MAKING THE MOST OF CLIMATE INFORMATION FOR ROBUST DECISION MAKING

CHRISTEL PRUDHOMME

COST VALUE Workshop: Linking climate data and impacts with end user needs to enable robust adaptation. Bern 1-2 Dec 2014

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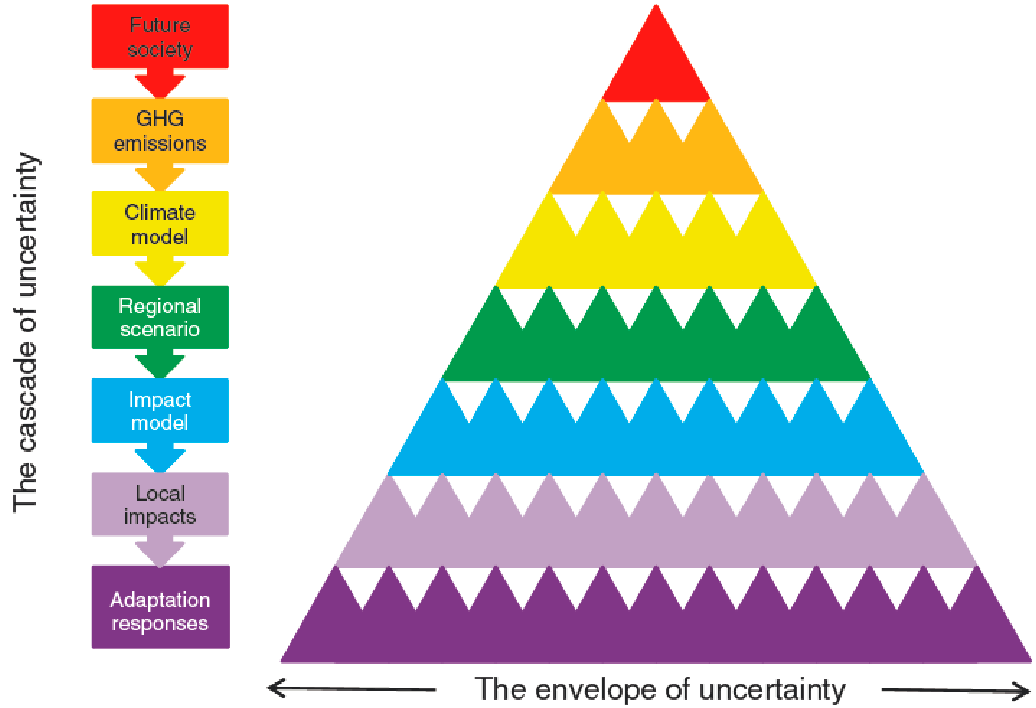
Climate change adaptation process

1. Agree on common language
2. Understand limitations (time/ budget/ information)
3. Define stressor-response indicator
4. Quantify and communicate uncertainties
5. Information for robust decision making



Wilby & Dessai, 2010, Weather, DOI: 10.1002/wea.543

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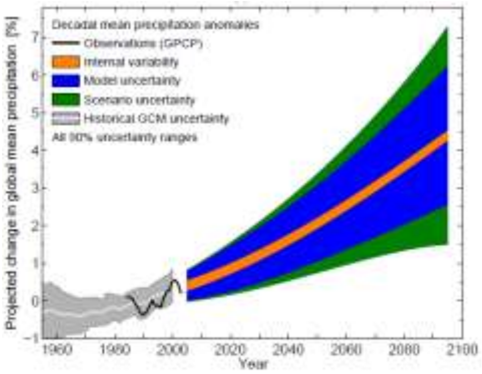
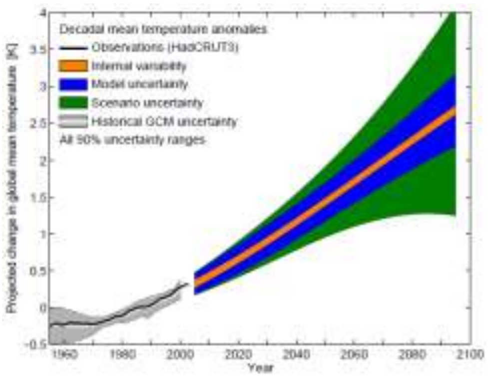
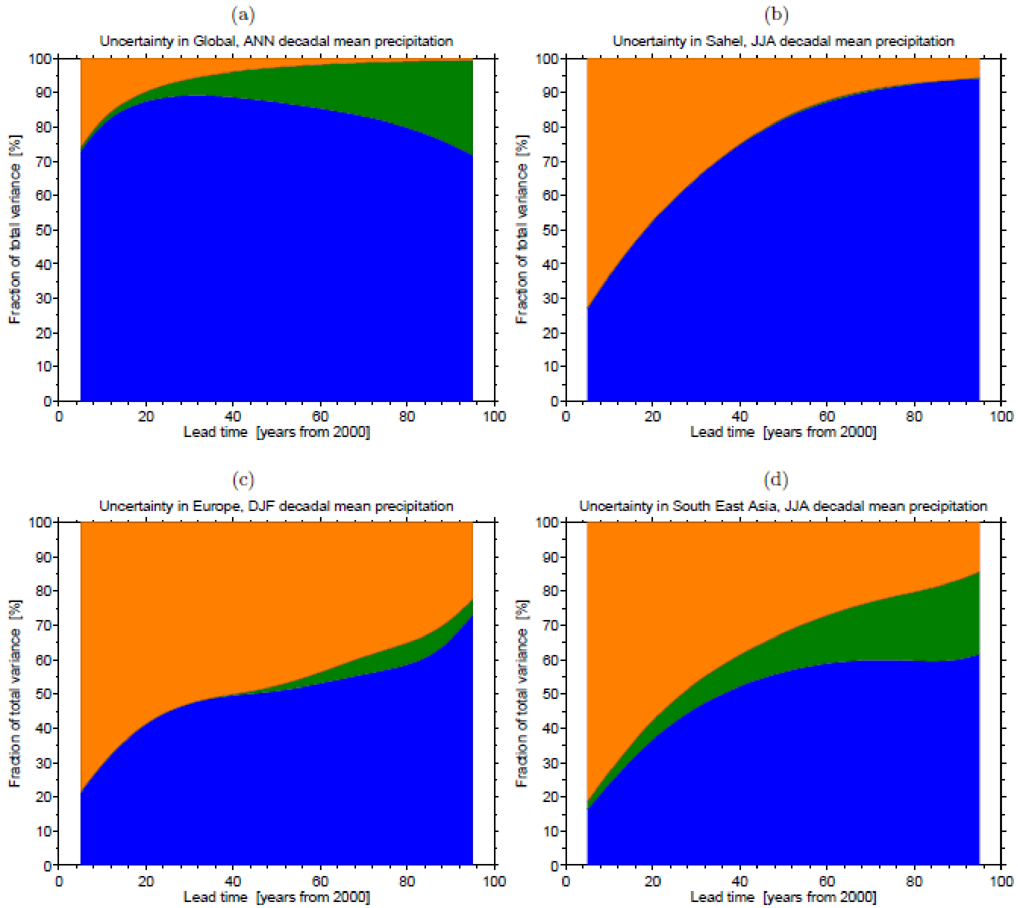
Understanding cascade of uncertainty

Global and regional climate







Hawkins & Sutton, 2011, Clim Dyn, Doi: 10.1007/s00382-010-0810-6

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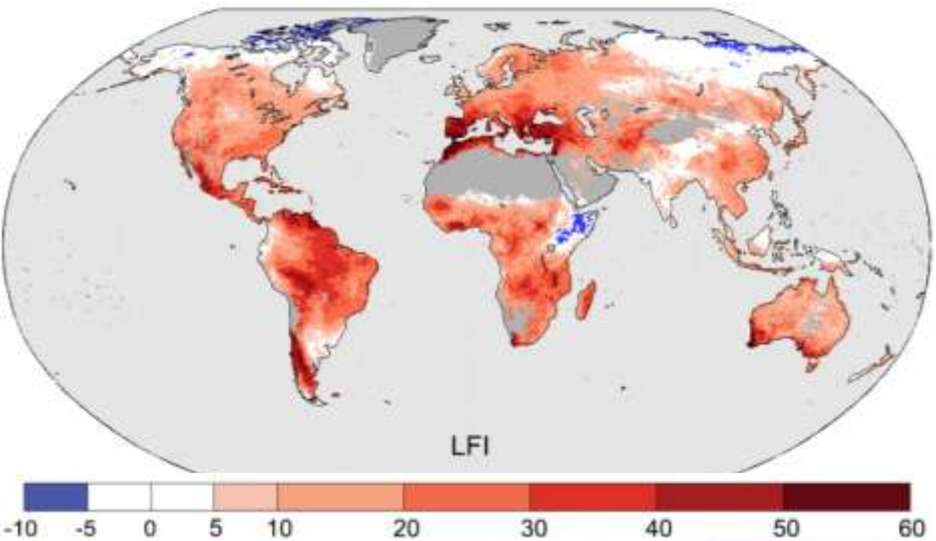
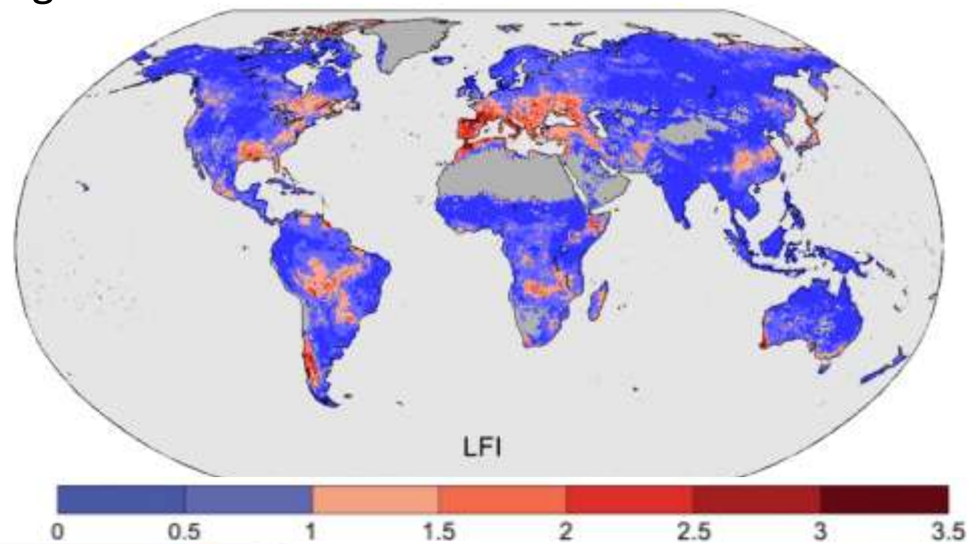
Understanding cascade of uncertainty

Global impact

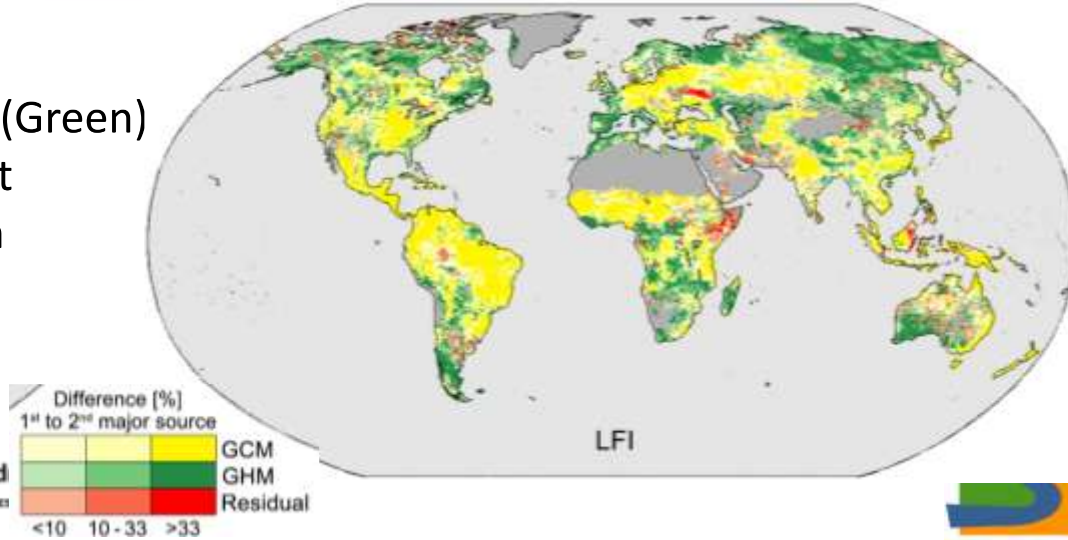
Mean annual change



Signal to noise



GIM uncertainty (Green)
-> large footprint
-> dominant high latitudes



No pattern of driving uncertainty in regions with high signal-to-noise

Prudhomme et al., PNAS, 2013
10.1073/pnas.1222473110
Giuntoli et al., in prep, ESD,

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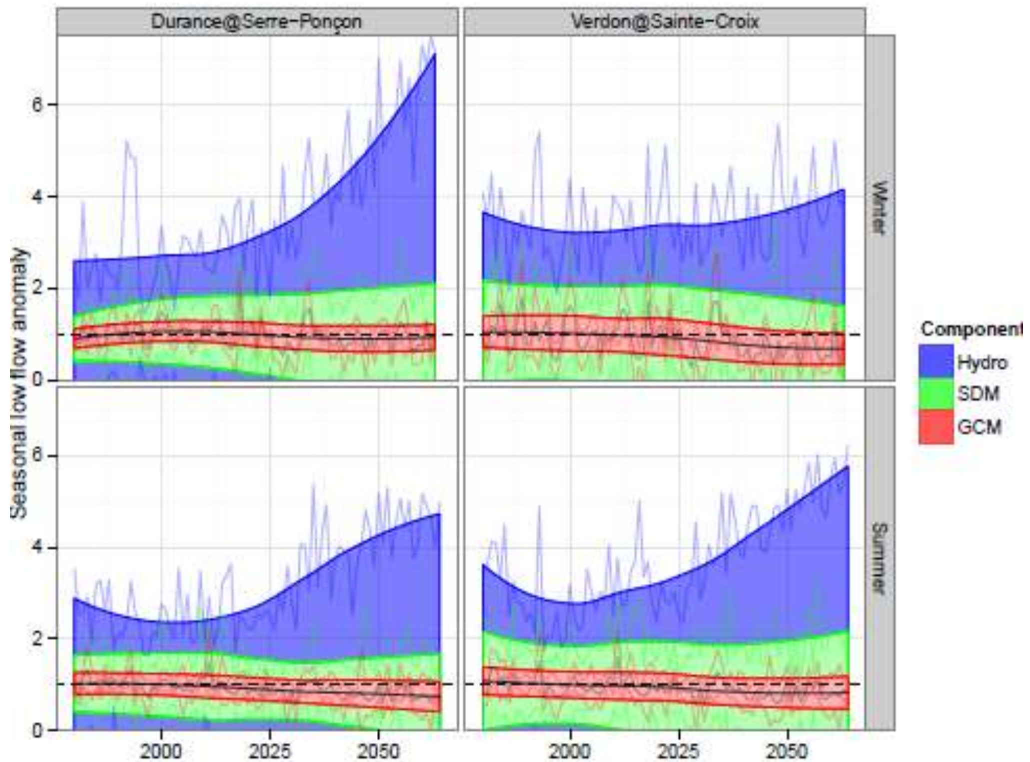
Understanding cascade of uncertainty

Local impact

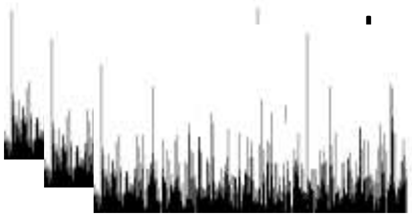


Seasonal low flow

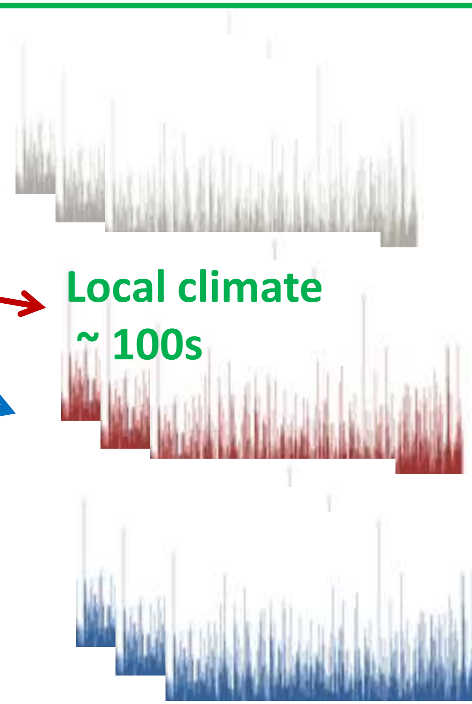
Vidal, EGU Leonardo, Prague, 2014

Conventional approach: scenario-led

Large scale climate (x emission scenario x GCM) ~ 10s

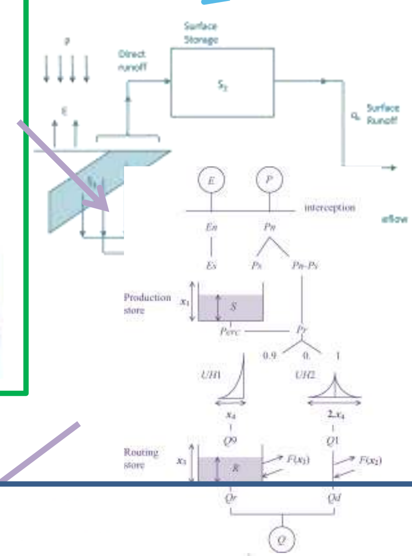


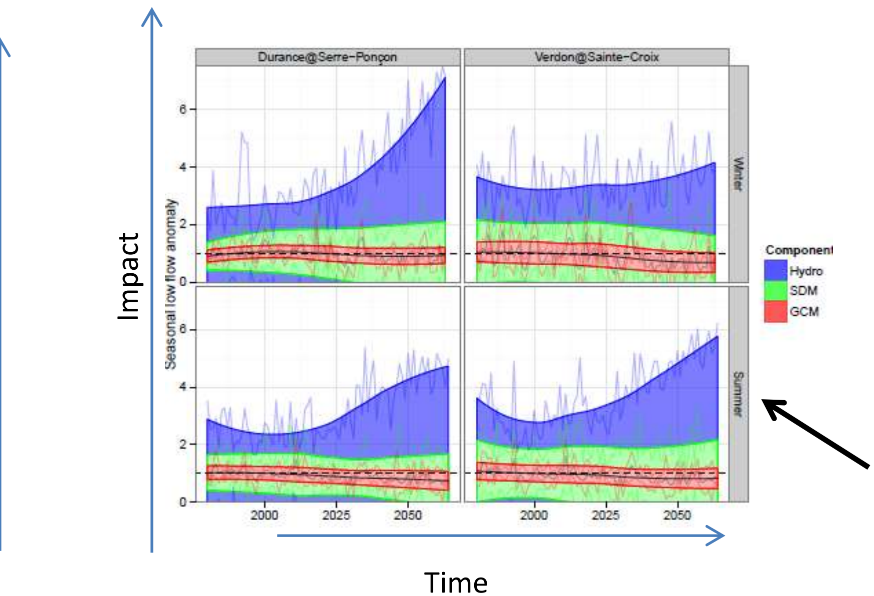
Downscaling/ bias correction methods



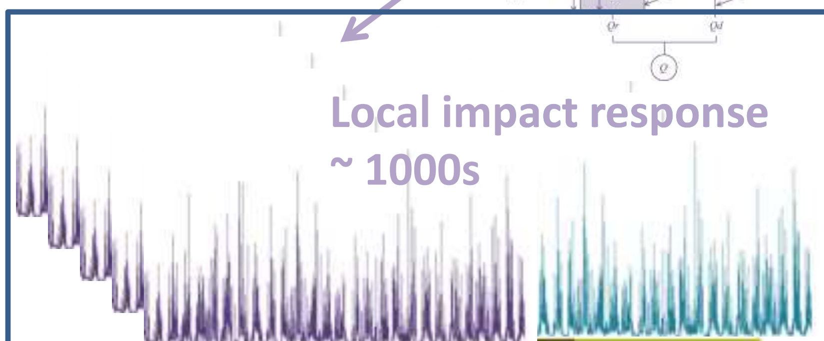
Local climate ~ 100s

Impact models





Vidal et al, 2014, EGU Leonardo



Local impact response ~ 1000s

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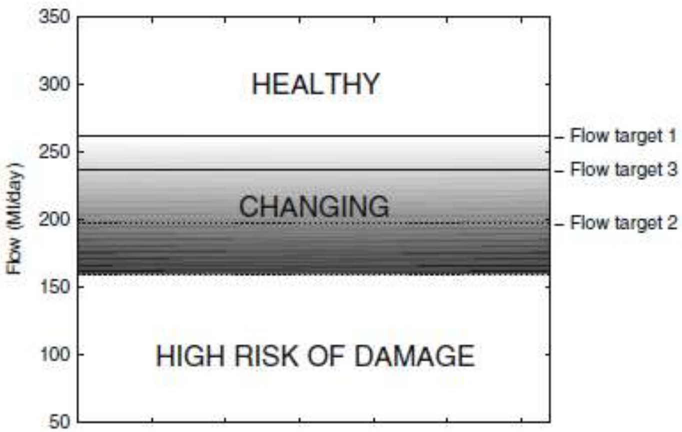
Communicating uncertainty

Flow bands based on LIFE indicators (affect on invertebrate community)

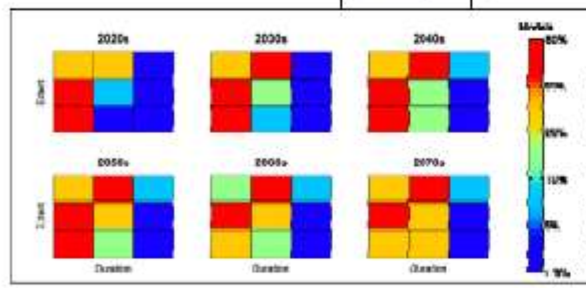


Ecological Impacts Matrix

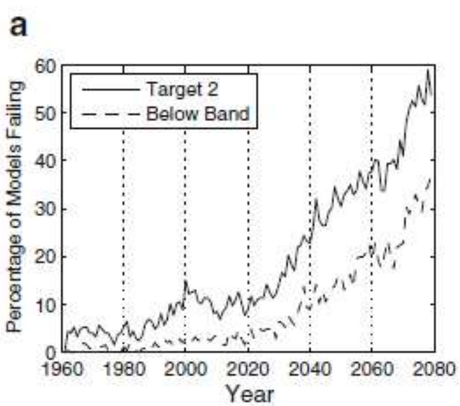
Duration

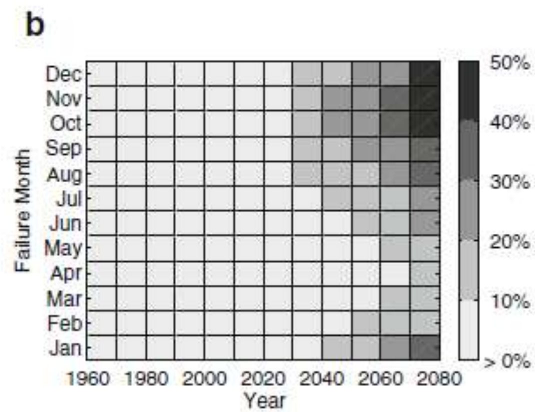
Flow

	1 year only	2-4 consecutive years	> 5 consecutive years
Upper flow warning band (188 - 282Ml/day)	No adverse impacts on invertebrates and overall ecology of river remains healthy	Some risk of invertebrate community being harmed but recovery possible	High risk of community changing with some chance of recovery
Lower flow warning band (167 - 188Ml/day)	Some risk of invertebrate community being harmed but recovery possible	High risk of invertebrate community changing but with high chance of recovery	High risk of community changing with some species remaining
Below flow warning band and RAM threshold (< 167Ml/day)	Invertebrate community harmed and some risk that recovery is not possible	High risk of invertebrate community changing permanently to slow flow-type communities	Highly modified community more typical of arid environments could develop, including species with adaptive strategies enabling survival over extended periods of drought. Iconic species such as salmon, lamprey, otter no longer present



Colour scale: number of models





Percentage of model runs that fail target 2 at least once in a given month

Fung et al., 2009, SC050045

Fung et al., 2012, DOI:10.1007/s11269-012-0080-7

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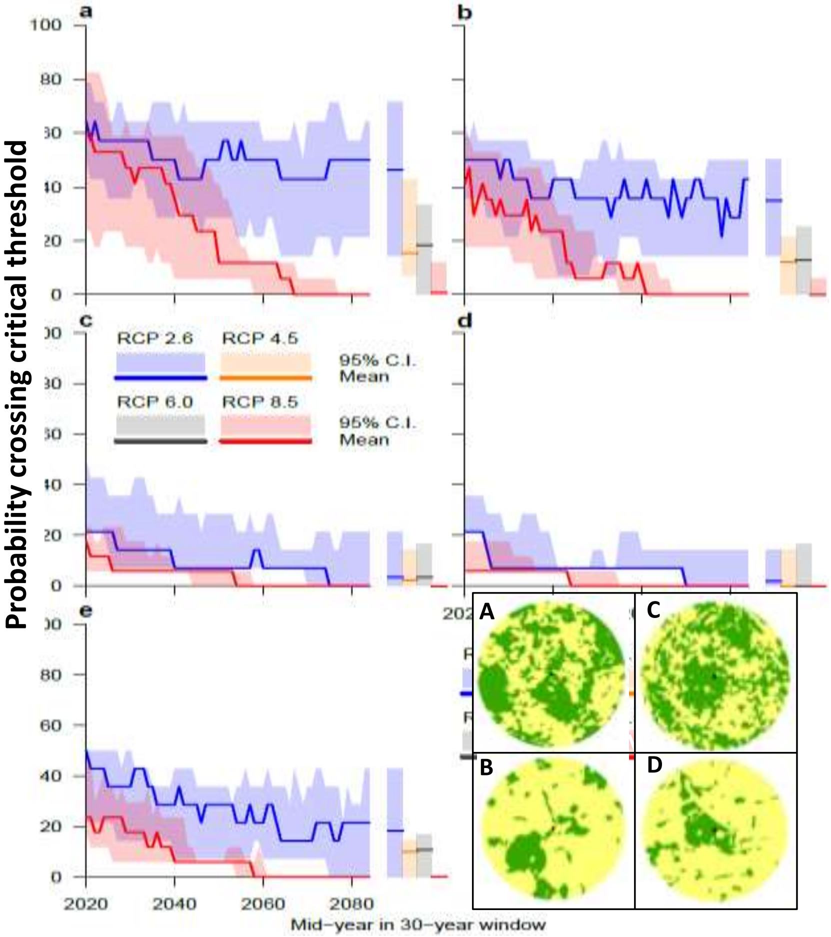
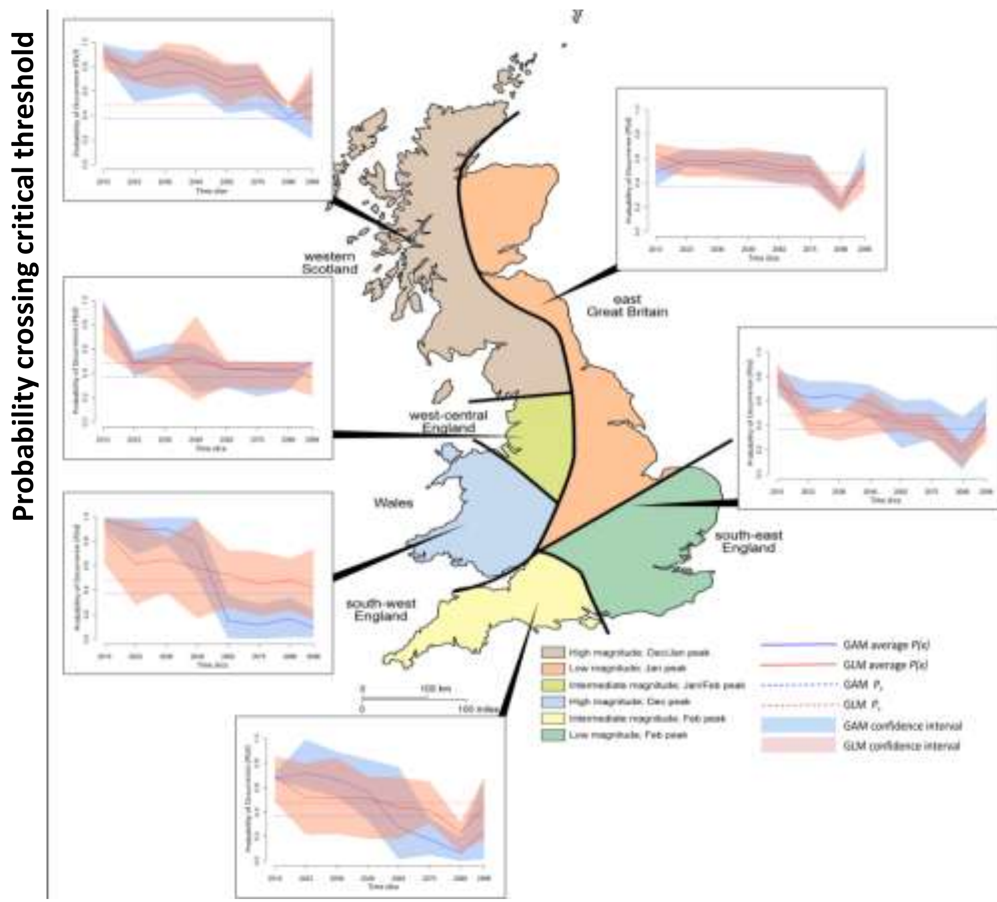
Communicating uncertainty

Butterfly recovery shorter than drought return period?



Oliver et al., under review, Nature CC

River bird (White Throated dipper) probability of presence > probability absence?



Royan et al., in press, Ecosphere

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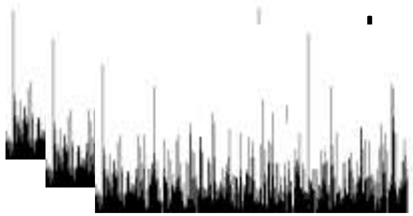
Conventional approach: scenario-led

Large scale climate (x emission scenario x GCM) ~ 10s



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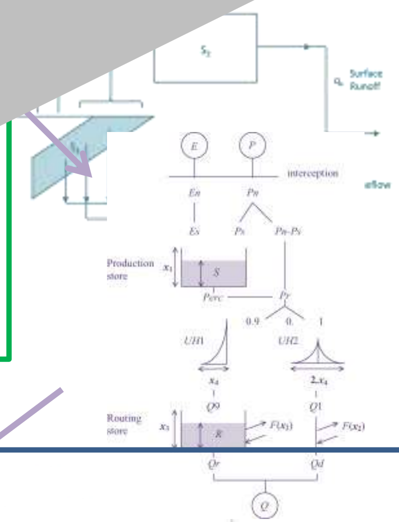
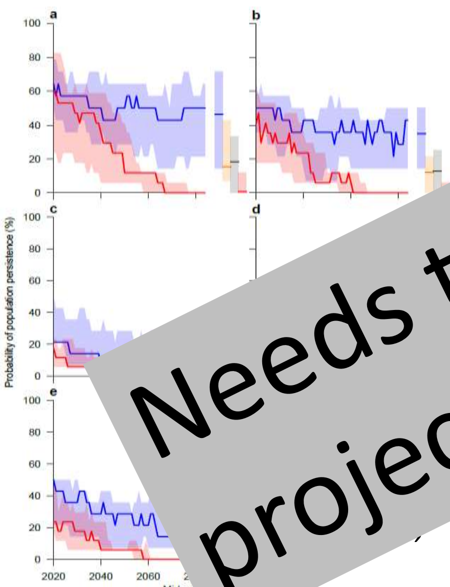
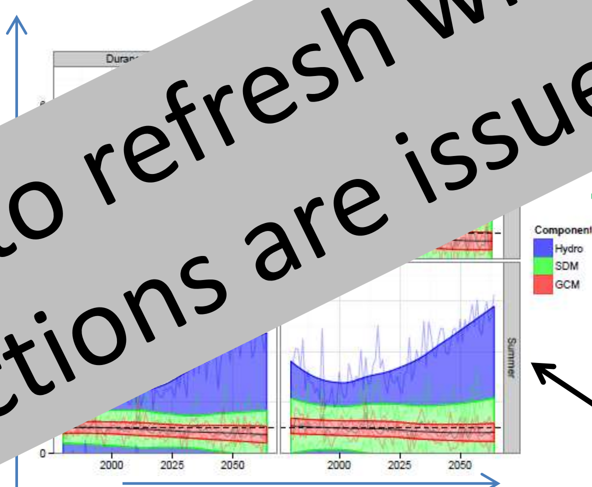


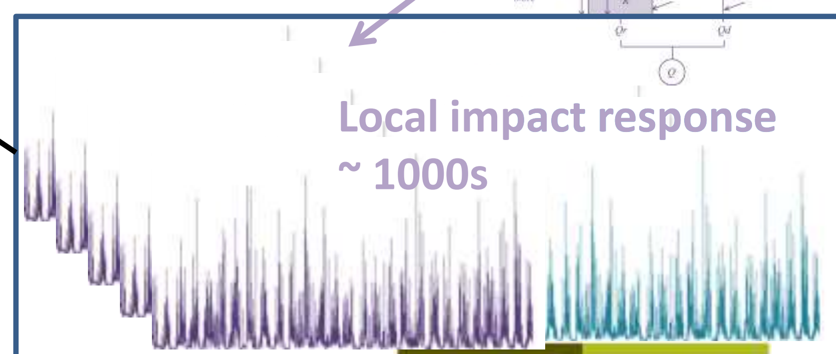


review, Nature CC



Time

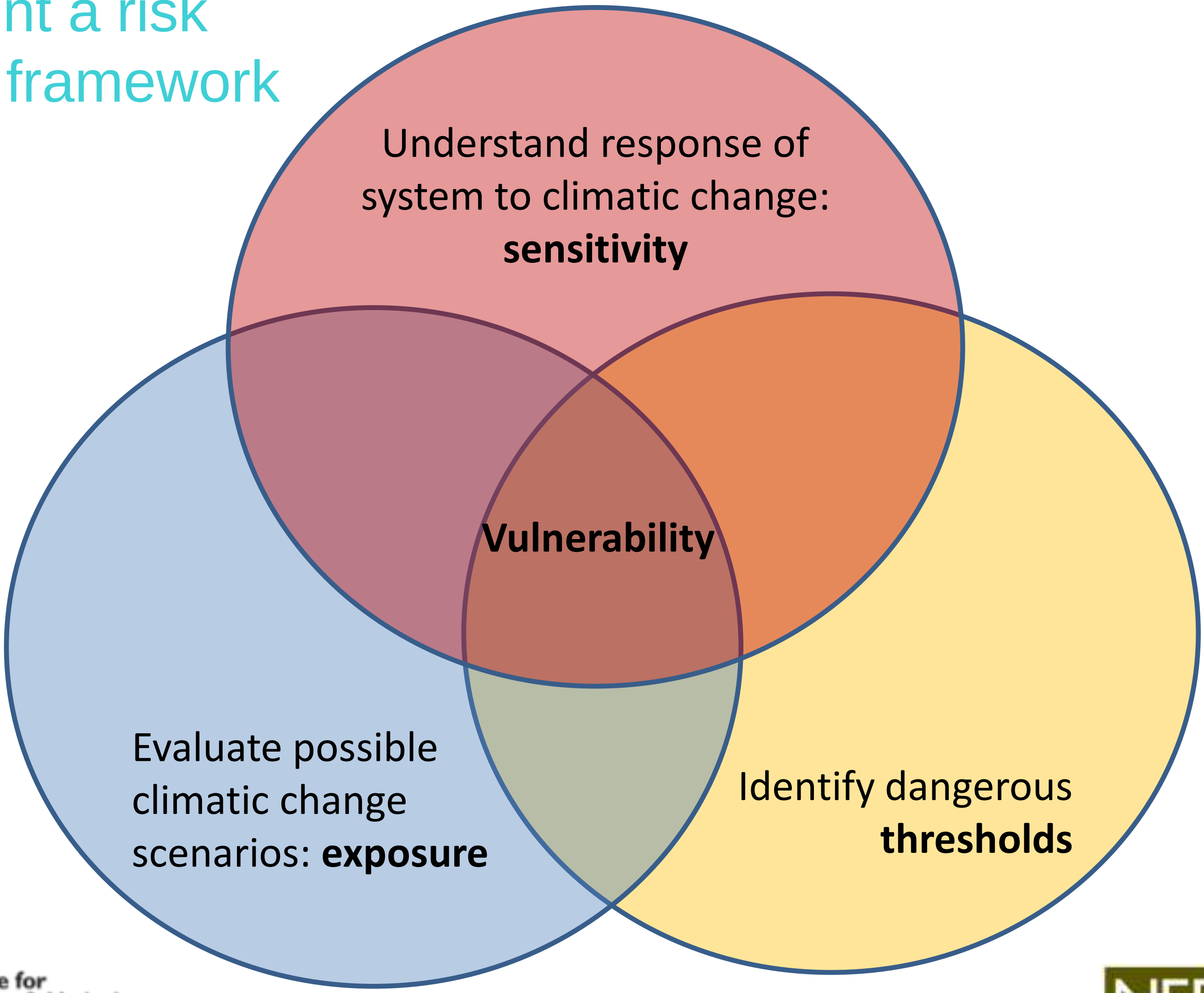
Vidal et al, 2014, EGU Leonardo



Needs to refresh when new climate projections are issued

How to make the most of the information?

Implement a risk analysis framework



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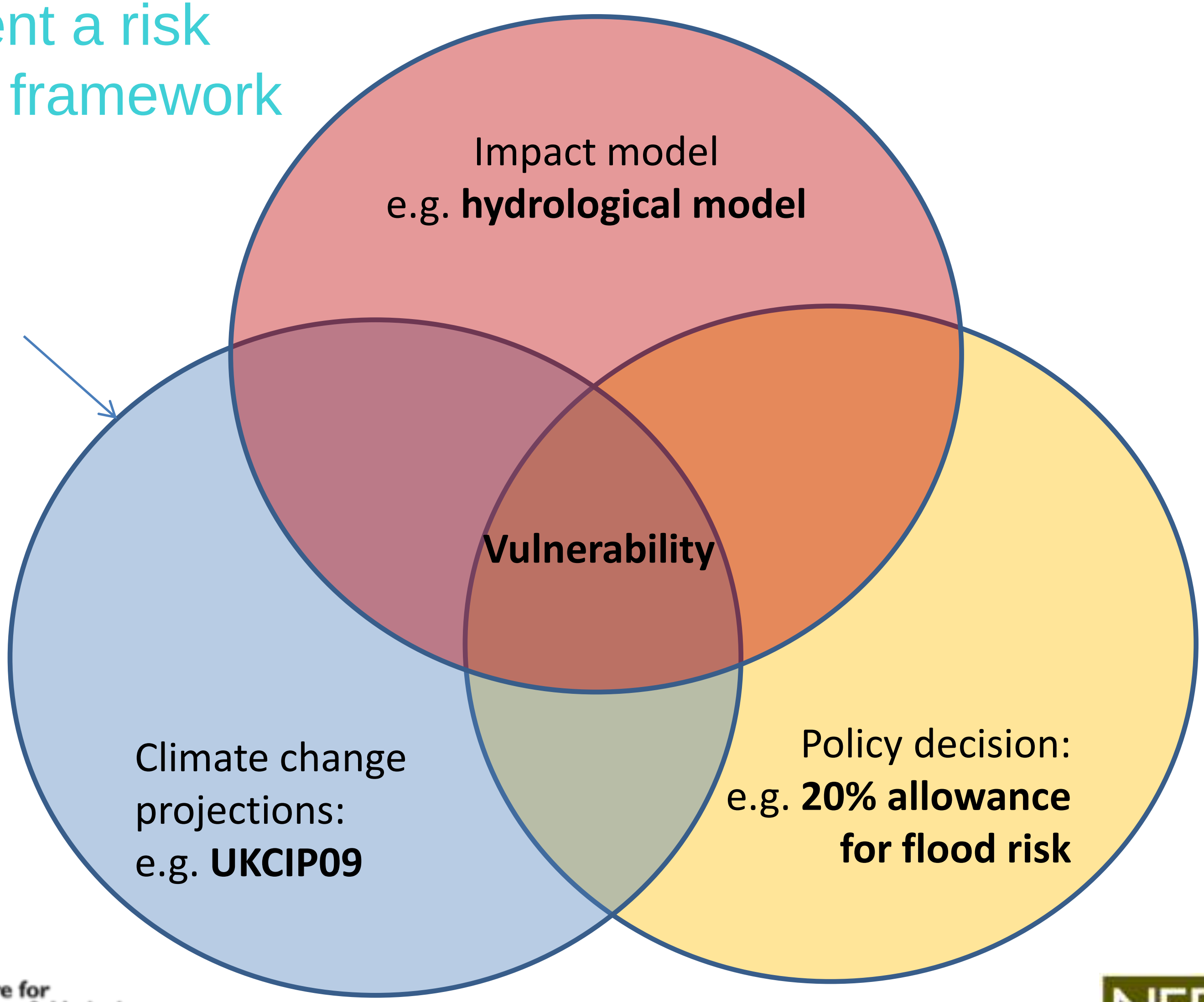
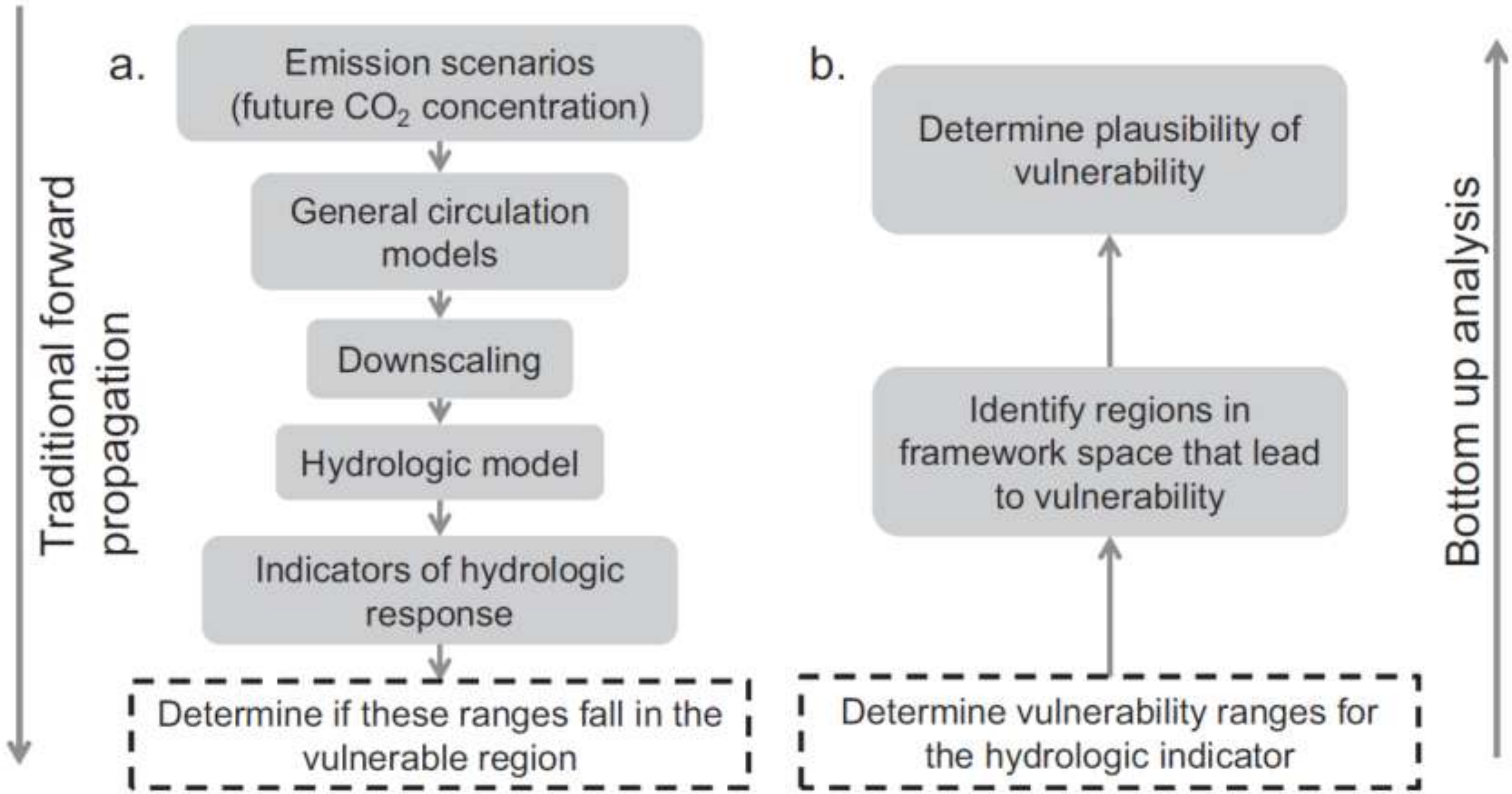
How to make the most of the information?

Implement a risk analysis framework

Only part to refresh with evolution of climate science

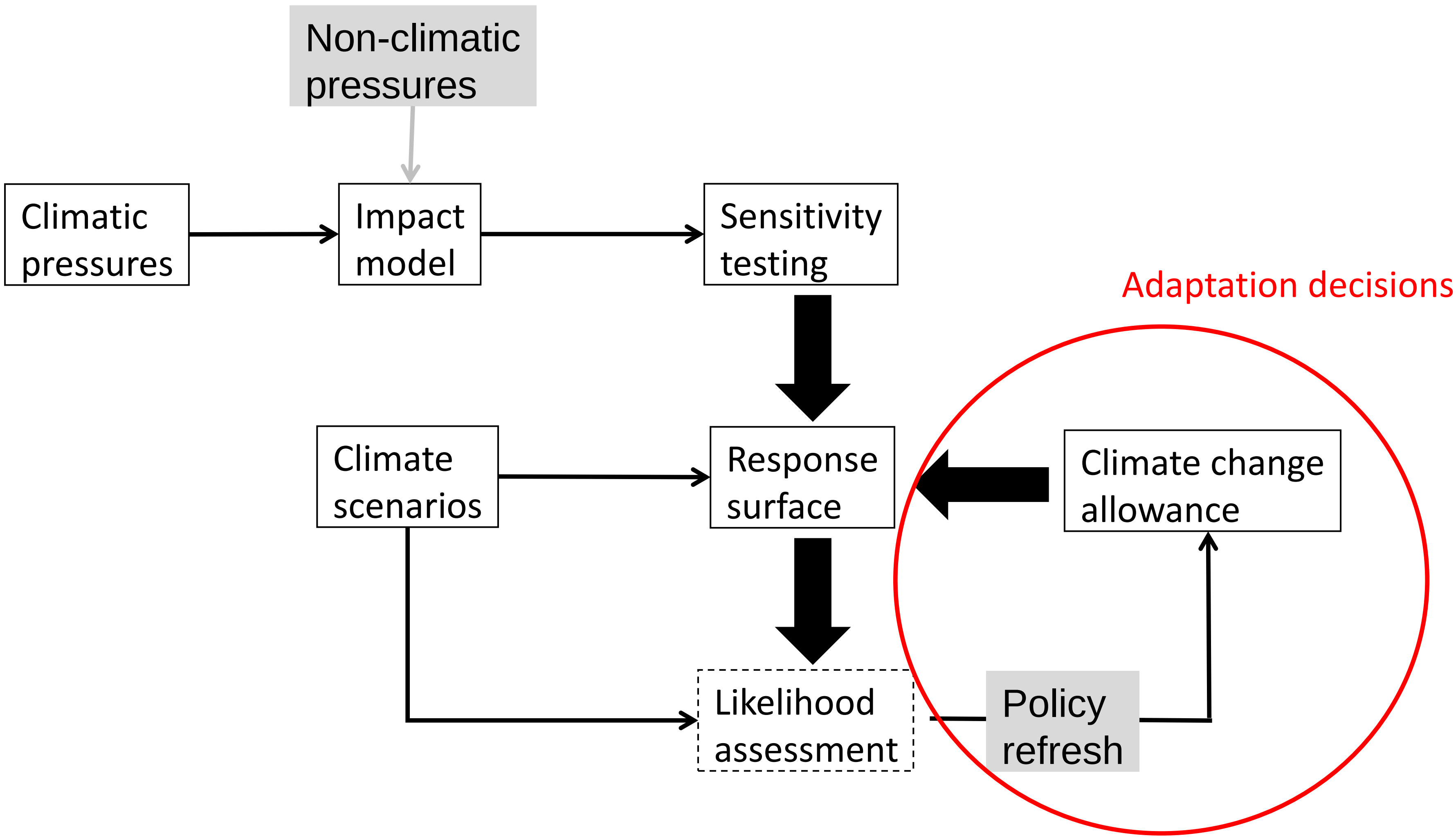


Scenario-neutral to adaptation planning



Sing et al., 2014, WRR, DOI: 10.1002/2013WR014988

Scenario-neutral to adaptation planning



Prudhomme et al., JH, 2010, DOI: 10.1016/j.hydrol.2010.06.043

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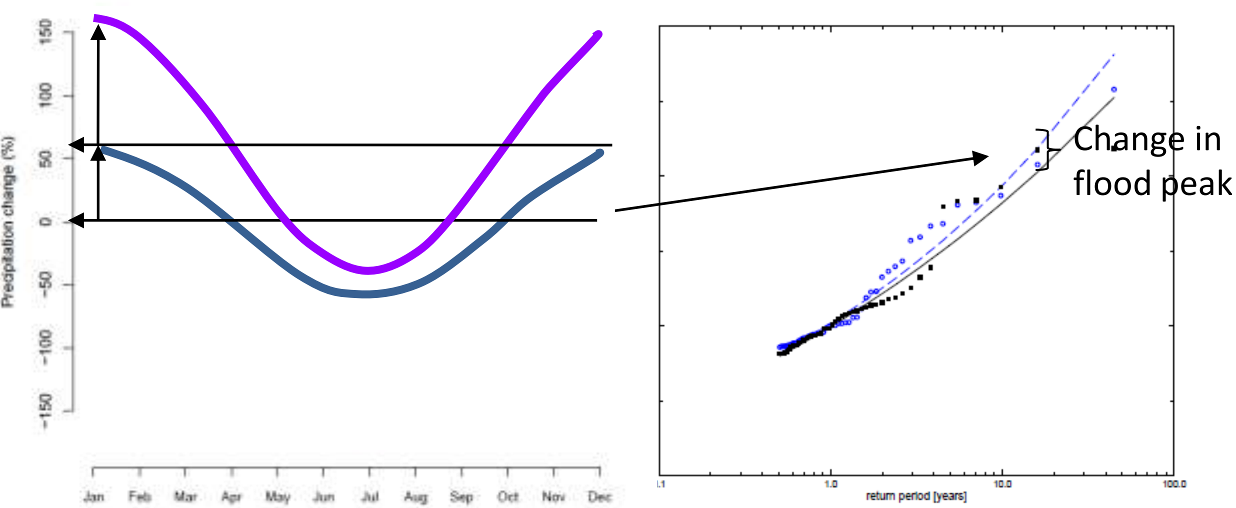
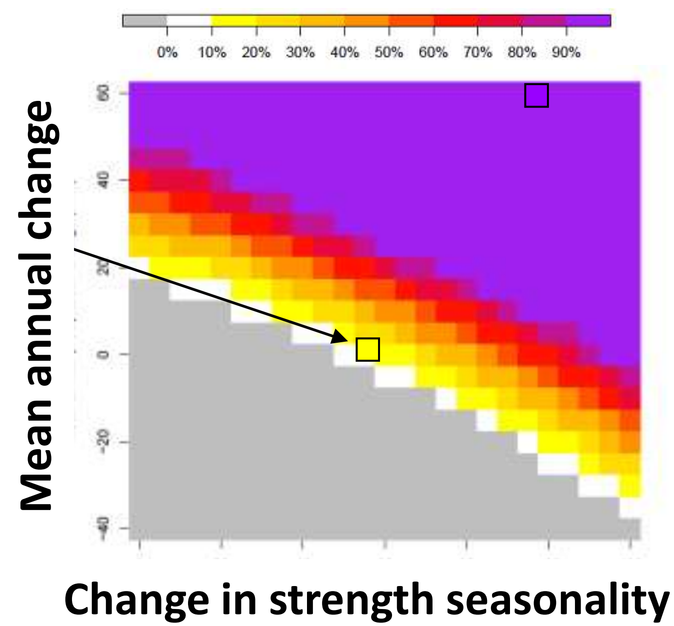
1. Sensitivity – Response surfaces

Policy question: should the 20% climate-change allowance for flood risk in England and Wales be changed?

- Climate projection scenarios (CMIP3) show a seasonal pattern of precip & temp. change in GB; winter precip peak
- Flood Response Surface = quantify sensitivity of flood peaks to changes in precipitation and temperature

CF change + hydrological modelling

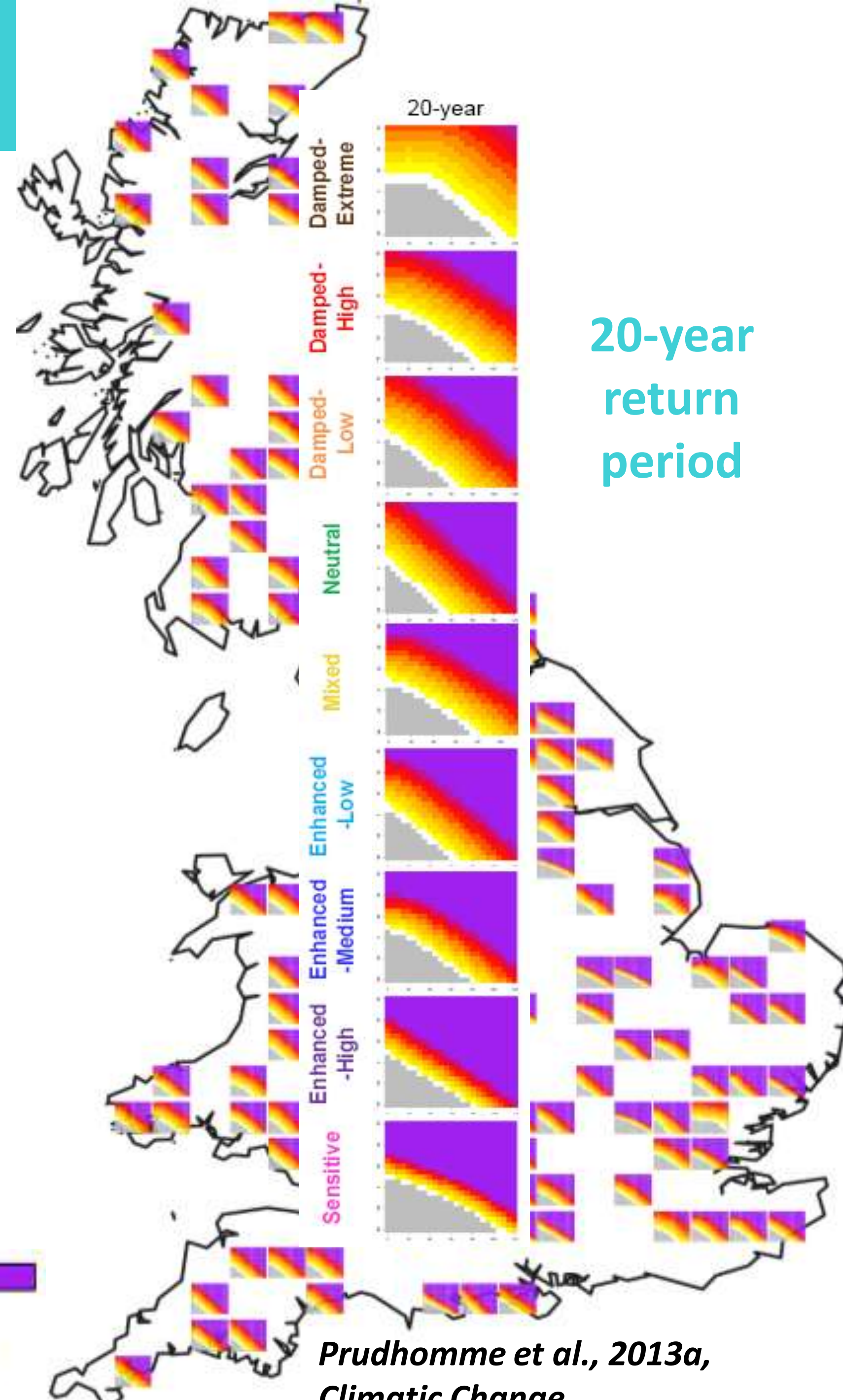




Prudhomme et al, 2010, J. Hydorlogy

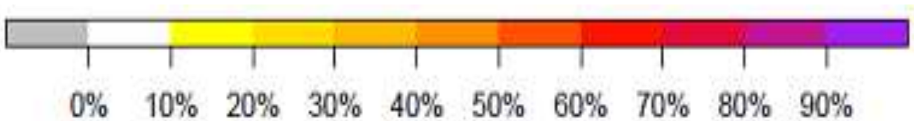
1. Flood response types

- Modelled sensitivity of 154 basins across Britain
- Clustering analysis
- 9 Flood response types in GB



20-year return period

Prudhomme et al., 2013a, Climatic Change



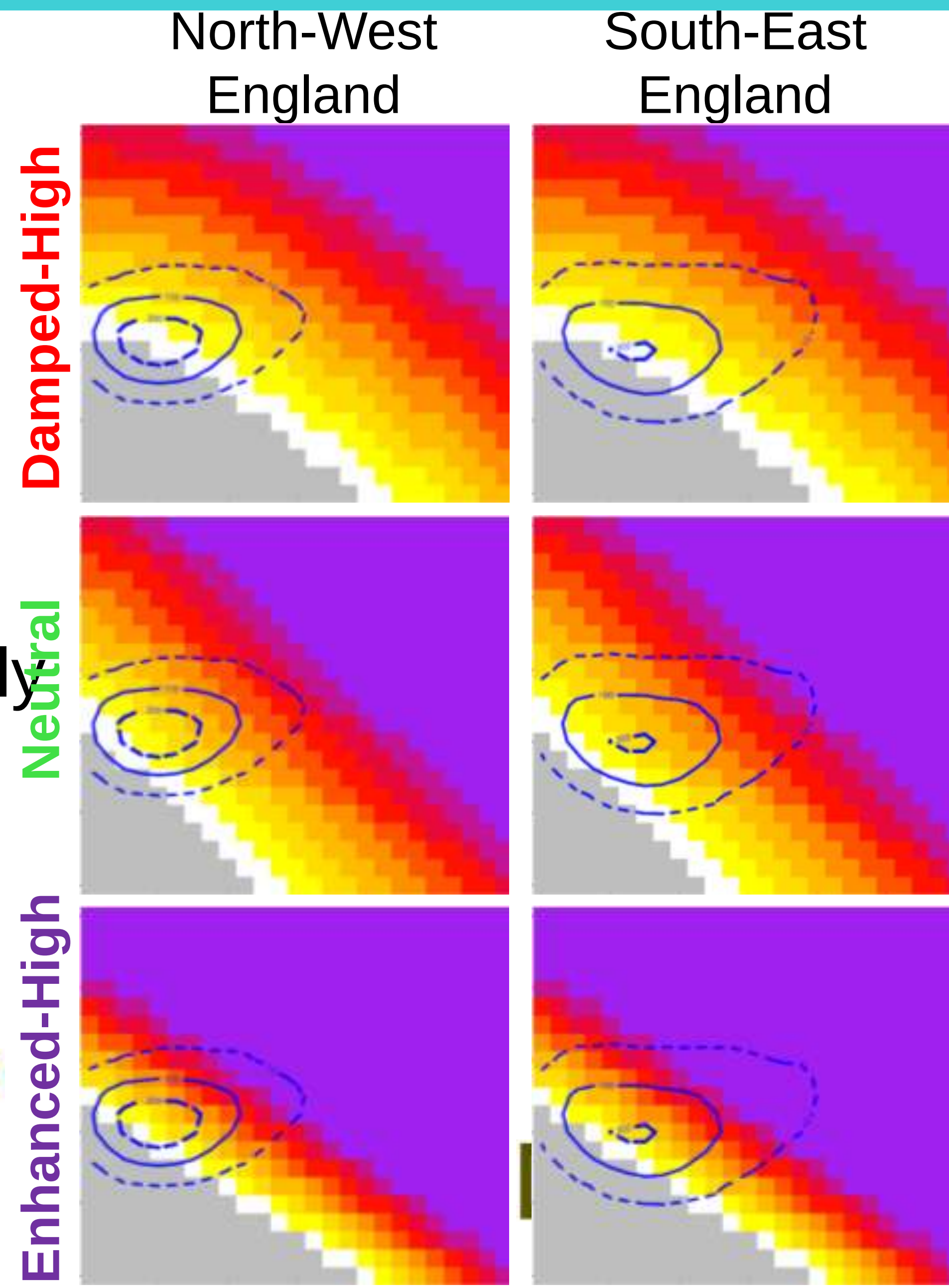
2. Exposure

- Identify plausible scenarios (e.g. from latest climate projections)
- Describe the scenarios in format of sensitivity framework
- For GB:
  - 10,000 sets of monthly changes of UKCP09 probabilistic scenarios
  - Seasonal changes in precipitation (harmonic function)

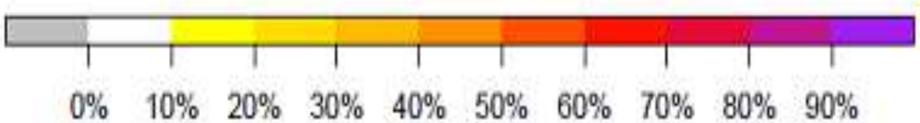
UKCP09: Murphy et al., 2009

2. Exposure (UKCP09)

- Express exposure same way as sensitivity framework
- Impact = Compare exposure with sensitivity using response surfaces
- Exposure varies regionally
- Same sensitivity can occur in several regions



See also Kay et al., 2013, REC, DOI: 10.1007/s10113-013-0563-y



2080s Medium (A1B) emissions

3. Vulnerability = exposure & sensitivity/ impact

- Vulnerability defined against a given threshold (adaptive capacity)
- C = maximum level of change to be protected against
- Vulnerability = proportion of scenarios with impact greater than C
- Vulnerability diagrams = vulnerability to many adaptive capacity thresholds

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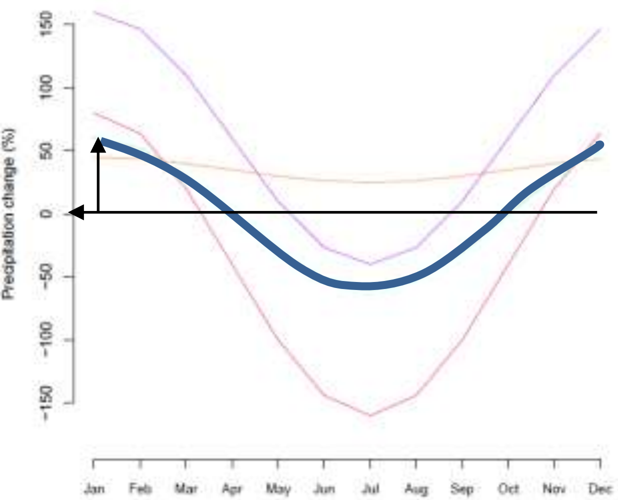
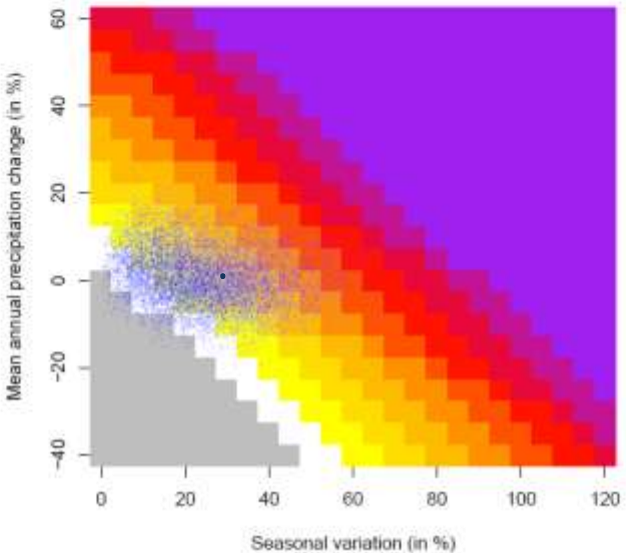
Kay et al., 2011, project report
Prudhomme et al., 2013b, Climatic Change

3. Vulnerability = exposure & sensitivity/ impact





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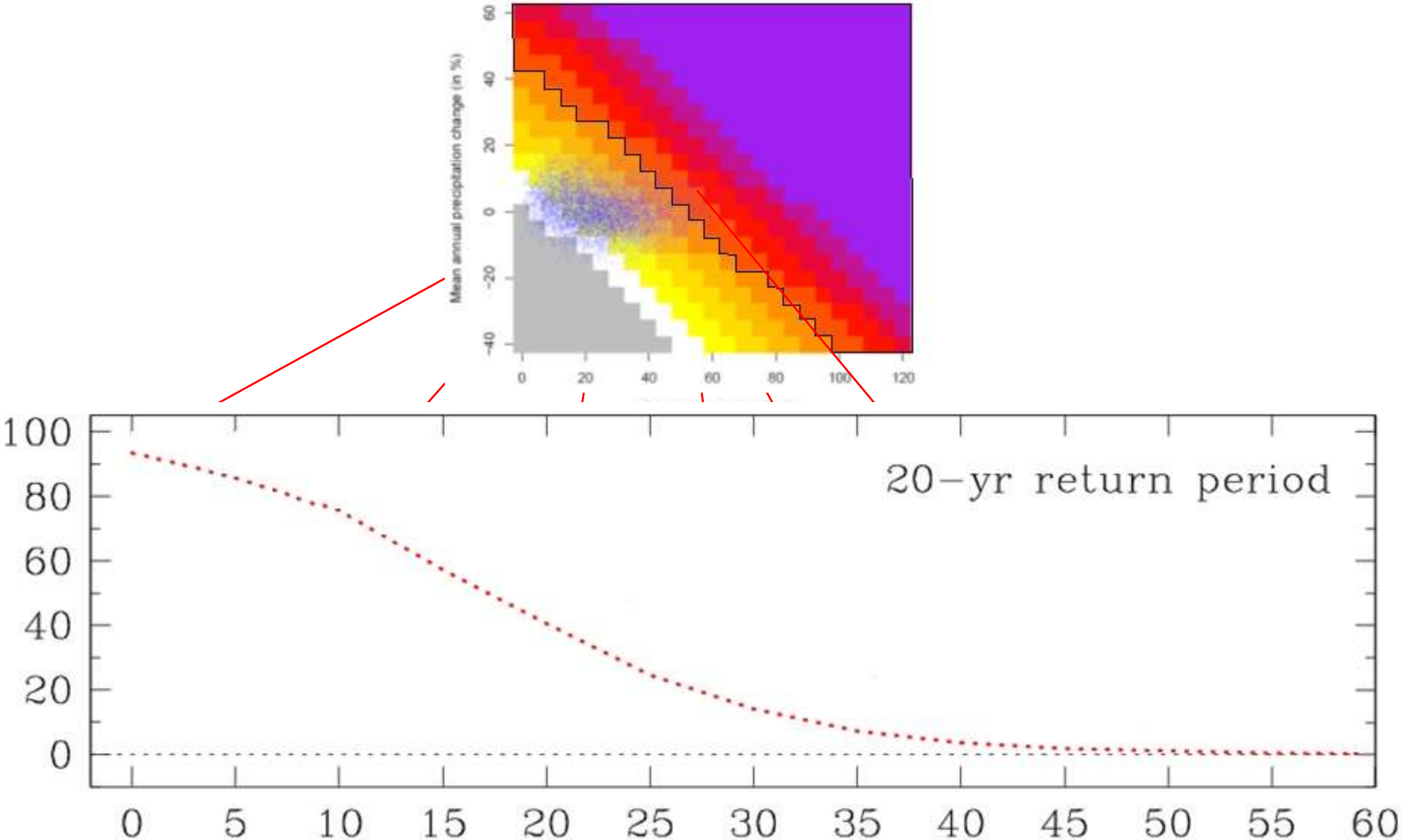
3. Vulnerability = exposure & sensitivity/ impact



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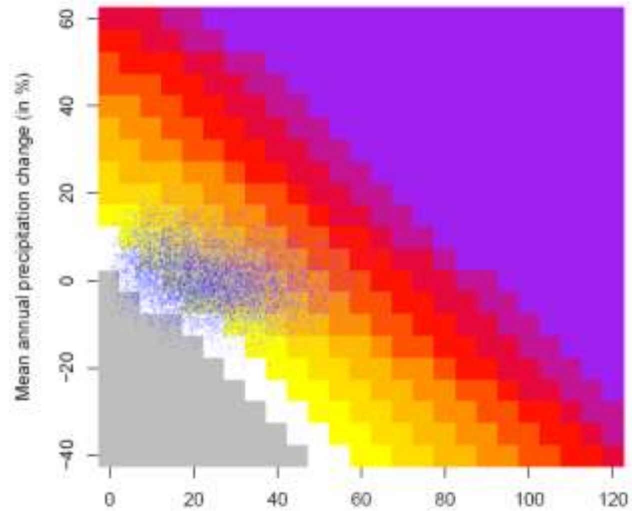
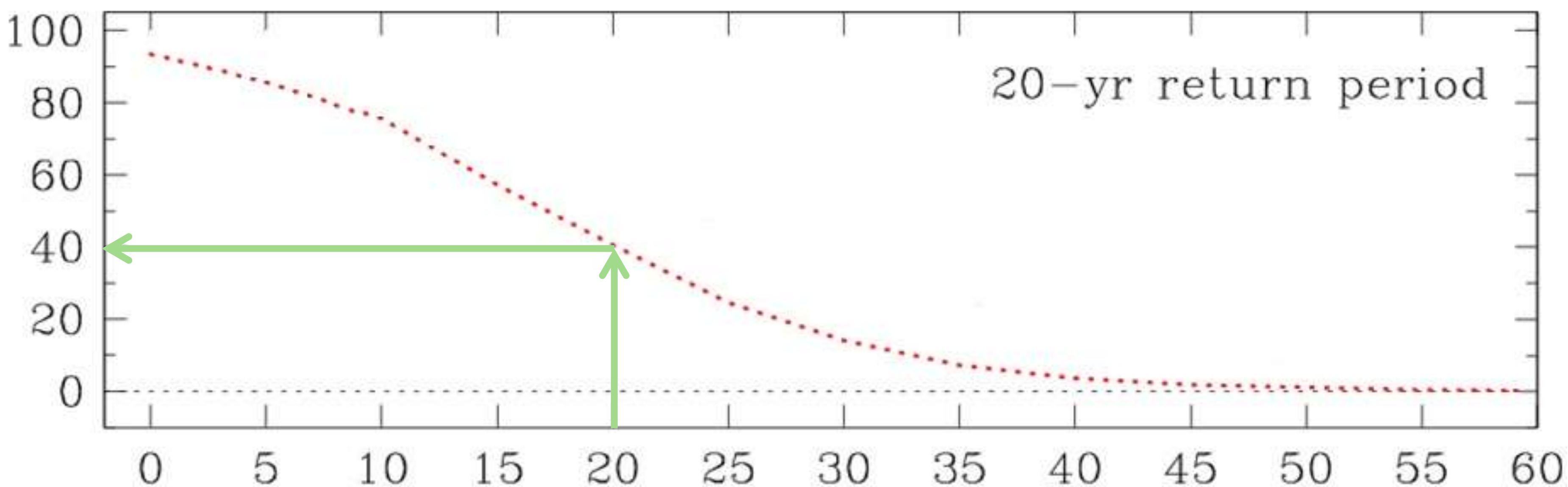
3. Vulnerability = exposure & sensitivity/ impact



Is a 20% allowance robust?

~ 40% scenarios exceed allowance for this catchment



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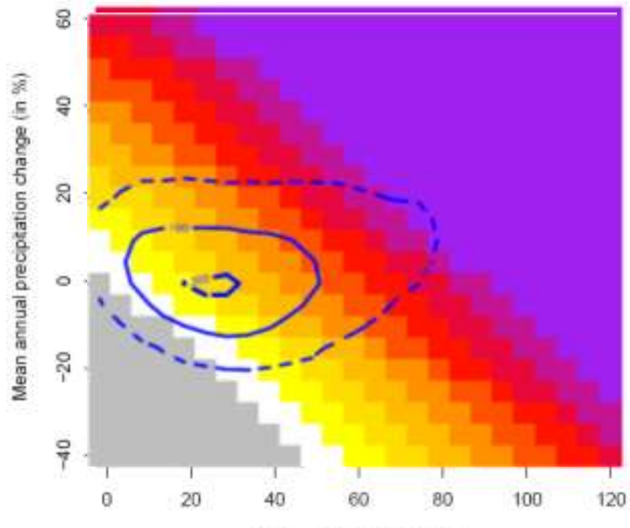
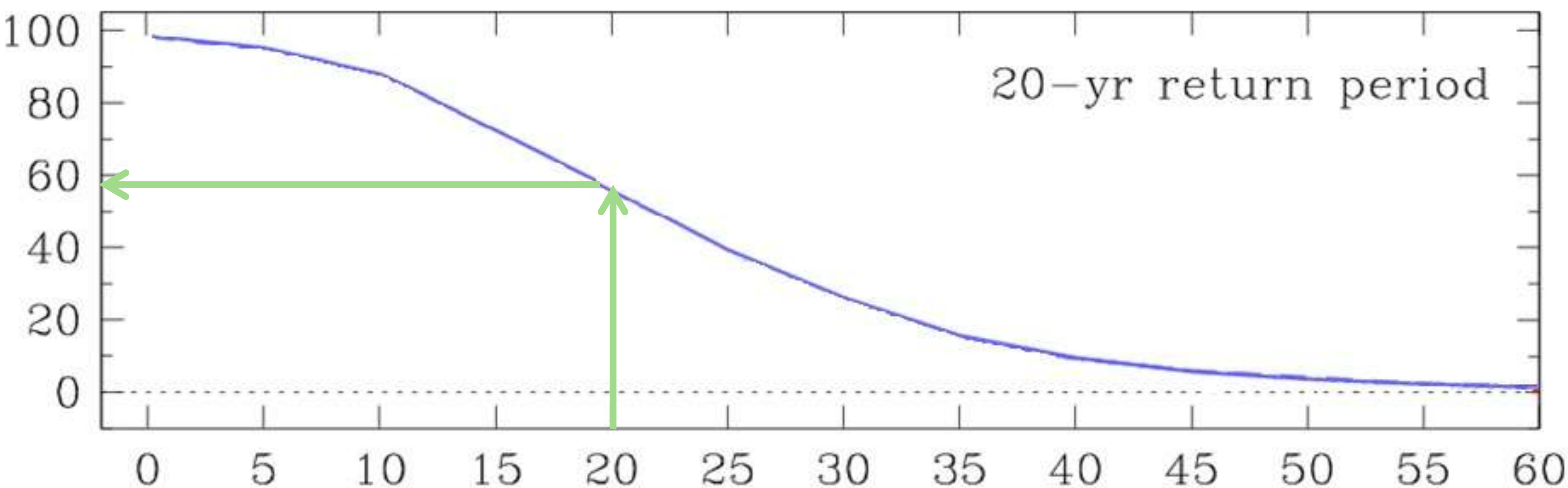
3. Vulnerability = exposure & sensitivity/ impact



Is a 20% allowance robust?

New projections?

~ 60% scenarios exceeds allowance for this catchment



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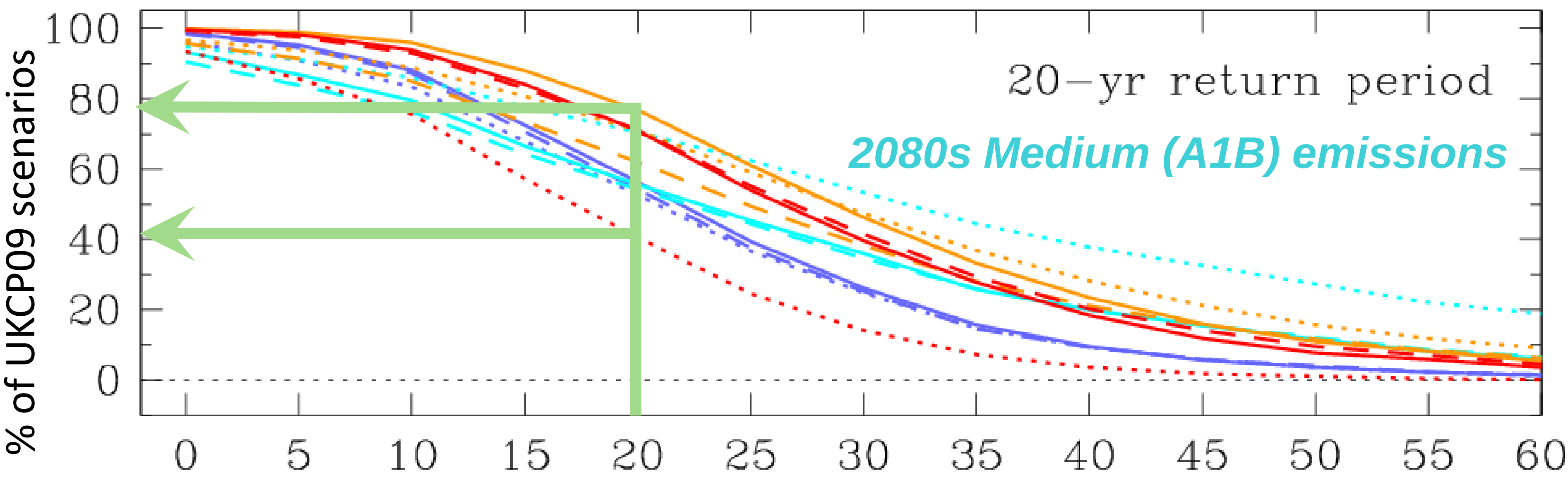
3. Vulnerability to national 20% allowance

- Between 40% and 80% of the 10,000 UKCP09 scenarios will exceed allowance ('dangerous threshold') depending on England/Wales region
- 20% allowance no longer precautionary



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Kay et al., 2011, Defra

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Kay et al., 2011

Policy refresh

Table 2 Changes to river flood flows by river basin district compared to a 1961-90 baseline

	Total potential change anticipated for the 2020s	Total potential change anticipated for the 2050s	Total potential change anticipated for the 2080s
Northumbria			
Upper end estimate	25%	30%	50%
Change factor	10%	15%	20%
Lower end estimate	0%	0%	5%
Humber			
Upper end estimate	25%	30%	50%
Change factor	10%	15%	20%
Lower end estimate	-5%	0%	5%
Anglian			
Upper end estimate	30%	40%	70%
Change factor	10%	15%	25%
Lower end estimate	-15%	-10%	-5%
Thames			
Upper end estimate	30%	40%	70%
Change factor	10%	15%	25%
Lower end estimate	-15%	-10%	-5%

continued on next page

Environment Agency

Adapting to Climate Change:

Advice for Flood and Coastal Erosion Risk Management Authorities

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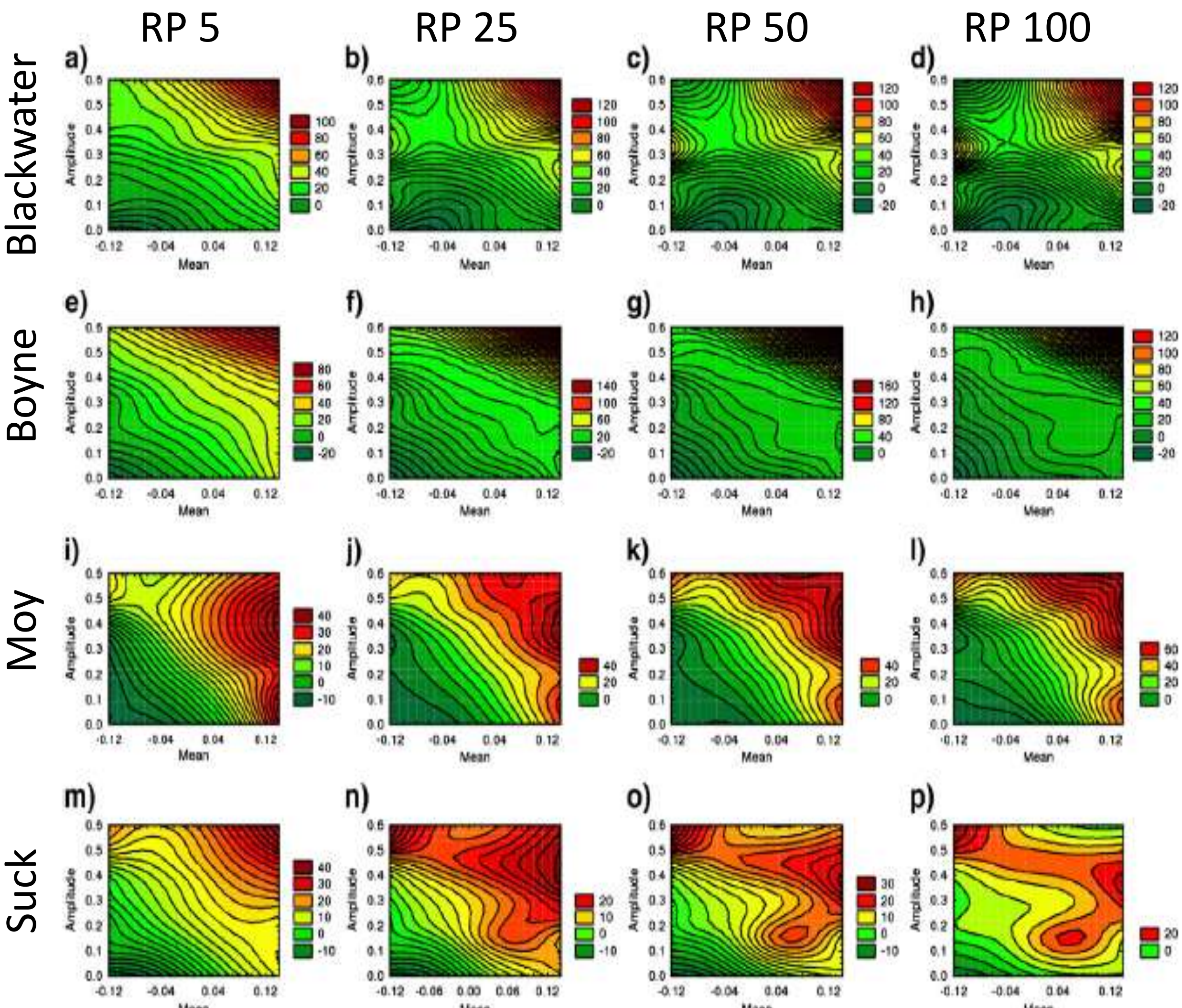
Flood peak sensitivity - Ireland

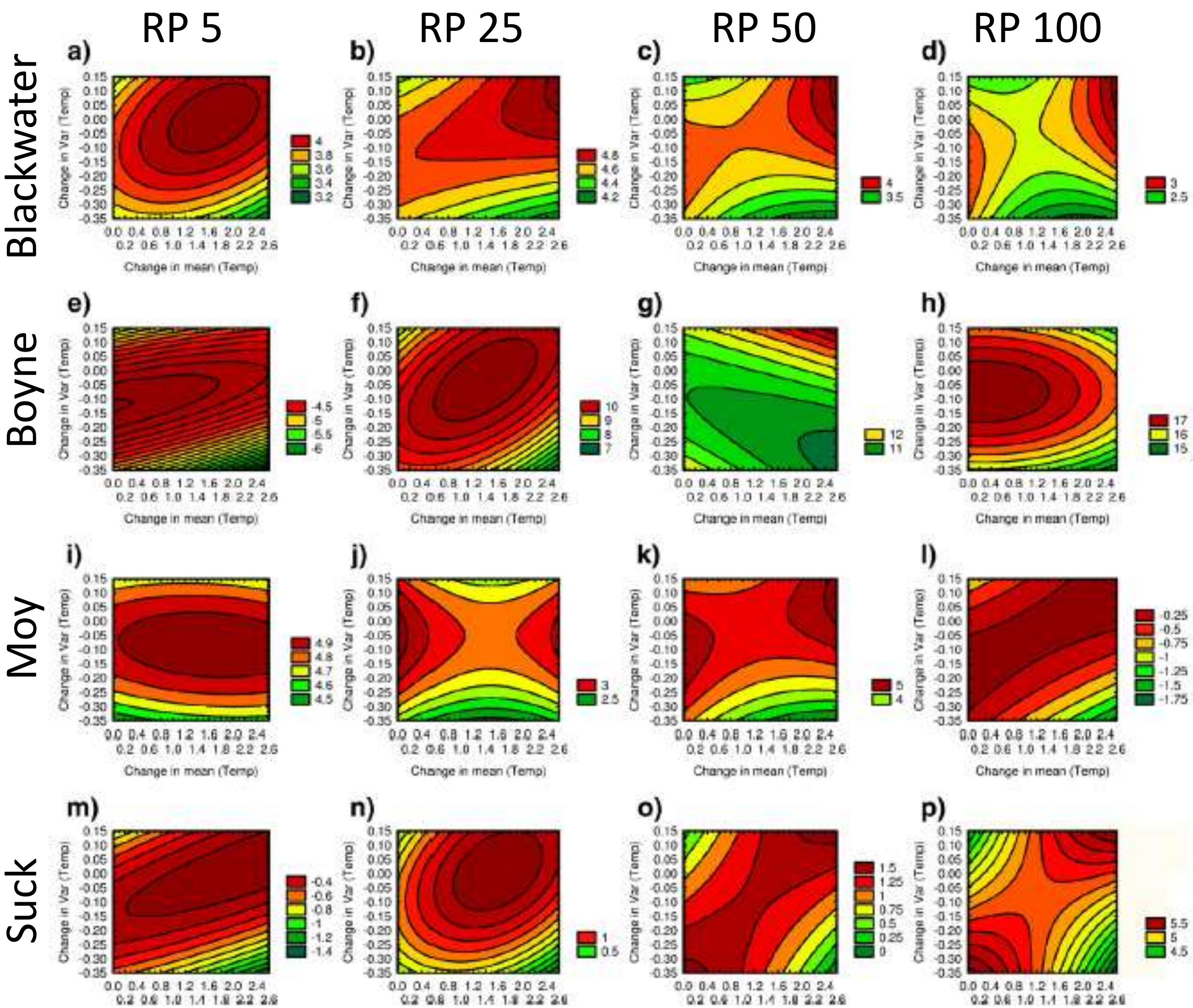


Sensitivity to precipitation

Scenarios: change factor method

Bastola et al., 2011, doi: 10.1016/jscitotenc.2011.08.042

Flood peak sensitivity - Ireland

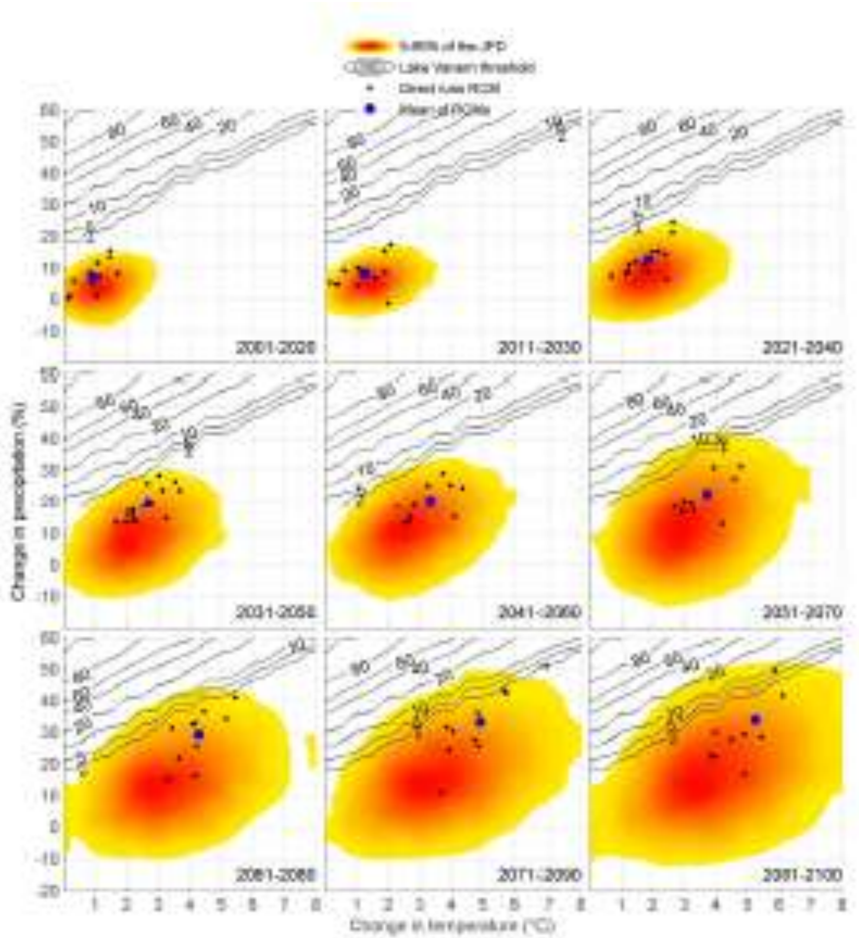


Sensitivity to temperature (through PET)

Scenarios: change factor method

Bastola et al., 2011, doi: 10.1016/jscitotenc.2011.08.042

Lake outflow - Sweden



Response surface of probability of exceedence of critical threshold (here 100 consecutive days with lake outflow >= 1000 m3/s)

Lake Vanern, Sweden

Scenarios: change factor method

Wetterhall et al., 2011, NHESS, doi: 10.5195/nhess-11-2295-2011

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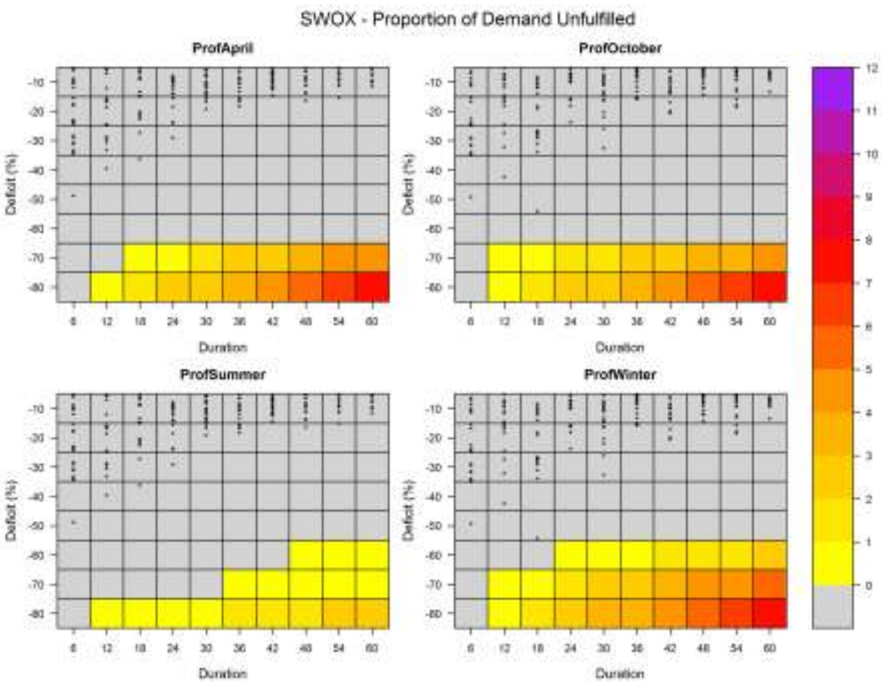
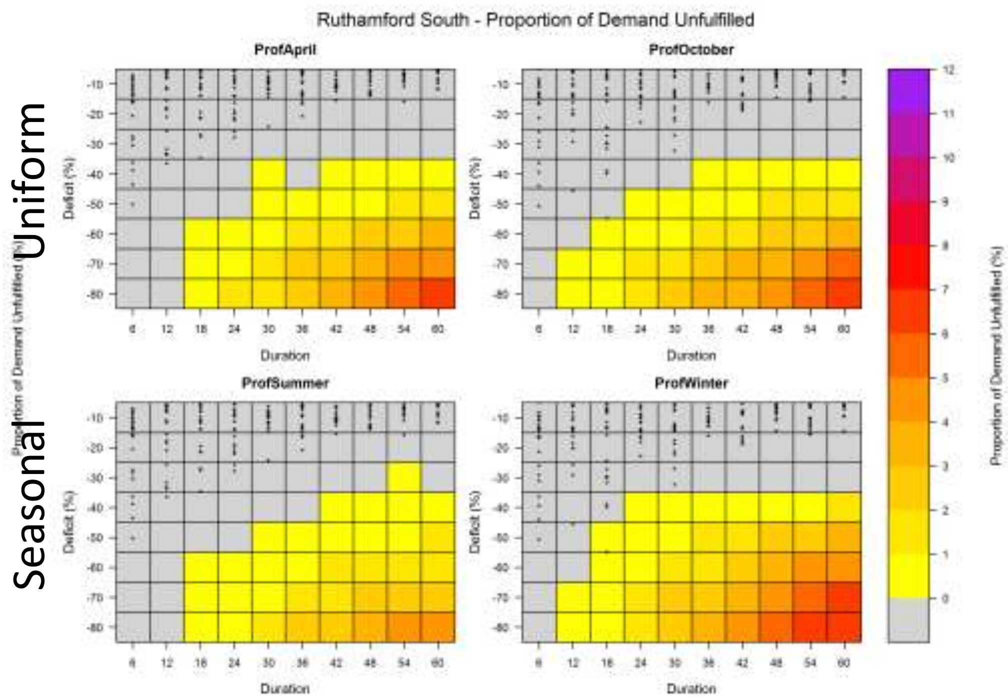
Water supply - UK

Proportion of demand unfulfilled under extreme droughts

Sensitivity to drought intensity (y-axis) and duration (x-axis)

Scenarios: resampling from historical period





Spring start | Autumn start | Spring start | Autumn start

Ledbetter et al., SC120048 project board, 2014, London

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Stochastic scenarios for sensitivity testing

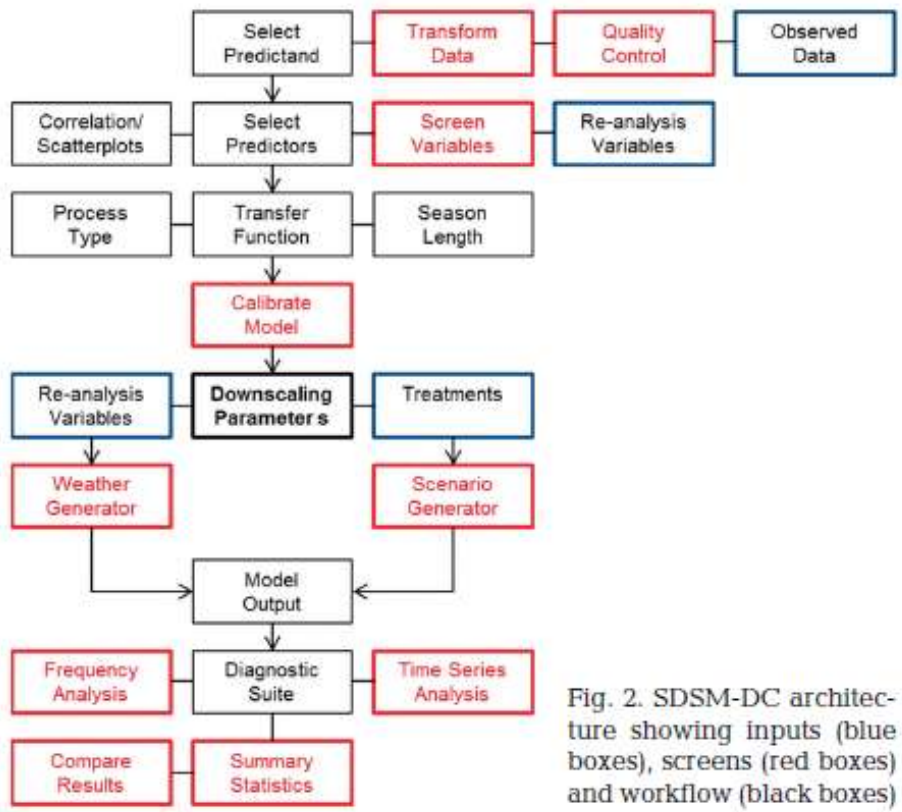
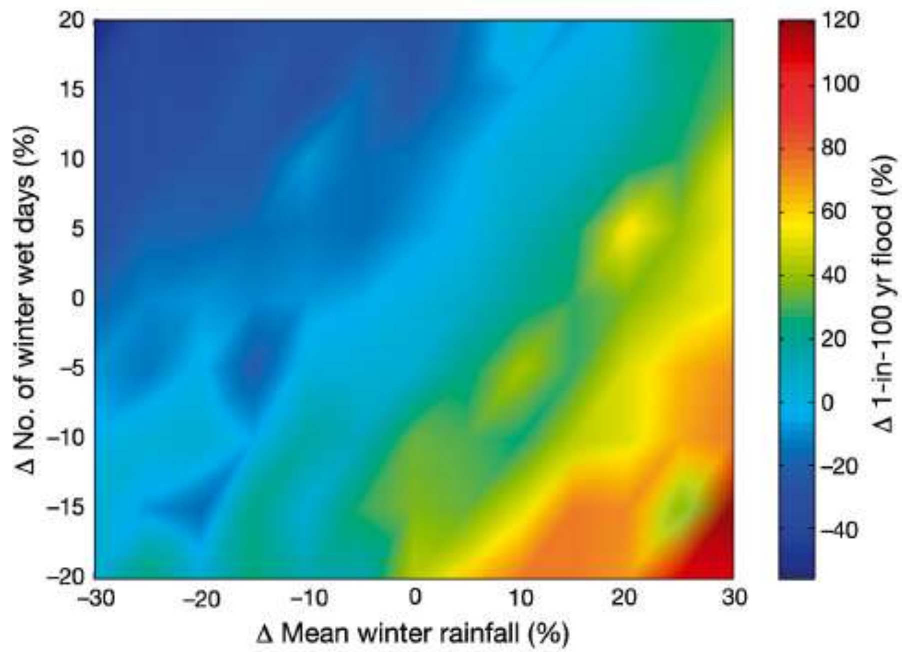


Fig. 2. SDSM-DC architecture showing inputs (blue boxes), screens (red boxes) and workflow (black boxes)

Scenarios: stochastic rainfall generator

Statistical Downscaling Model – Decision Metric SDSM-DC tool



Response surface of the sensitivity of percent changes in magnitude of winter 1-in 100 yr flood to changes in mean winter rainfall and occurrence of winter wet days

Wilby et al., 2014, Climate Research, doi: 10.3354/cr01254

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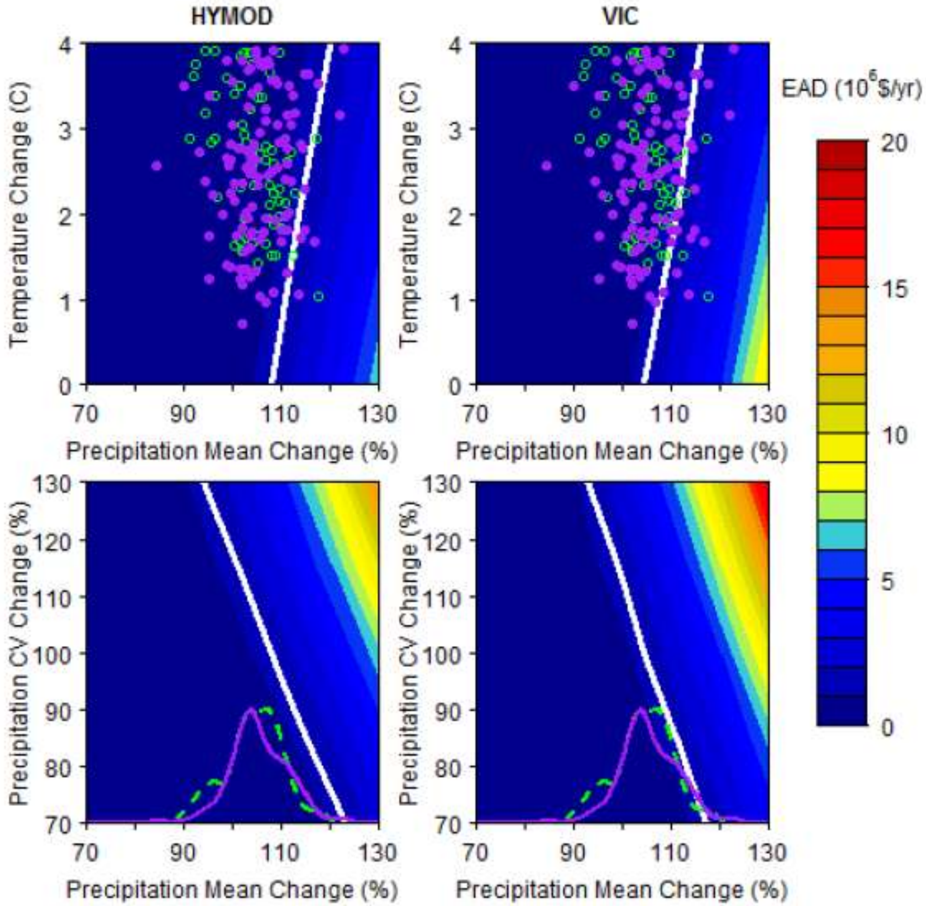
Flood-related economic damage - USA



Climate response surfaces of expected annual damage (million $/year)

White contour: baseline damage under no change

CMIP3 (green) and CMIP5 (purple)

Comparison of different sensitivity framework
➔ Greater sensitivity to precipitation than temperature

Steinschneider, HP, 2014, doi:10.1002/hyp.10409

Conclusions - uncertainty

Understand uncertainty

- Main uncertainties depend on variable, location and time horizon
- Impact model uncertainty can be large
- Use smart resampling of climate uncertainty to reduce ensemble size

Communicate uncertainty

- Weaknesses in modelling chain: e.g. Short intense storms
- Likelihood to exceed critical threshold

Conclusions – robust decision making

Scenario-neutral approach

- Sensitivity to system easy to communicate
- Can be combined with sophisticated climate downscaling methods
- Applicable to wide-ranging climate-dependant systems
- Robust to projection ‘time-life’ including GCM versions and time horizon of interest
- Enable rapid risk assessment refresh

Thanks

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