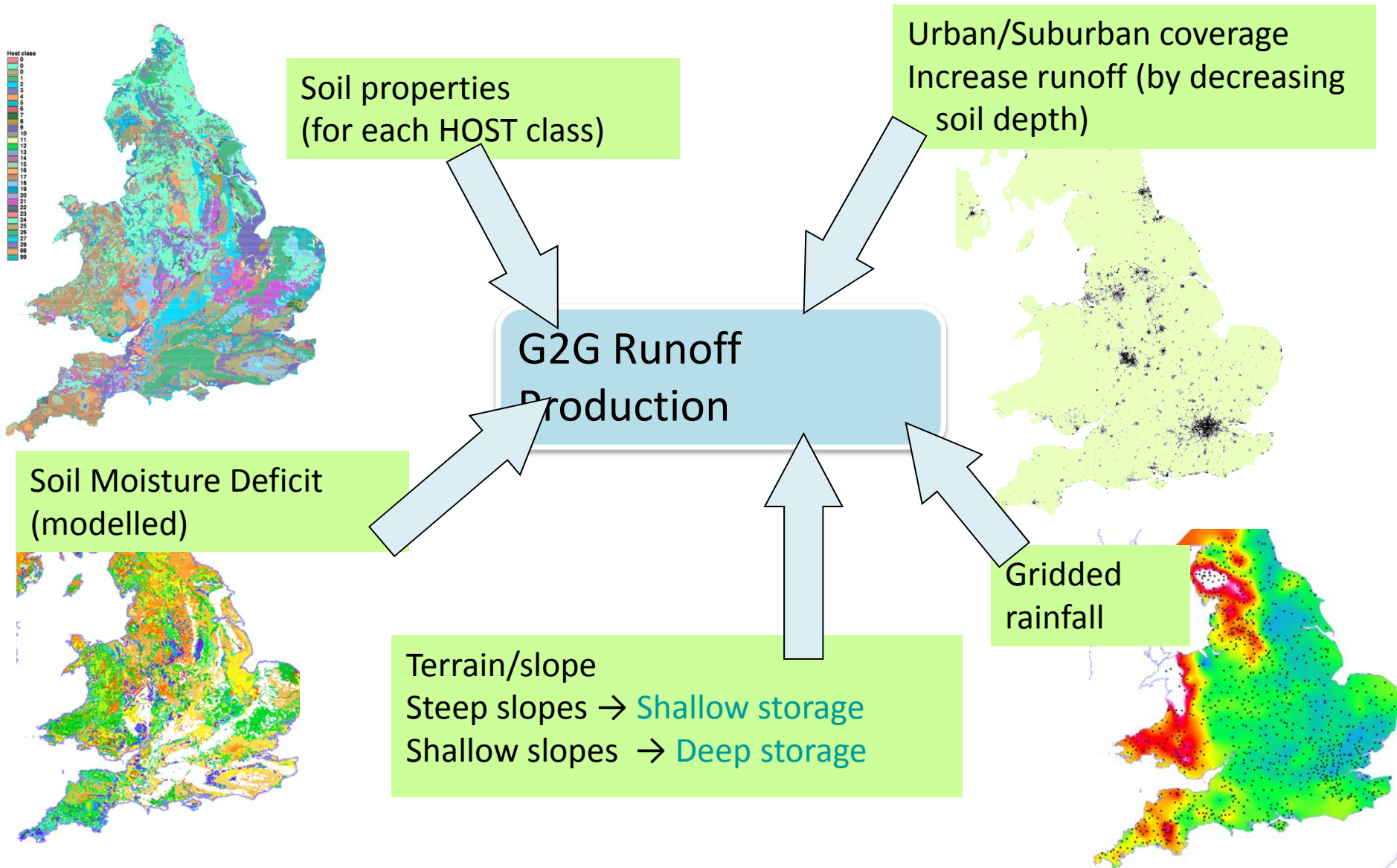
Cost of insured losses £3.25Bn

“The Environment Agency and the Met Office should work together, through a joint centre, to improve their technical capability to forecast, model and warn against all sources of flooding.”

Sir Michael Pitt

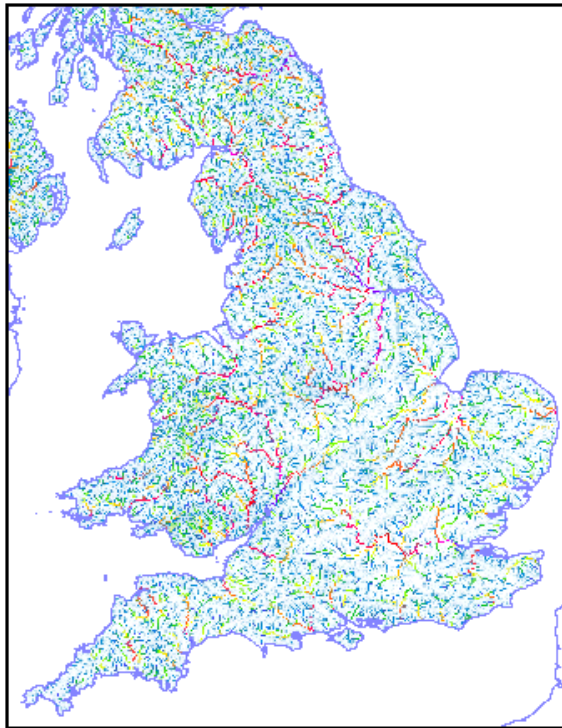
FLOODFORECASTINGCENTRE

Factors affecting G2G runoff production



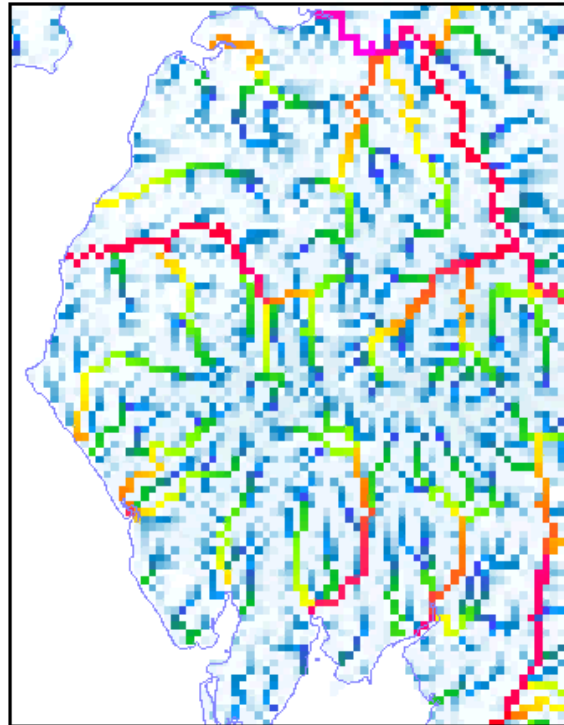
UK Flood Forecasting Centre

Grid-to-Grid (1km) model outputs



15:00 GMT Wed 09-Jan-2008

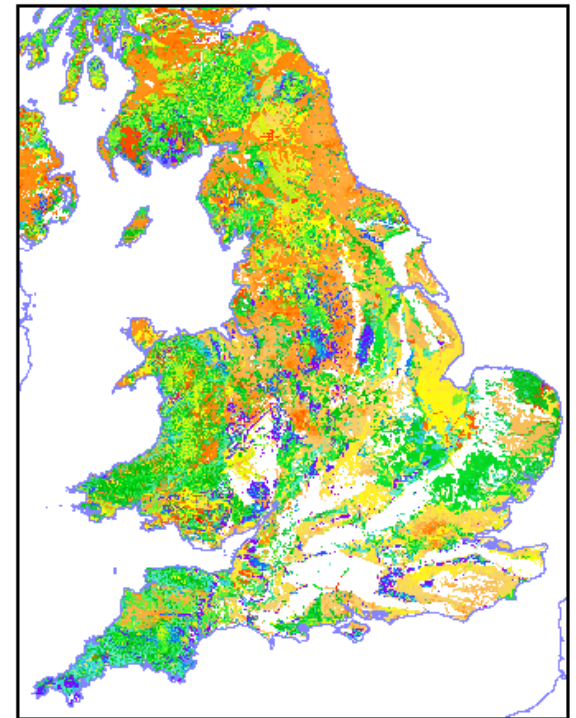
River flow



15:00 GMT Wed 09-Jan-2008

River flow

Zoomed-in view



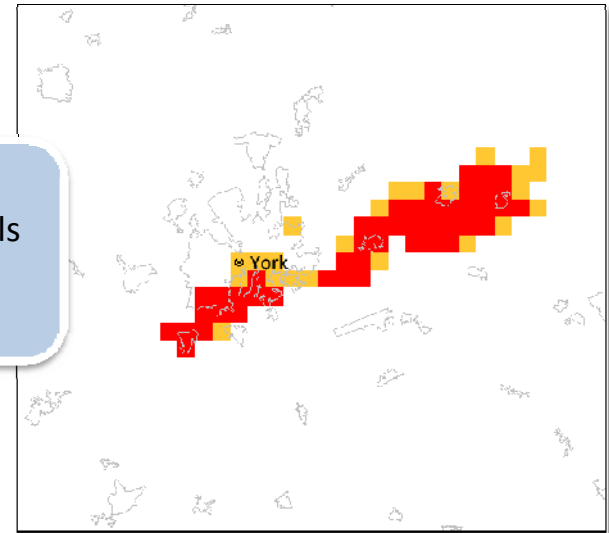
15:00 GMT Wed 09-Jan-2008

Soil moisture deficit

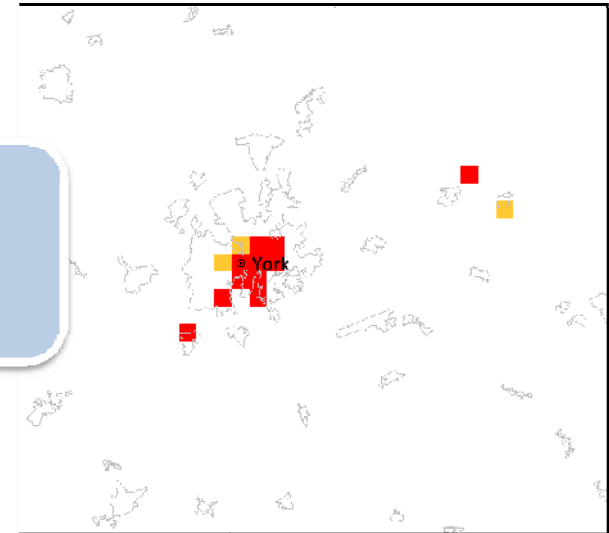
Alerts for surface flooding

- Extreme Rainfall Alerts (ERA)
 - National rainfall-threshold based method
 - Based on FEH 30 year return period rainfalls “averaged” across 8 UK cities
- G2G runoff production affected by:
 - Rainfall amount plus
 - Urban/suburban coverage
 - Soil and geology properties
 - Antecedent soil moisture conditions
- Prototype runoff threshold exceedances seem more targeted

1h radar
rainfall totals
■ >30mm
■ >25mm



1h runoff
totals
■ >8.5mm
■ >7mm

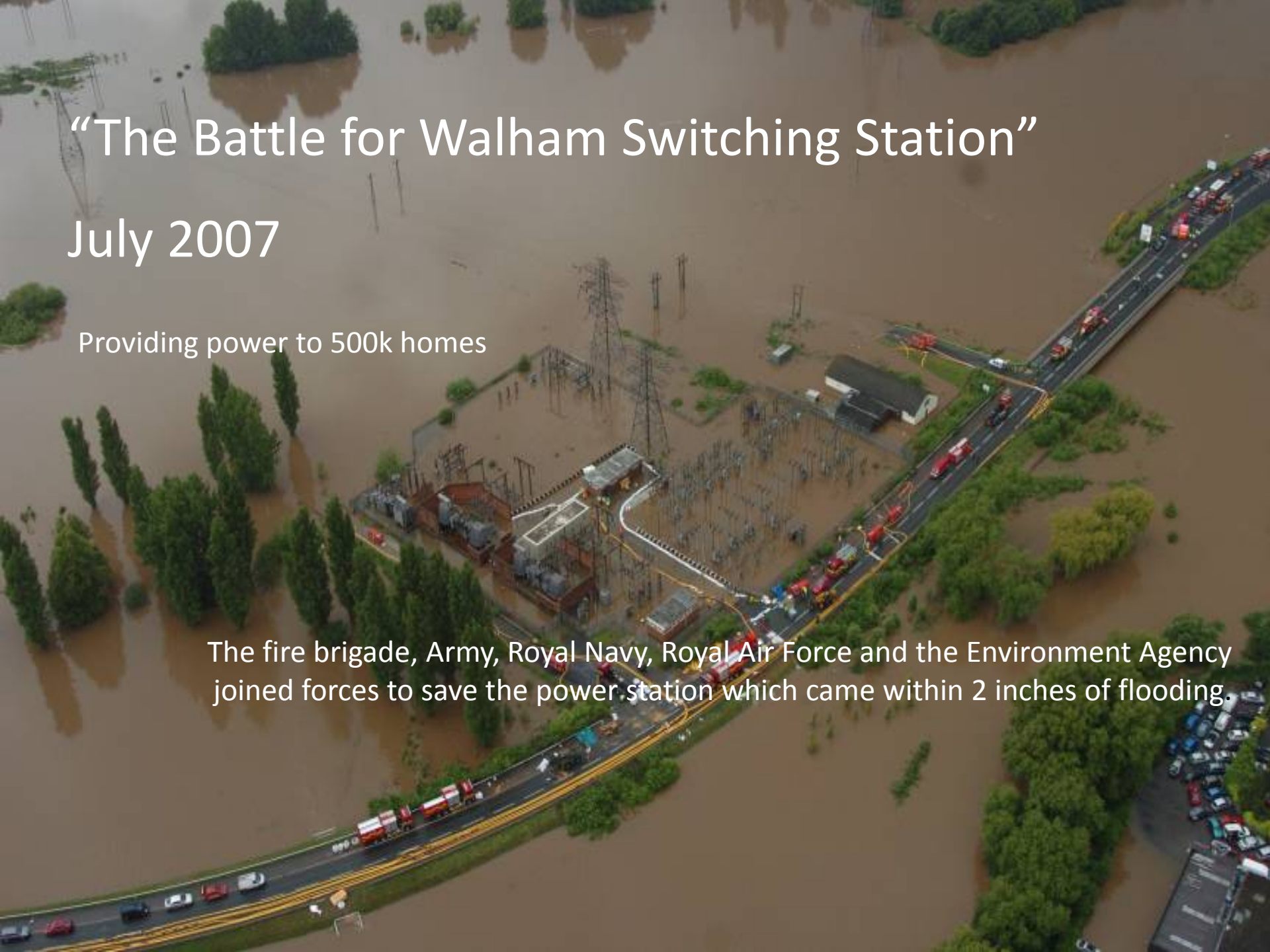


“The Battle for Walham Switching Station”

July 2007

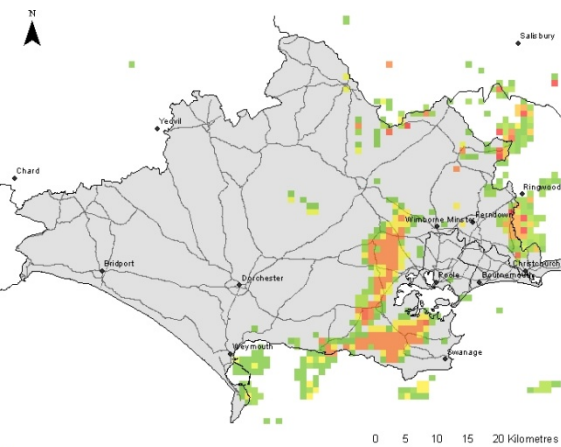
Providing power to 500k homes

The fire brigade, Army, Royal Navy, Royal Air Force and the Environment Agency joined forces to save the power station which came within 2 inches of flooding.



Hazard impact framework

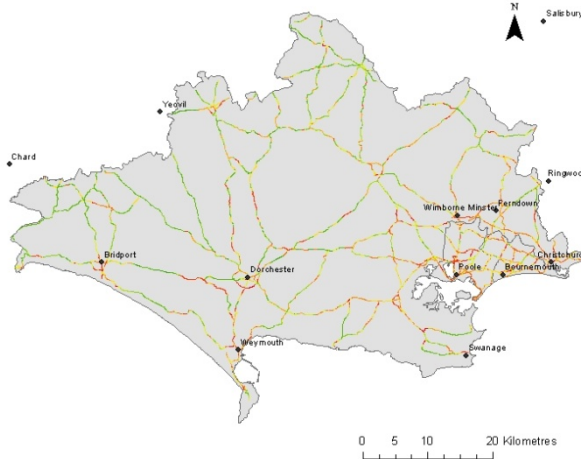
Example of early approach for surface flooding of roads



Hazard

Rainfall based,
multiple durations
and thresholds

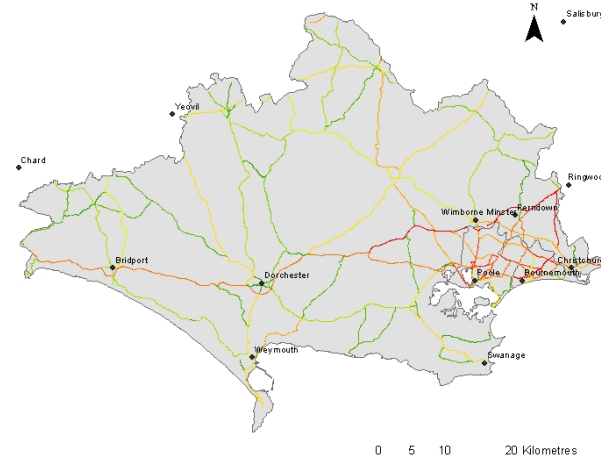
X



Vulnerability

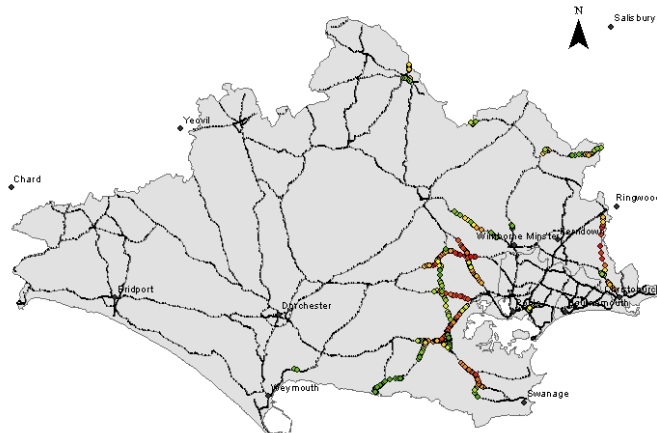
e.g. low lying roads

X



Exposure

e.g. volume of traffic



= Risk

Scale/units?

All on 0-1?

Vulnerability and
exposure can
be linked.

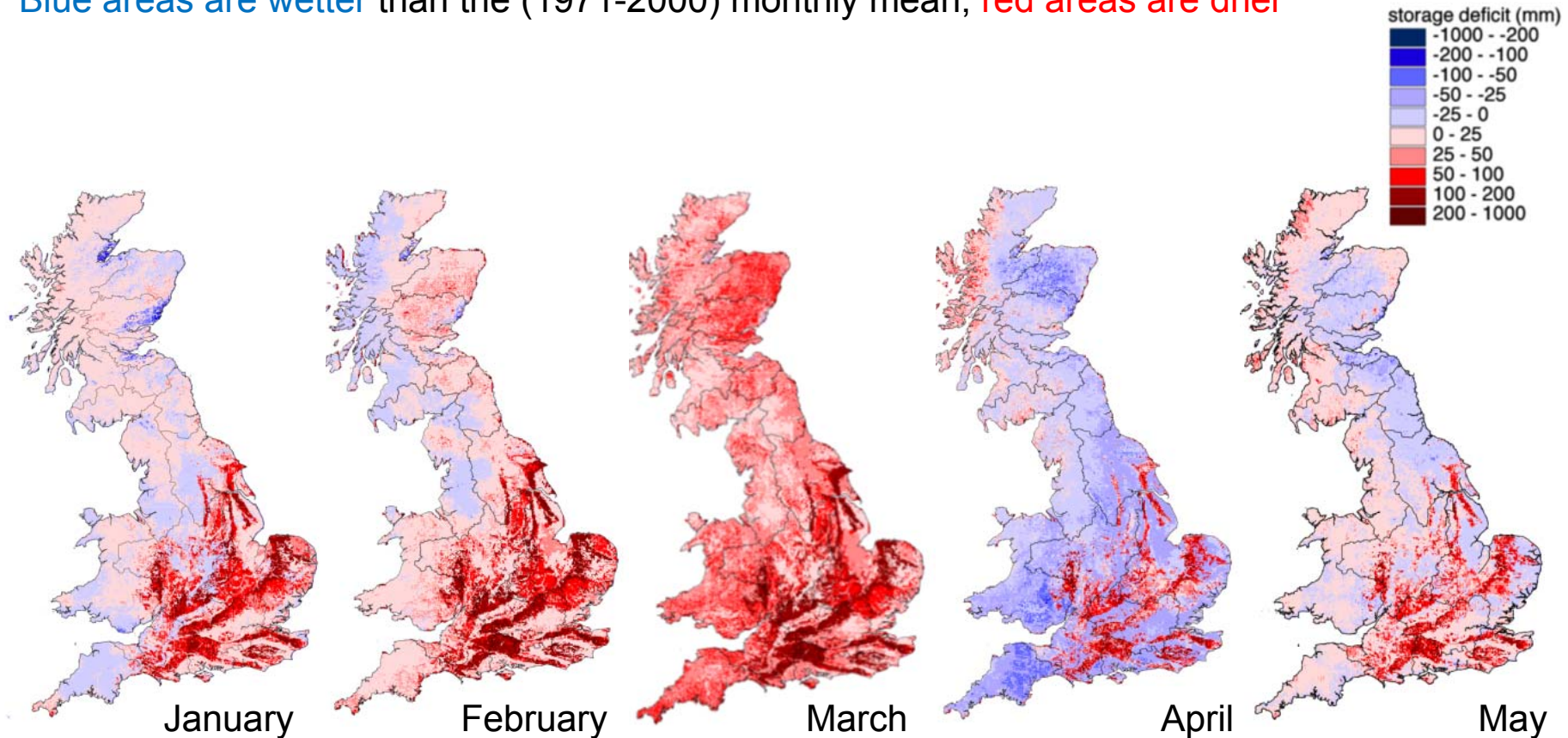
 **CabinetOffice**



The Natural Hazards Partnership provides accessible, coherent advice and information across a range of natural hazards for governments and responder communities.

Modelling the onset of drought in the UK - 2012

- Use of anomalies in the (G2G) Hydrological Initial Condition (HIC) to assess drought severity
- The modelled storage anomaly (mm) encompasses both soil-moisture and groundwater
- Each month, 1km gridded estimates of subsurface storage are compared to the monthly mean (1971-2000)
- **Blue areas are wetter** than the (1971-2000) monthly mean, **red areas are drier**



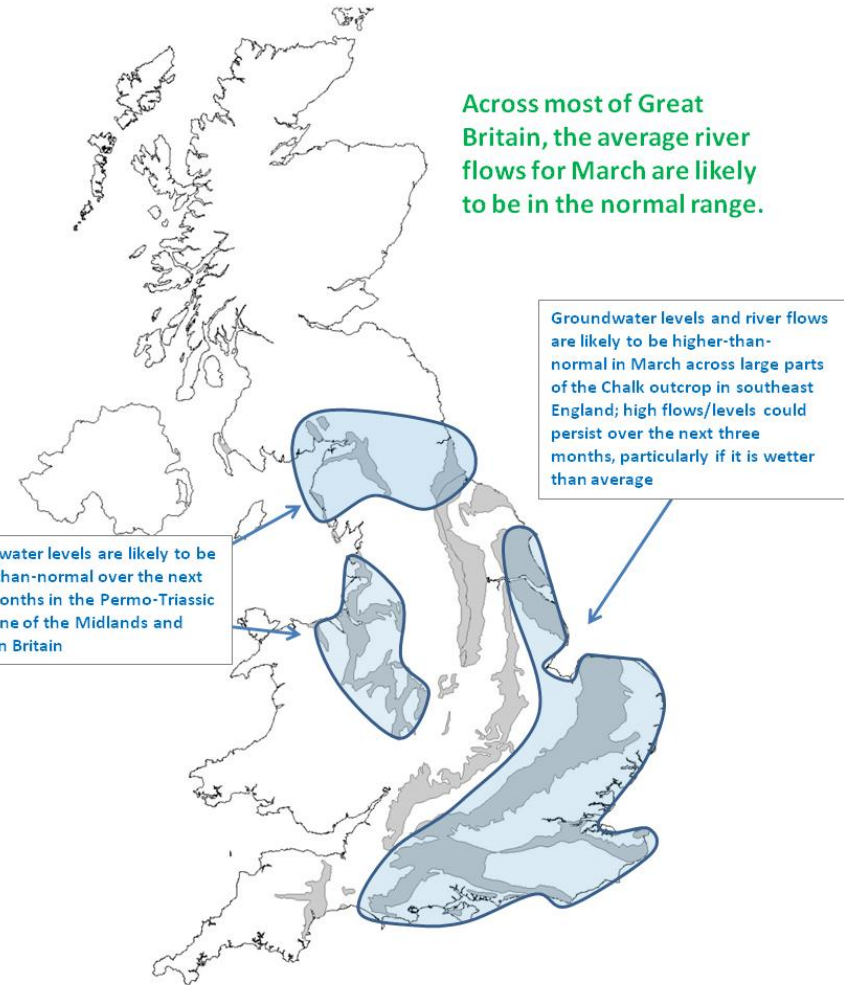
Hydrological Outlook UK – March 2013

River flows in March are likely to be in the normal range for much of the UK, but river flows and groundwater levels are likely to be higher in some aquifer areas. This situation is likely to persist for the next three months (and possibly longer) – this implies a healthy water resource outlook but an elevated risk of groundwater and fluvial flooding in vulnerable areas if high amounts of rainfall occur.

Rainfall: Consistent with below-average temperatures, rainfall during March is more likely to be below average than above average. For the March-April-May period as a whole near- to below-average rainfall amounts are most probable. The probability that UK precipitation for March-April-May will fall into the driest of our five categories is around 20% and the probability that it will fall into the wettest category is around 15% (the 1981-2010 probability for each of these categories is 20%). Click [here](#) for more detailed information on the Met Office long-term forecast.

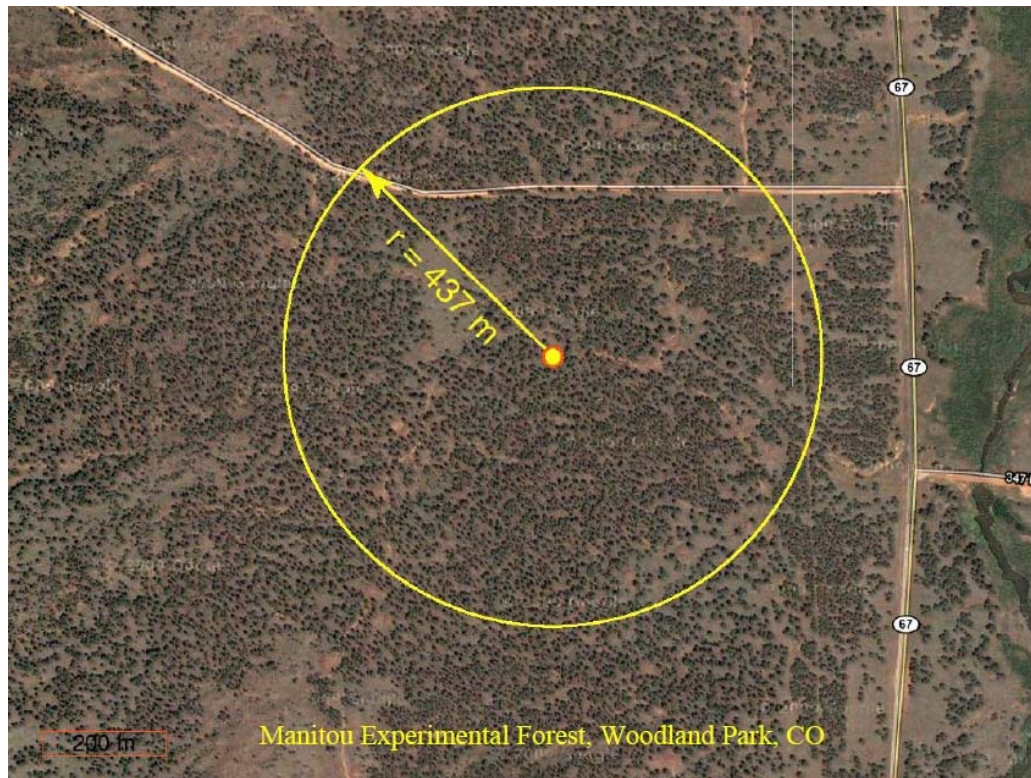
River flows: Following a relatively dry February, with a particularly dry period in the last two weeks, river flows in responsive catchments were declining at the end of the month, but flows were high in many permeable catchments (click [here](#) for further information on the situation at the end of February). The model-based outlook for one month ahead is indicative of March river flows being in the normal range across most of Great Britain, unless high amounts of rainfall are received. A comparison with historical analogues, coupled with the 3-month groundwater forecasts, implies that river flows are likely to be higher than normal in permeable catchments in the southeast of England over the next three months. Similarly, the long-term outlook suggests that, given typical rainfall conditions, high river flows are likely to persist over longer timescales in some permeable catchments.

Groundwater: February levels were above average across all aquifers, reflecting the exceptional rainfall received in 2012, but levels were declining towards the end of the month in some boreholes, as a result of the recent dry weather (click [here](#) for further information). The modelled groundwater level forecasts suggest that average groundwater levels for March are likely to be higher than normal across most of the Chalk outcrop (except parts of the southern Chalk) and in the Permo-Triassic sandstones of the Midlands and northern Britain. The 3-month outlook also favours higher-than-normal levels in the Permo-Triassic aquifer, but lower levels in the Jurassic limestone. In the Chalk, levels are likely to be in the normal range or higher (given high rainfall amounts) across most of the outcrop.



UK Soil Moisture Observing System

COSMIC RAY SOIL MOISTURE OBSERVING SYSTEM - COSMOS



A Shifting Landscape of Risk

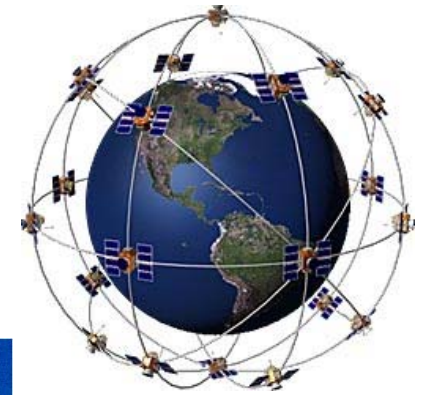
- Changing Exposure

- Where we live



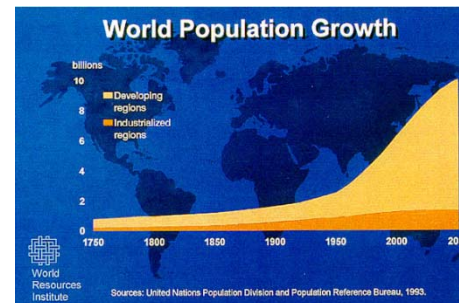
- Changing Vulnerability

- How we live



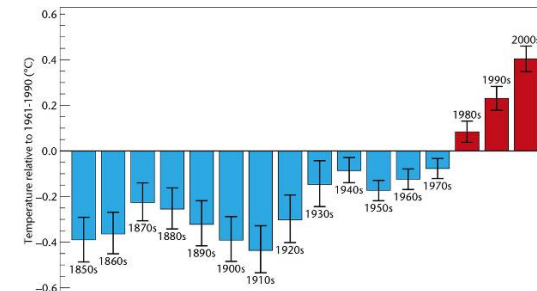
- Growing Population

- Pressure on resources



- Changing Climate

- Hazardous weather & climate extremes



Observational evidence from CEH



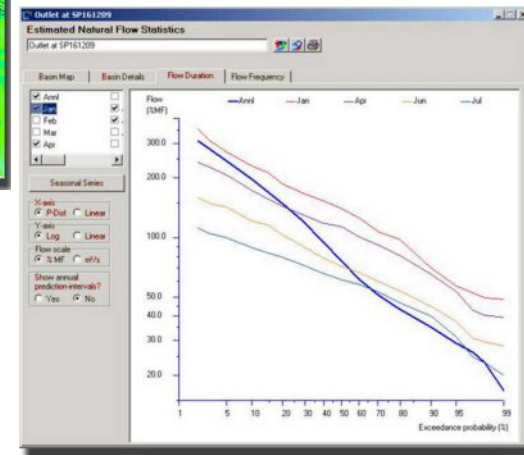
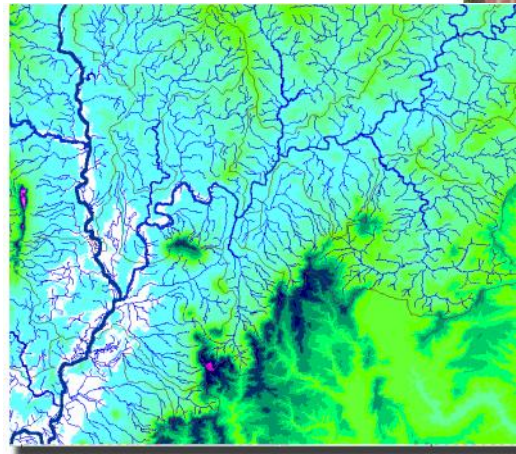
National River Flow Archive

- UK focal point for hydrometric data
- QC/QAs, stores and disseminates UK river flow data...
- from EA, SEPA, Rivers Agency (NI)



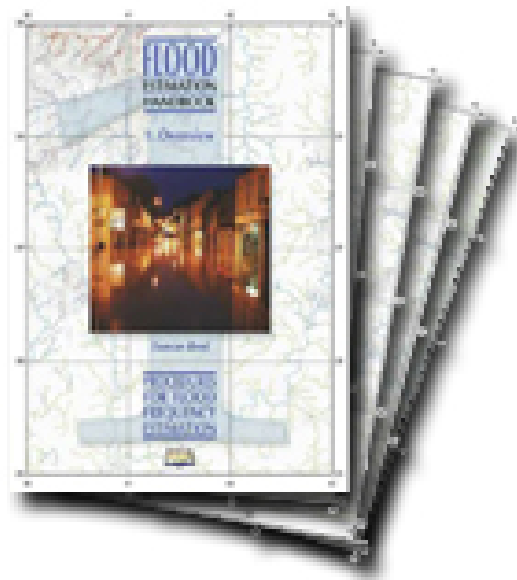
Low Flows 2000

- Decision support tool to estimate river flows at ungauged sites
- Map-based user interface. Universal data base Low flow estimation module
- Assists the management of catchment and regional water resources
- Flow duration curves predicted for ungauged catchments based on comparisons with flows from similar hydrogeological catchments



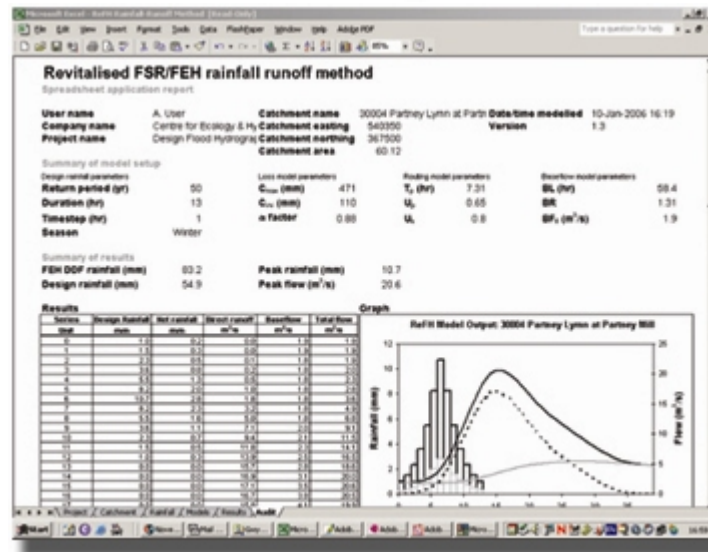
Flood Estimation Handbook

- Guidance on rainfall and river flood frequency estimation in the UK
- Increasing demand for estimates to form basis of flood risk maps – important in the planning of new developments
- Revitalised Flood Hydrograph (ReFH) model developed to simulate flood events – improvement on previous FEH model



- Flooding from rivers or sea without defences
- Extent of extreme flood
- Flood defences
- Areas benefiting from flood defences

© Crown copyright.
All rights reserved.
Environment Agency,
100026380, 2004

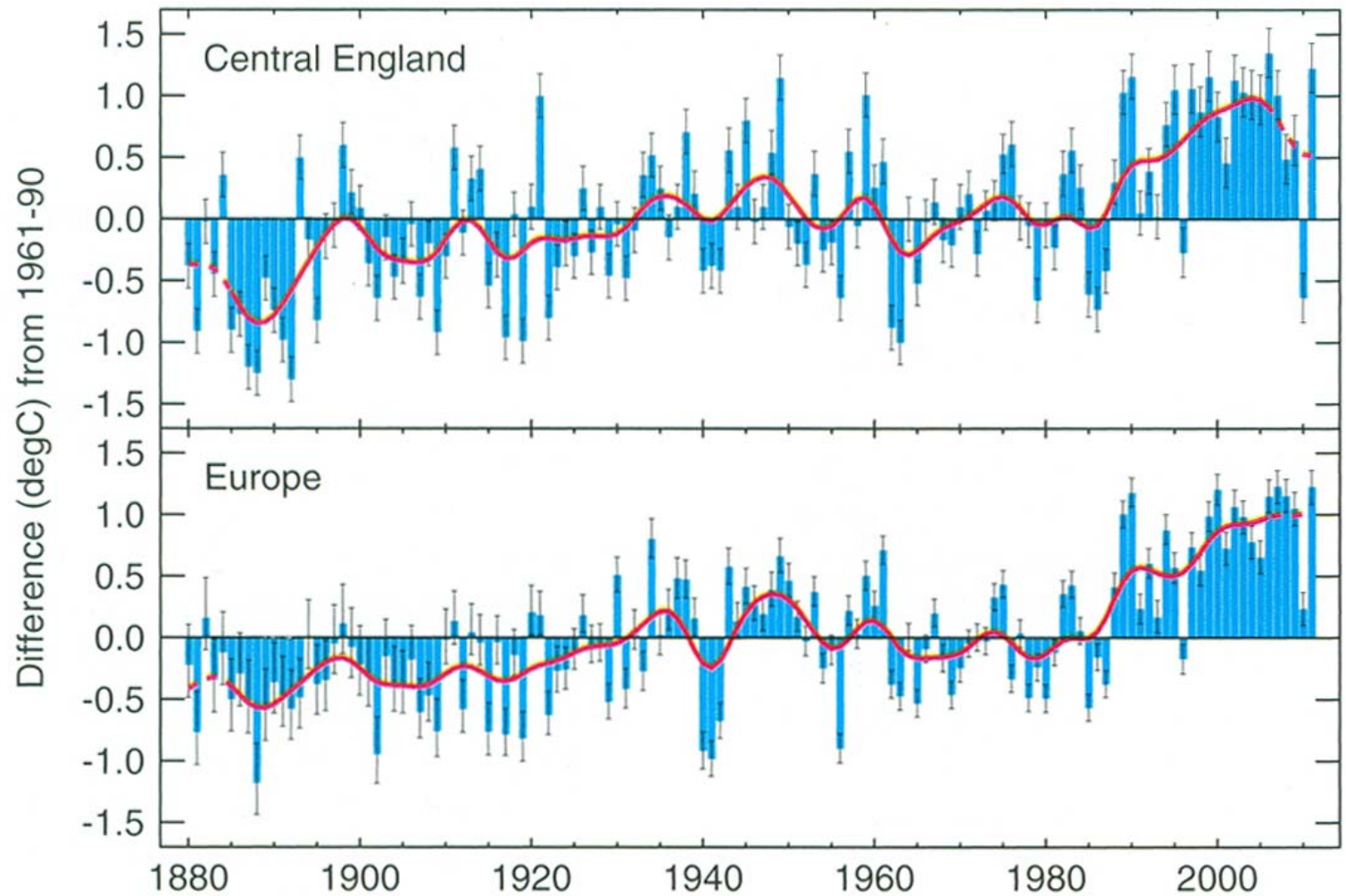


Stationarity is dead – the future is not what it used to be!

Climate change undermines a basic assumption, stationarity, that historically has facilitated management of water supplies, demands and risks.

It implies that any variable (eg. Mean annual flow or maximum annual flood peak) has a time-invariant probability density function whose properties can be estimated from the instrument record.

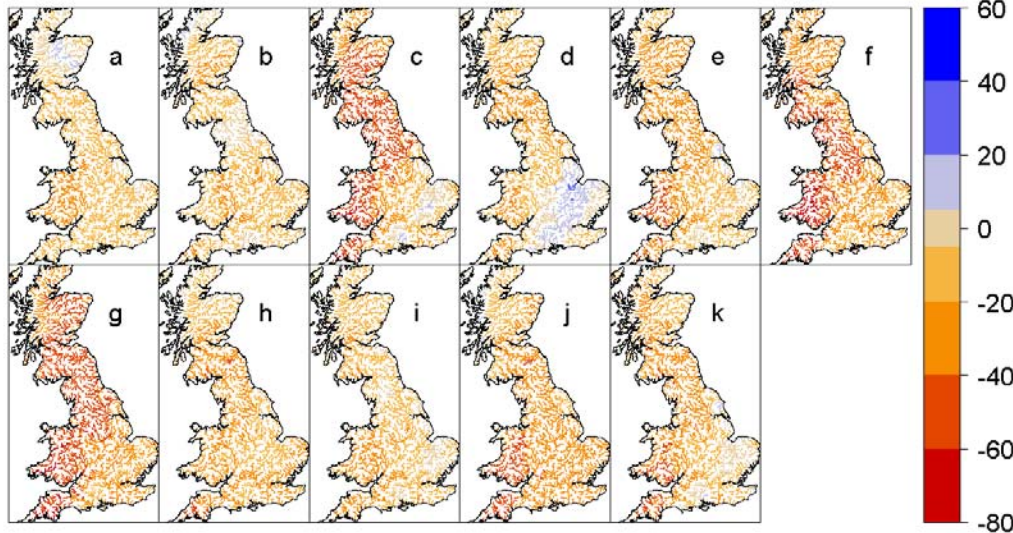
Annual temperature anomaly



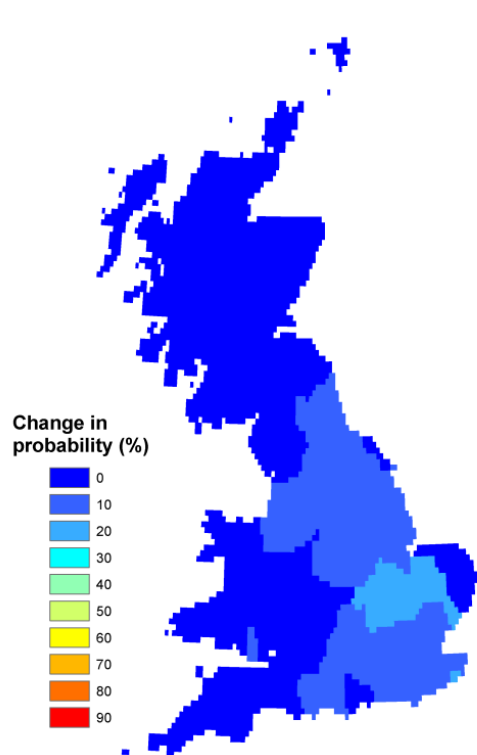
Future flows and groundwater levels

- Need for a set of consistent hydrological projections for water-related climate change assessment in GB
 - From latest recognised climate projections
 - Include climate change uncertainty
 - Based on national consistent method
 - Valid for range hydro indicators
 - Available to wide science community

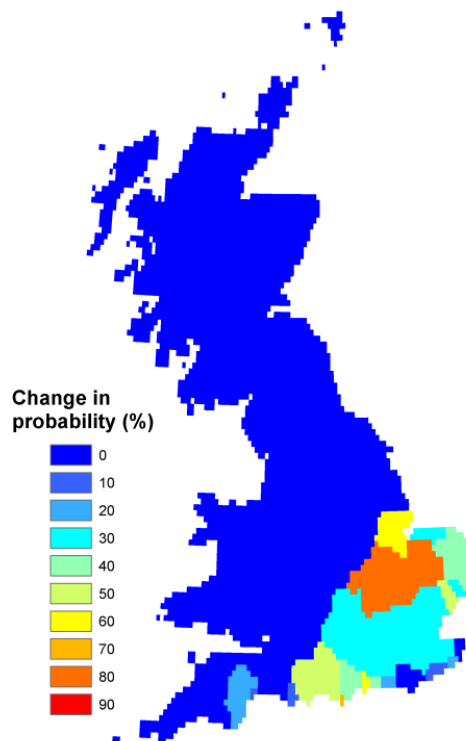
Summer (JJA)



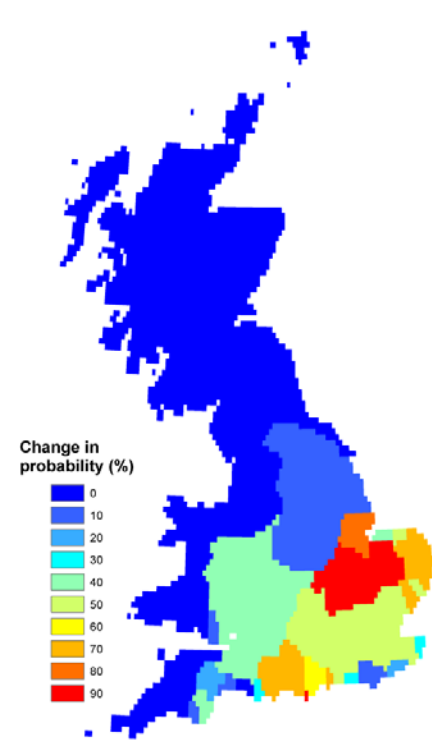
Water Security Assessment 2050



Population change



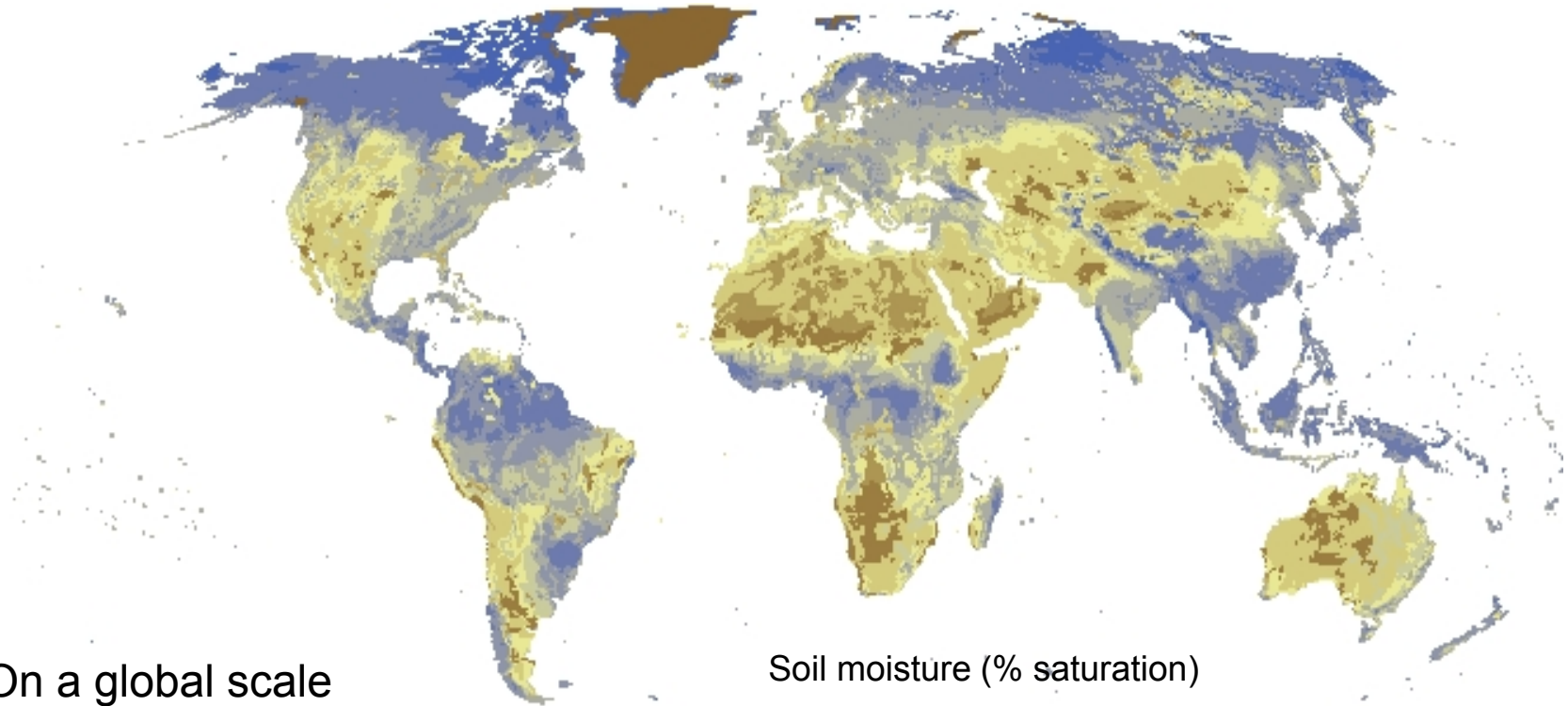
Climate change



Climate + Population change

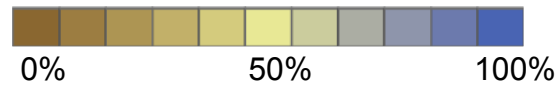
Change in probability of a hosepipe ban

Global Water Assessments



On a global scale changes in Soil Moisture depend on the season and climate zone.

Soil moisture (% saturation)



Thank you!

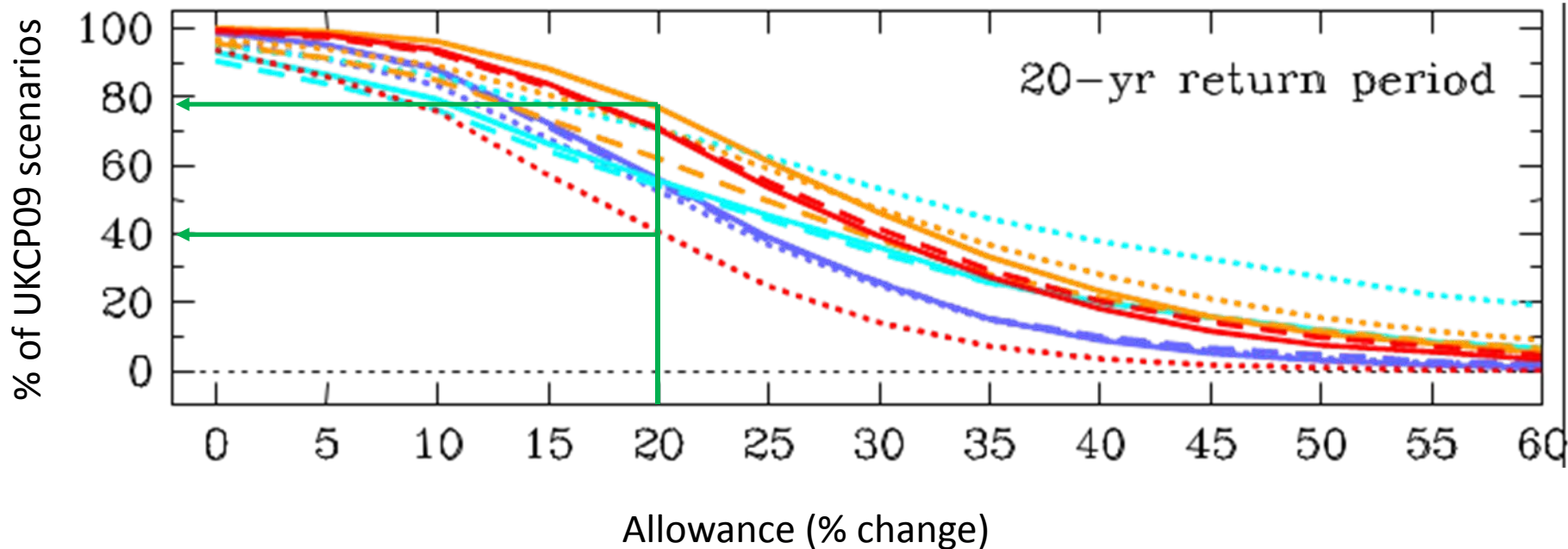
Investment in R & D benefits society!

UK Climate change allowances

Parameter	1990-2025	2025-2055	2055-2085	2085-2115
Net sea level rise (SE England) – mm/yr	4.0	8.5	12.0	15.0
Peak rainfall intensity	+5%	+10%	+20%	+30%
Peak river flows	+10%	+20%		
Offshore winds	+5%		+10%	+10%
Extreme wave height	+5%		+10%	+10%

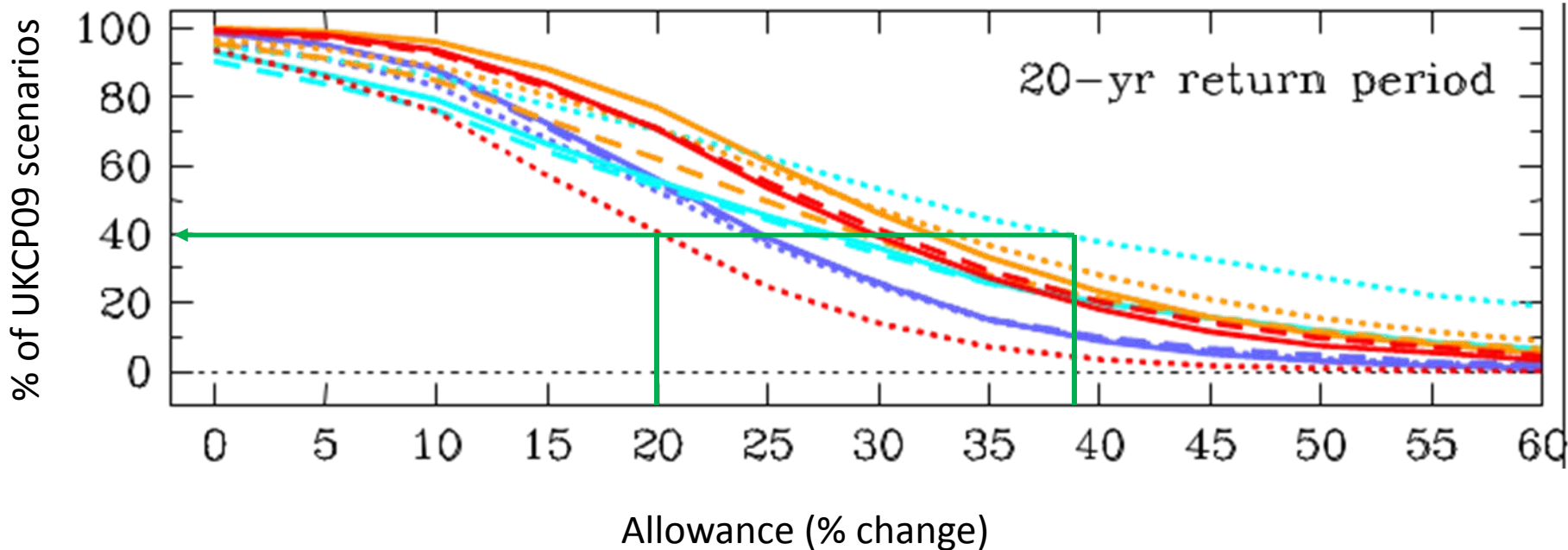
HOW APPROPRIATE IS A NATIONWIDE 20% ALLOWANCE?

Between 40% and 80% of the 10,000 UKCP09 scenarios will be exceeded, depending on region



WHAT SHOULD THE NEW ALLOWANCE BE?

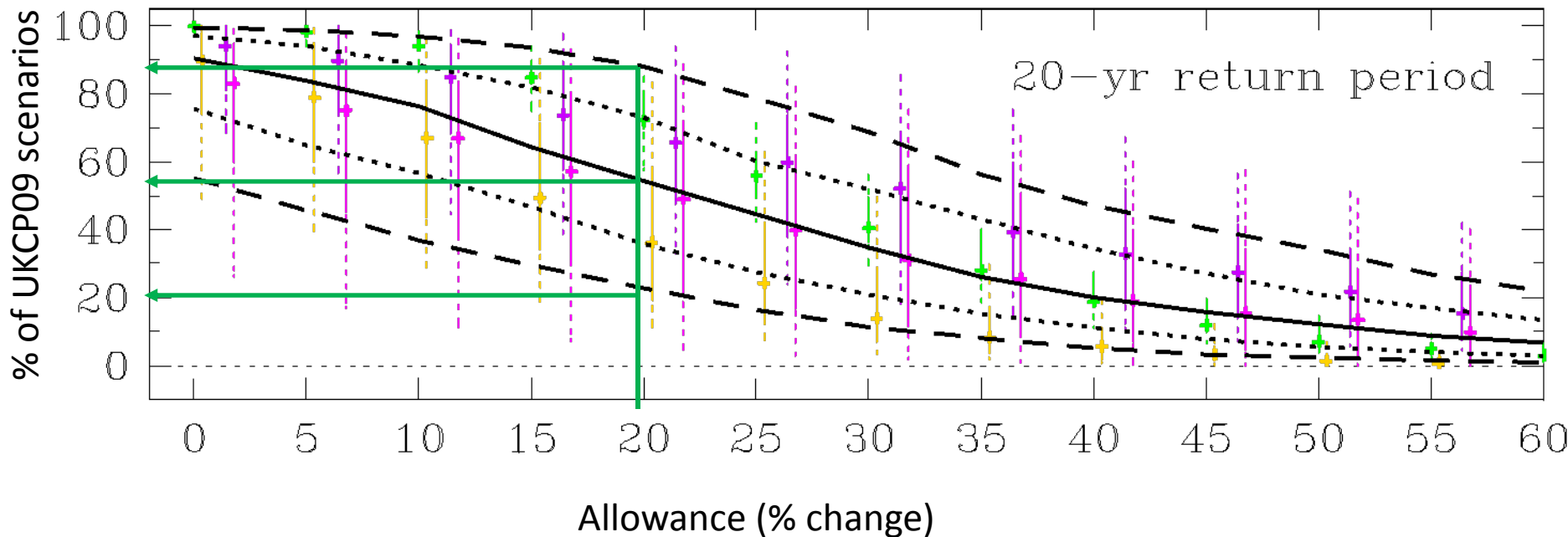
Between 20% and 40%, depending on region



WHAT ABOUT THE UNCERTAINTY?

Thames region:

- The median suggests that nearly 60% of scenarios are exceeded with a 20% allowance
- The range is between 20% and 90%



Achievements to date

- Improved cross-working: more joined-up scientific advice and analysis.
- Provision of single source of daily hazard assessment.
- New level of scientific expert challenge to the UK NRA.
- The provision of prepared scientific advice packs for all emergency responders.

Natural Hazards Partnership
Daily Hazard Assessment

Working together
Daily Hazard Assessment

Issued 14:00 on Monday, 29th January 2013

The Daily Hazard Assessment is for guidance only. You are advised to seek detailed information from the relevant Partner Organisation before taking any action.

Hazards Five Day Summary
FLOOD: AMBER, LANDSLIDE: YELLOW, SNOW: YELLOW, WIND: YELLOW.

FLOOD: There is a medium risk of flooding for parts of Wales and southwest England today and tomorrow.

LANDSLIDE: Heavy rainfall coupled with saturated ground in Southwest England and Wales today and tomorrow will give an increased likelihood of landslides and slope failures.

SNOW: Snow showers are expected to affect parts of Scotland and northeast England tomorrow morning.

WIND: Strong winds are expected to affect Northern Ireland, Scotland and parts of northern England tomorrow. Strong winds also expected to affect parts of southwest England tomorrow afternoon and evening.

Hazards Five Day Summary Detail

FLOOD: The Met Office is forecasting a band of heavy, locally intense rainfall to move across Wales and southwest England today, evening and tomorrow. The Met Office has an Amber forecast for parts of Wales and southwest England today and tomorrow. For England and Wales, the Flood Outlook Forecasting Centre (FFC) states, "The flooding in parts of Wales and southwest England today and tomorrow is of a medium likelihood of significant flooding".

LANDSLIDE: Heavy rainfall coupled with saturated ground in Southwest England and Wales today and tomorrow will give an increased likelihood of landslides and slope failures, especially in the south west. Please refer to the BOS Landslide web page for further details.

SNOW: Snow showers are expected to affect parts of Scotland and northeast England tomorrow morning.

WIND: Strong winds are expected to affect Northern Ireland, Scotland and parts of northern England tomorrow. Strong winds also expected to affect parts of southwest England tomorrow afternoon and evening.

Pre-prepared Scientific Advice
Working together
Drought

What is drought?

A drought is a period of water shortage for people, the environment, agriculture or industry. A hot, dry summer is an example of a short, intense drought, and dry winters can have a big impact on water resources(1). Droughts are different to other hazards, in that they tend to develop slowly, over a large area, with the exact beginning and end often difficult to identify. Several factors play a part(2) including:

- lack of rainfall
- an environment, soil or bedrock, which is poor at retaining water or lacks underground storage
- hot weather, which increases evaporation of water

Am I affected?

- The Environment Agency produces maps of drought affected areas and the management framework for drought in the UK.
<http://www.environment-agency.gov.uk/homeandleisure/drought/default.aspx>
- UK Water companies have more detailed local information and guidance.
<http://www.water-guide.org.uk/companies.html>
- The Natural Hydrological Monitoring Programme publishes every month a hydrological summary reporting current status of rivers, aquifers and reservoirs compared to the historical average.
<http://www.cmh.ac.uk/drain/nhmp/summary.html>

How does drought affect the UK?

Drought impacts on a very wide range of sectors including agriculture, industry, water supply, fisheries, health, environment, wildlife, buildings. The impact of droughts is poorly documented in the scientific literature and is often associated with potential risks, in particular on sectors such as health and water supply. Whether or not these become actual risks depends on several factors including:

- Preparedness for drought: Drought forecasting is notoriously difficult to do because of the long time scales involved (months to years). Recent work has shown little skill in forecasting beyond about one month ahead. (3). However, advance warning would enable better planning and actions aimed at minimising the adverse effects of drought.
- Vulnerability to drought: The effects of drought on a water resource system, environment or population health can vary based on the context of where and when drought occurs; certain systems are more likely to be affected e.g. those whose systems depend on heavy water use and/or have little headroom or buffering capacity.

What are the impacts of drought?

There are numerous different types of impact associated with drought. However, in developed countries, with resilient water supply and robust sanitation systems, the potential for physical impacts of drought is relatively low. However, its consequences in terms of economical cost can be high.

- **Reduction / loss of agricultural production**
Drought conditions due to rainfall deficit and/or high temperature increase the drying of soils, when both lack of rainfall and high temperatures are combined this impact is amplified. This in turn can reduce crop yield with a potential for loss of