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Climate Change
Economics and Policy

Grantham Research Institute on
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the Environment

Revisiting the Generation and Interpretation of Climate Information for Adaptation Decision Making

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Introduction

- Many countries are making significant investments in climate information for adaptation; *e.g. UK:*
  - £7 million over 2009-2010 to develop evidence base for adaptation.
  - £11 million to produce probabilistic climate projections for the UK (UK Climate Projections 2009).
- Key question: **what types of climate information are useful for adaptation decision making…**
- Contents:
  1. <u>Limitations:</u> challenges in using current climate projections for adaptation planning
  2. <u>Need</u>: what types of climate information are needed? Sector-by-sector approach

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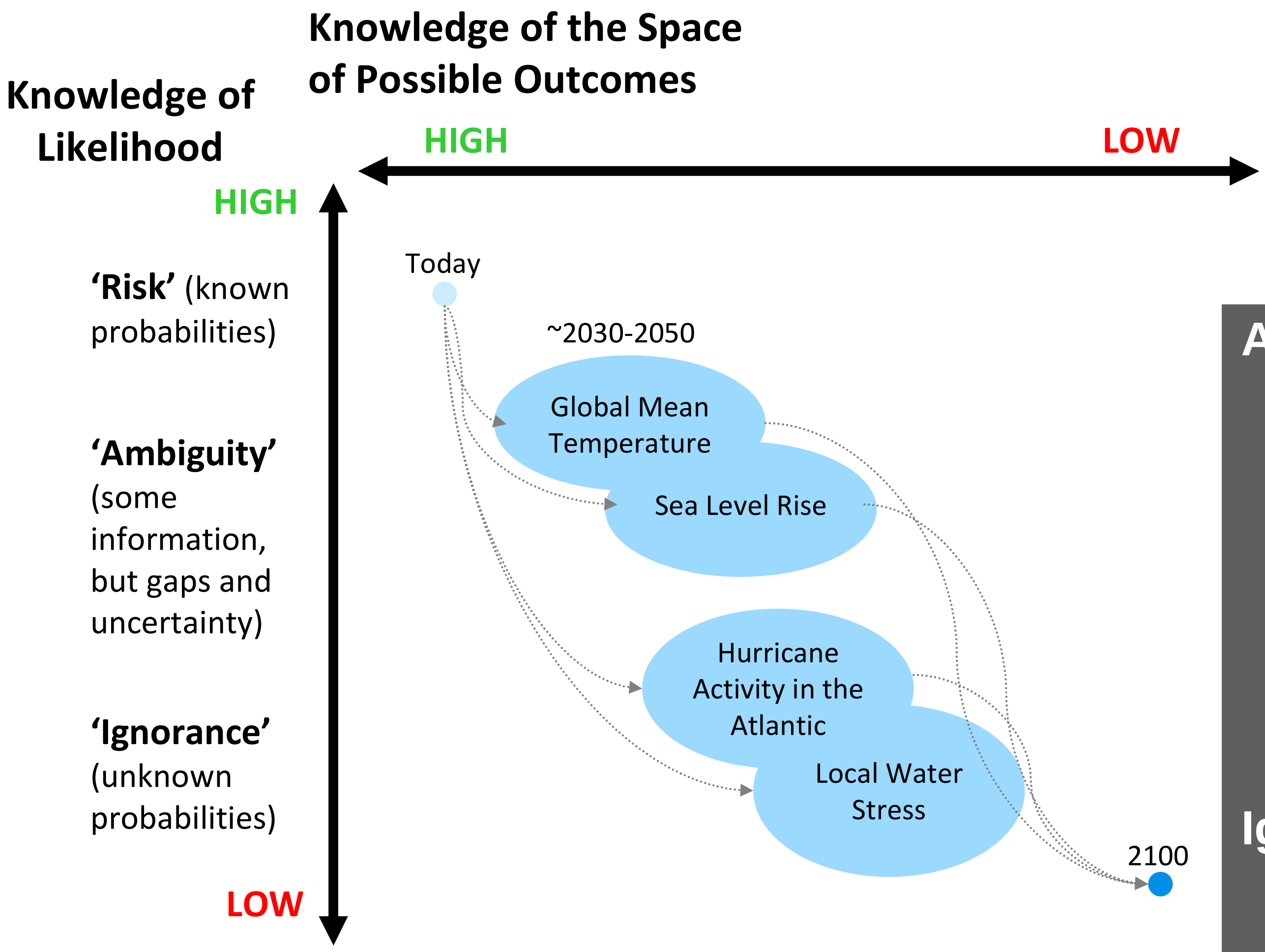
Adaptation: a unique problem for decision makers?

- Adaptation defined as *"a series of adjustments, measures or policies, to reduce the vulnerability or enhance the resilience of a system to observed or expected climate change"* (IPCC, 2007)
- Some adaptation reactive, but the greatest benefits will come from <u>anticipatory</u> adaptation. Requires planning and <u>foresight.</u>
- Adaptation will require making decisions under conditions of changing risk. **Decision making must shift from a backward looking paradigm to one based on forecasting current and future levels of risk.**
- Important challenge of anticipatory adaptation: **<u>it is impossible to predict with certainty the future conditions</u> (both the climate and its impacts) we need to adapt to.**
- **Uncertainty itself it not necessarily a problem, as long as it is well-defined.**
- **For <u>climate change the uncertainty is such that the science is not yet able to provide a unique set (e.g. model independent) of probabilities of different outcomes</u> and therefore, require decision making under <u>deep uncertainty</u>**

A climate of deep uncertainty



Ambiguity: incomplete information about the likelihood of different outcomes or multiple conflicting estimates (residual uncertainties).

Ignorance: no information about likelihood of different outcomes

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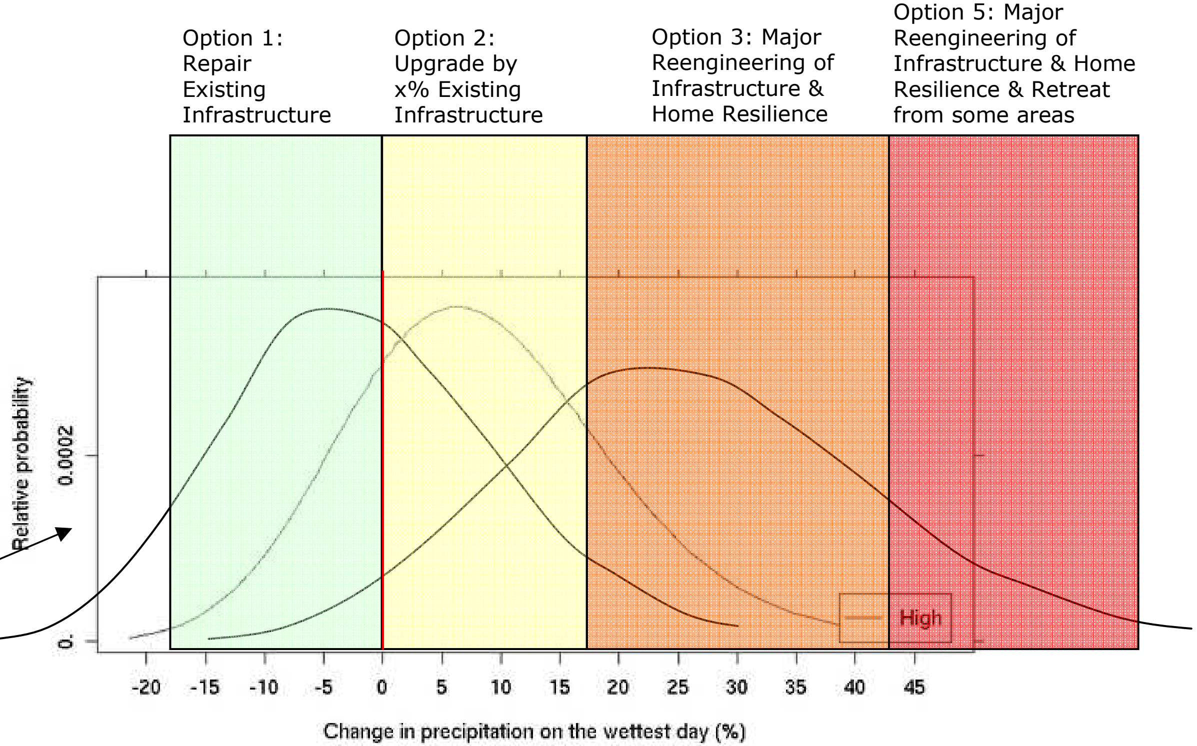
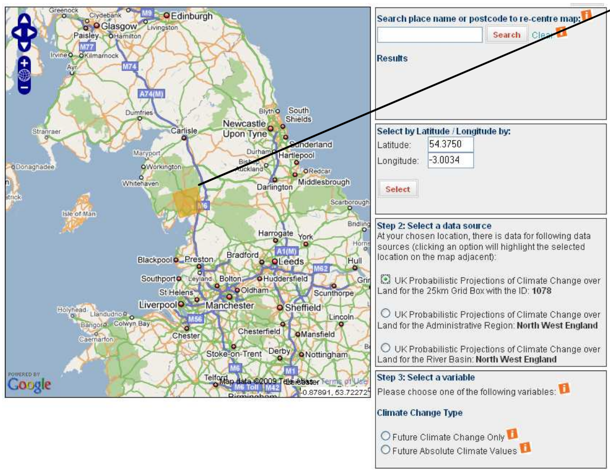
Sensitivity of Adaptation to Climate PDFs

"Improper consideration of residual uncertainties of probabilistic climate information (which is always incomplete and conditional) in optimisation exercises could lead to mal-adaptation and be far from optimal" Dessai et al. 2009 based on Hall 2007

For illustration only…





Traditional Approach: Apply Expected Utility Analysis to Optimise the Costs versus Benefits of Action under Known Uncertainty

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What climate information is needed?

- It is important that we continue to develop the science and modelling to better constrain uncertainties and generate more robust probabilistic projections
- However, this research is unlikely to yield significant improvements in our long-term prediction capability on the timescales that many adaptation decisions need to be made – there will continue to be residual uncertainties
- But, it is not necessarily the case that adaptation requires robust probabilistic projections… (e.g. work of Lempert, Dessai etc)
- In many cases, it is possible to make good adaptation decisions with the climate information available today, but I argue that:
    1. the utility of existing climate information and modelling could be increased to inform near-term adaptation decision making
    2. we need a new stream of climate research/expert advice to fulfil the urgent information requirements for adaptation
- *N.b. In many cases, improvements in other types of non-climatic information can be of equal or greater value to decision making.*

What climate information is needed?

- Need to look at a broad range of adaptation decisions and identify what types of climate information would have the **highest value.**
  - Highest value information is the information that the decision is most sensitive to.
  - This is determined by the interplay of:
    - The rate and level of change in climate (particularly extremes)
    - Other risk drivers (e.g. growth in demand or land use change)
    - Level/type of uncertainty in each of the above
    - The system itself – particularly critical thresholds
    - The characteristics of the adaptation options available, in particular their lead times, lifetime, flexibility and irreversibility
- What is high value is specific to the adaptation decision
- Here, look for any general rules about what generic types of climate information is high value.
- High level review of four sectors (UK-based): food, flooding, water, ecosystems

Implications for climate information needs

- Information on past and current climate variability, particularly extremes
  - The most valuable information in a decision will come through understanding the vulnerability of the system to present-day climate, as well as non-climate stressors and shocks.
  - This is important for planning many types of no-regrets adaptation measures: e.g. better managing current climate variability and short-lived adaptation measures
- Evaluation of current risk (the roles of natural and forced changes)
- Monitoring of decision-relevant quantities to ensure early detection of trends and to trigger response strategies
- Knowledge of long-term climatic changes is most valuable where the risk of maladaptation is significant:
  1. decisions are sensitive to different plausible climate futures;
  2. the timescale of adaptation measures is long (e.g. >5 – 10 years); and
  3. decisions have high sunk-costs (i.e. irreversibility)

  (e.g. public infrastructure and sector-level planning).

‘High-regrets’: Flexibility vs. Optimality

- For potential ‘high-regrets’ projects, one approach to reducing the chance of maladaptation is to make a decision more robust to climate change uncertainties; through:
    - **Use measures that are suitable over a range of climates**
    - **Build in an option to adjust the adaptation measure if required**
    - **Build flexibility into the decision process itself by incorporating sequencing, waiting and learning over time** (take no-regrets options now and wait for more information before taking more inflexible options)
- Strategies that reduce flexibility can limit robustness
- But there are trade-offs: building in flexibility can often incur a additional cost or productivity trade-off
- Decision methods provide a framework to assess trade-offs.

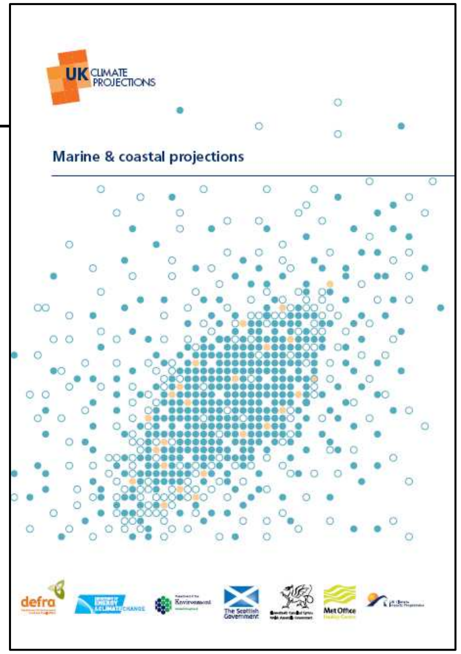
Robust and relevant projections for adaptation

- In making any assessment, it is crucial to first **assess the robustness and relevance of climate model projections in the context of the decision problem**. Climate modellers and climate science is crucial in this respect.
- Projections used for decision making must be ‘fit-for-purpose’:
  - Robust: unlikely to change over time in ways that will affect the decision
  - Relevant: its basis includes all the relevant processes at appropriate scales that are needed to represent changes that the decision is sensitive to (e.g. high resolution cloud physics or appropriate topography)

Robust and relevant projections for adaptation

- If not ‘fit-for-purpose’, ‘best-guess’ projections and ‘likely ranges’ are useful but there is a need to **explicitly recognise the residual uncertainties** in estimates (preferably quantitatively) and their implications for adaptation decisions.
    - Build an understanding of the **range of plausible outcomes** (e.g. based on the physics) and provide decision-relevant **scenarios that span the range of plausible outcomes**
    - Provide **information on if/how projections are likely to change over time with learning**. Including, estimated timescales on which uncertainties can be better captured or narrowed
    - Identifying key indicators of the pathway of change and their relevant timescales
- **Climate science (as well as modelling) is important in this respect;** only by understanding the underlying processes can we understand the relevance of models and other data and build scenarios that capture the full range of plausible outcomes.

Example: UKCP09 Marine Report

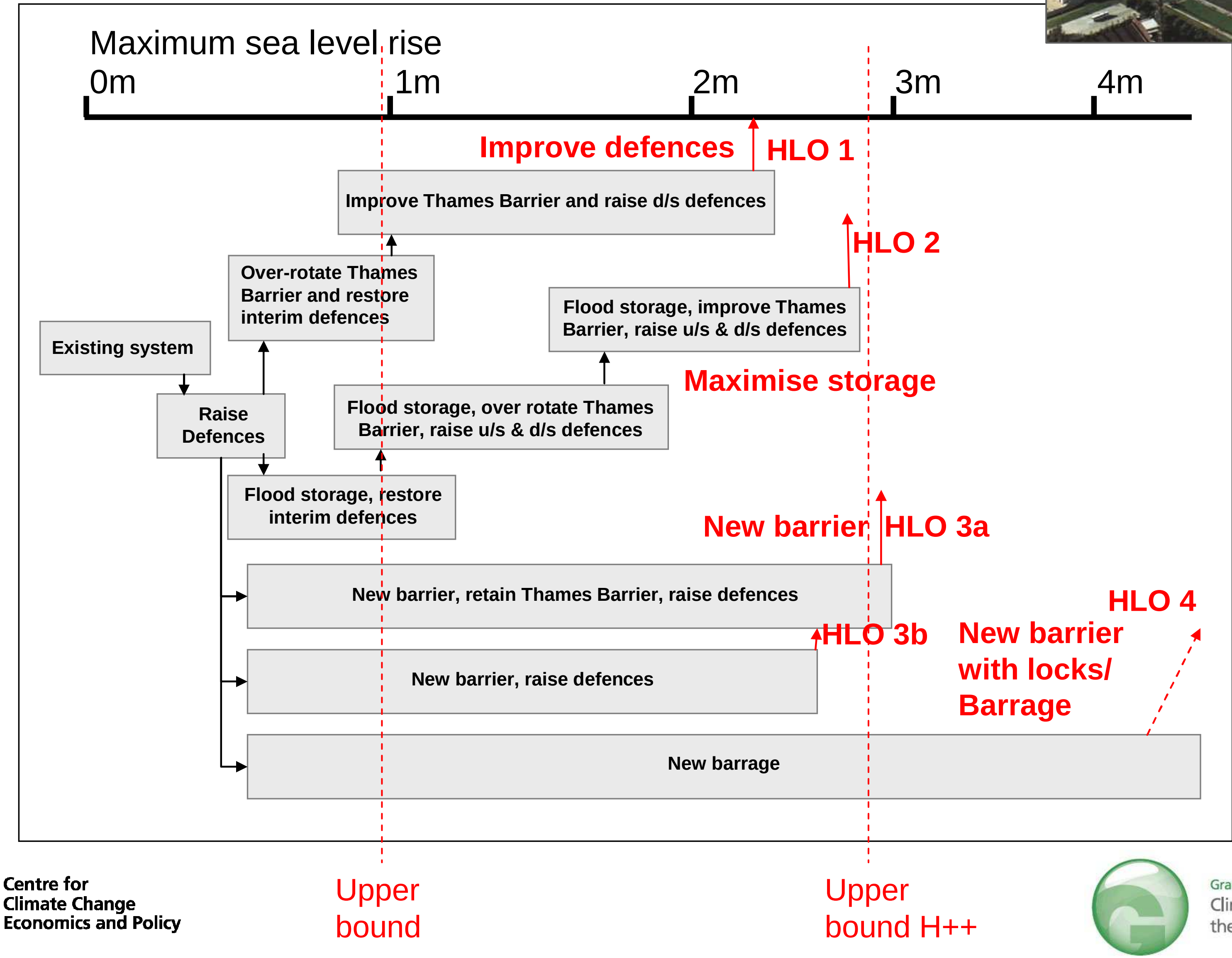


UKCP09 Coastal and Marine Projections Report:

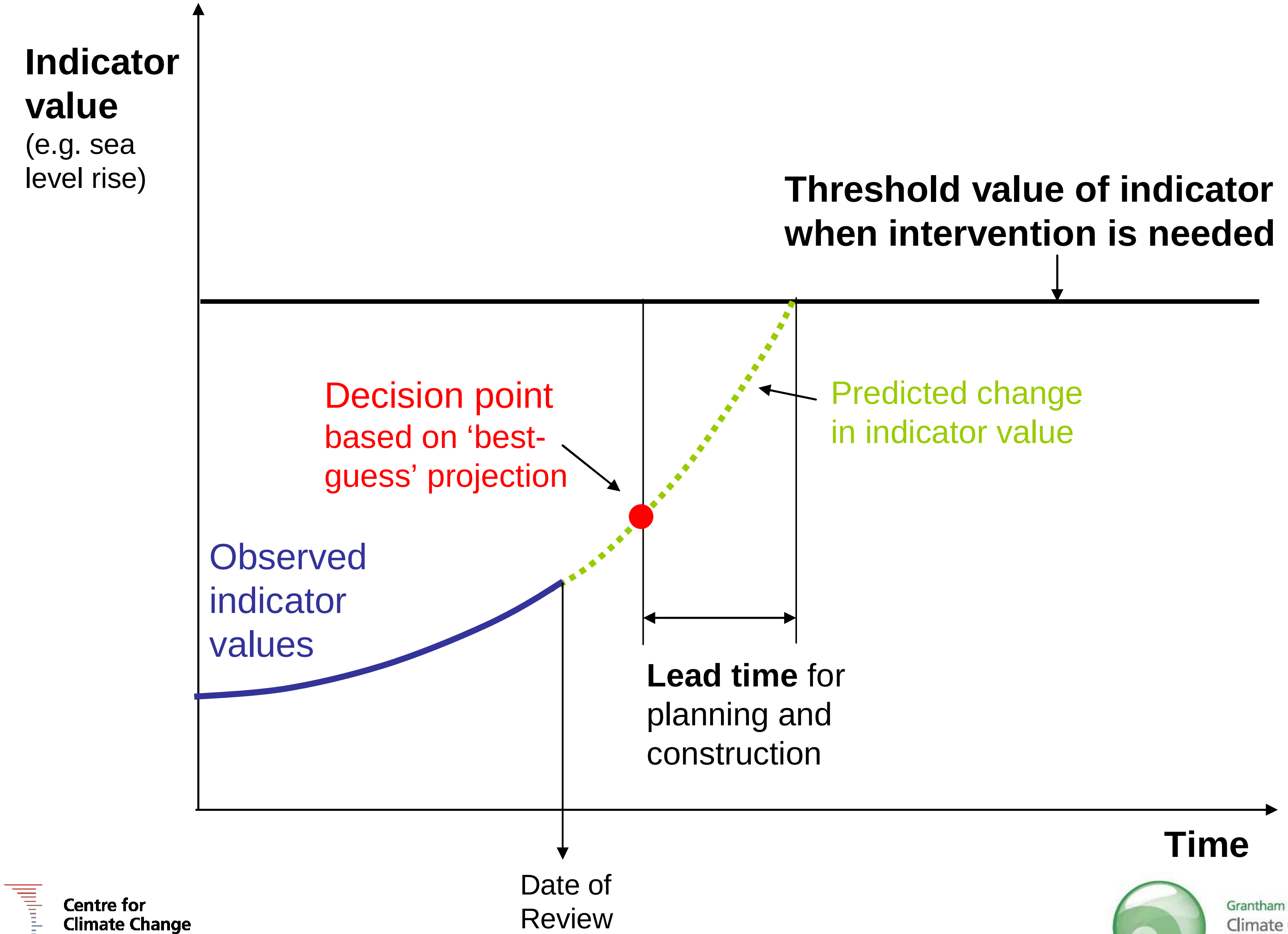
"In the marine scenarios we do not attempt to quantify a probability of future changes. We make cruder estimates of the minimum uncertainty range (together with some discussion of a low probability, high impact scenario range) where possible".

"We choose to do this for several reasons. First, knowledge gaps in our understanding of marine processes … mean that current models may not simulate the full range of possible futures. Second, even where we might estimate the range of possible futures there is an insufficient number of model simulations … to credibly fill in the range between the projected highest and lowest values. Finally, insufficient work has been carried out in the maritime community on suitable observational constraints for projections of global and local marine and coastal climate change"

Example: the Thames 2100 Project



Example: the Thames 2100 Project



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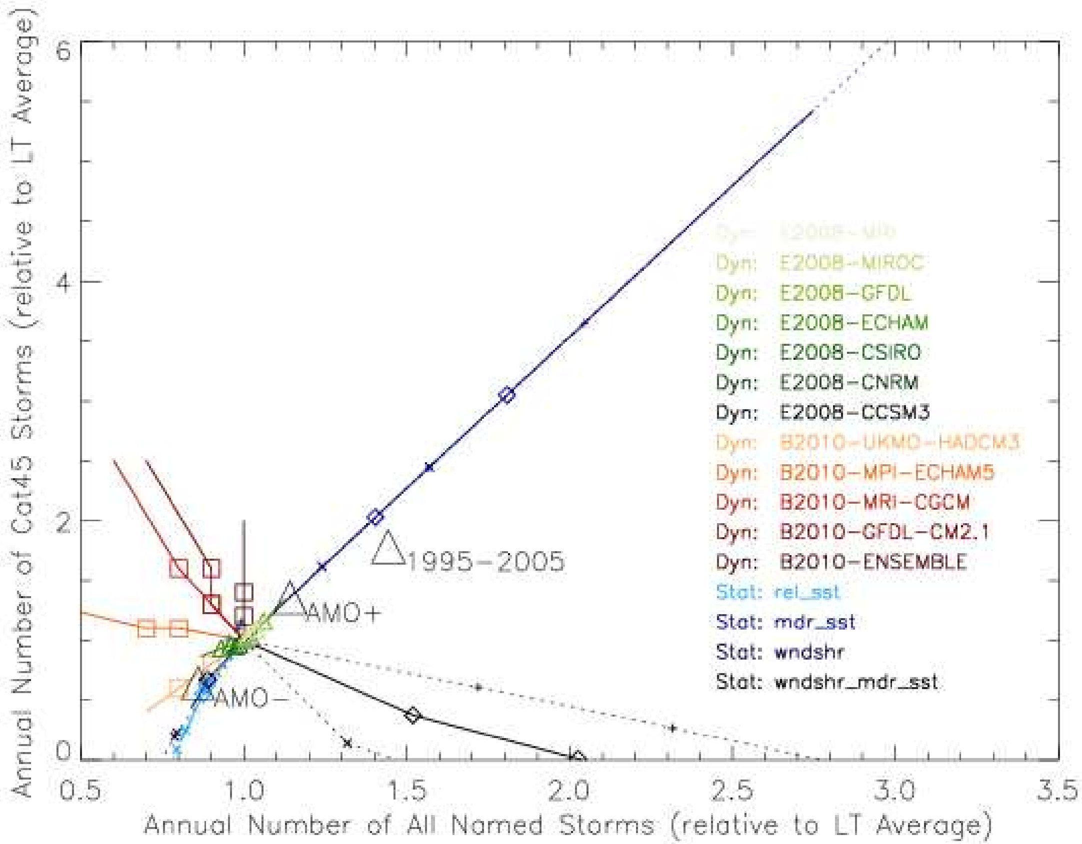
Next steps

- Application of lessons learnt to generating decision-relevant scenarios to inform long-term irreversible adaptation decisions for hurricane wind risk in the South East US



Summary

- Continued research to better constrain uncertainties and provide robust projections is important for building our long-term adaptive capacity
- However, adaptation need not and can not wait for this research to be completed; in many cases, it is possible to make good near-term decisions with the climate information available today.
- In terms of improving near-term decision making, the highest value investments are likely to come through:
  - Improving understanding of current climate variability and risk
  - Supplementing existing climate projections with information to aid in their robust interpretation for decision making; including:
    - Improved communication/representation of residual uncertainties
    - Understanding the range of plausible future outcomes on different timescales and developing scenarios to explore this space
    - Providing information on if/how projections are likely to change with learning
    - Improving monitoring of key decision-relevant indicator variables

Further Information

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EXTRA SLIDES

Case Study 1: UK Food Sector

- **Main near-term drivers** of risk/opportunity:
  - Local and global **climate variability**: extremes, precipitation, temperature (direct/indirect effects)
  - Local and global **non-climate drivers and shocks**: changing patterns of production and demand, shocks (pests & diseases or global price shocks)
- **Long-term drivers** of risk/opportunity (more than 10 years): as above, plus:
  - **Local and global climate change**: gradual changes in CO_2, temperatures and precipitation (particularly extremes; indirect and direct effects)
  - **Economic and social change and shocks**; changing production and demand
- **Adaptation Options:**
  - **Effective short-term reactive and/or anticipatory measures**: changing crop varieties, planting times, relocating or expanding production, pest management
  - **Longer term technology-based approaches, either short lead-time or low-regrets:** research into new crop varieties, biotechnology and irrigation systems.
  - **Some more ‘sensitive’ long-term decisions:** planned expansion of production to increase food security or broad-scale irrigation infrastructure

Case Study 2: flood management

- **Main near-term drivers** of risk/opportunity:
  - **Local weather and climate variability (shocks)**
  - **Local land-use change**
  - **Coastal: sea level rise and coastal erosion in some areas**
- **Long-term drivers** of risk/opportunity (more than 10 years):
  - **Local land use change**
  - **Climate change and variability**
- **Adaptation Options:**
  - **The most effective proven measures tend to be long-lived anticipatory measures**: hard infrastructure (flood defences, storage, resistant buildings etc)
  - **& reducing other risk drivers:** land-use planning/building codes.
  - Also available are shorter-lived 'soft' adaptation options (but more uncertain benefits) with co-benefits: natural ecosystem-based flood management
  - No-regrets measures to enhance resilience: risk information, early warning
  - Many no-regrets reactive measures (tend to be less effective): emergency response, evacuation planning and temporary resistance measures (sand bags)

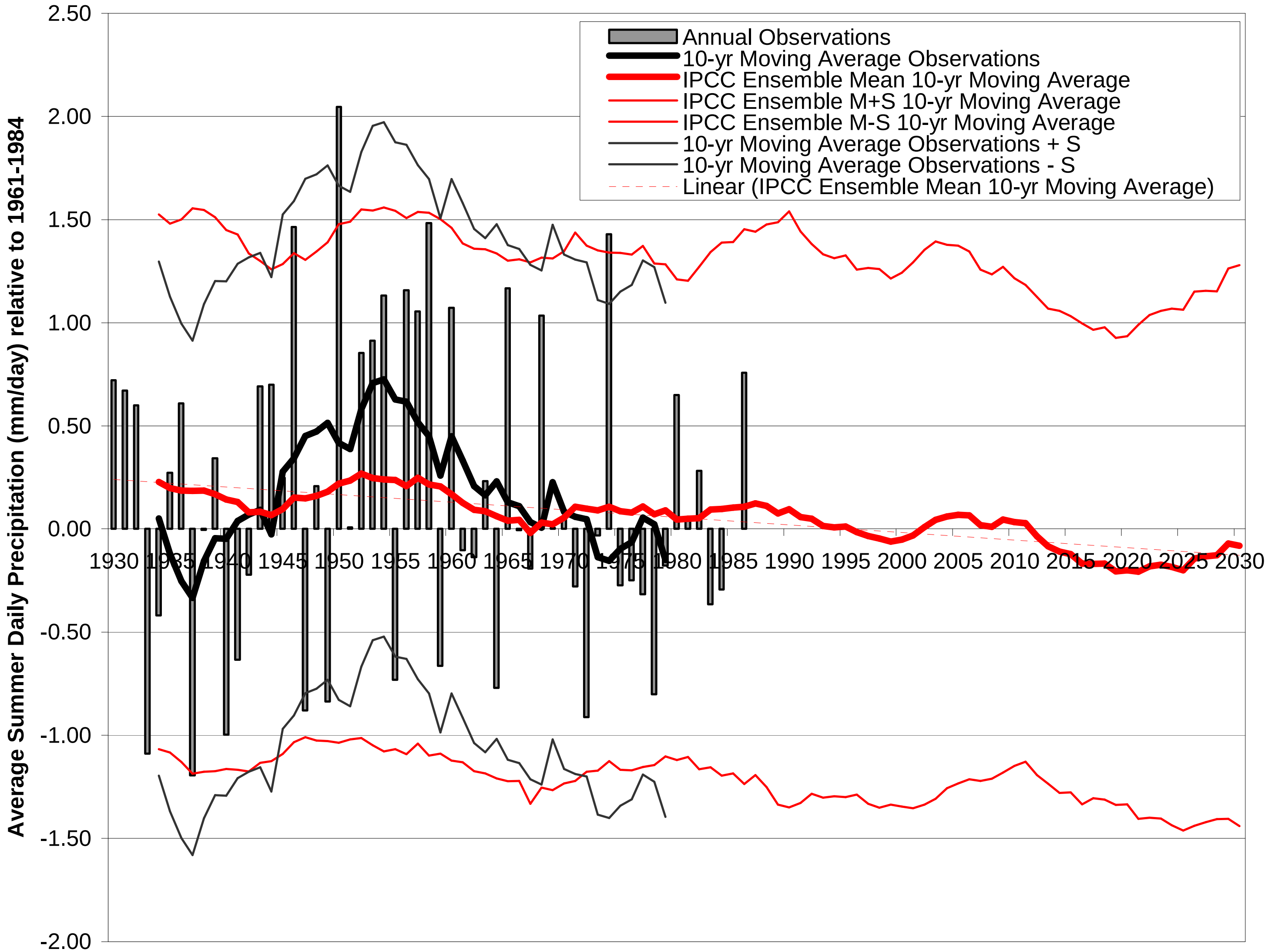
Sector Summary

Ecosystems	Water Sector
Near-term risks: land-use change, shocks (e.g. extreme weather, pests & diseases), environmental degradation & climate change Long-term risks: as above Adaptation: e.g. conservation of existing habitats, managing other risk drivers, ecological networks	Near-term risks: increasing demand, shocks (e.g. extreme weather) Long-term risks: increasing demand, climate change Adaptation: various demand-side and supply-side measures; the later includes many hard infrastructure options
Food Sector	**Flood Risk Management**
Near-term risks: changing demand, shocks (e.g. extreme weather, pests & diseases). Long-term risks: Economic and social change/shocks and climate change Adaptation: many short-lived adaptation options and some longer-term but relatively flexible options (e.g. biotechnology)	Near-term risks: land-use change, climate variability (extreme weather) Long-term risks: climate change & land-use change Adaptation: options to manage other risk drivers (land-use) and hard infrastructure (flood defences). Some softer options.

Learning from sector analysis

- **In many cases a range of 'no-regrets' options are available**;
  - Measures to better cope with current climate variability
  - Measures to manage non-climate drivers of risk
  - Short-lived adaptations (i.e. less than timescale of climatic change)
  - Measures to reduce systemic vulnerability or resilience to shocks
  - Some measures with strong co-benefits
- **There are relatively few potentially 'high-regrets' decisions/options** where benefit depend strongly on uncertain future climates
  - Typically limited to long-lived decisions with high sunk costs (e.g. infrastructure and buildings) [Flood and water sector]
  - **In many cases of long-lived decisions, such as public infrastructure projects, flexible options are available and can be shown to be desirable.**

Climate variability vs. climate change



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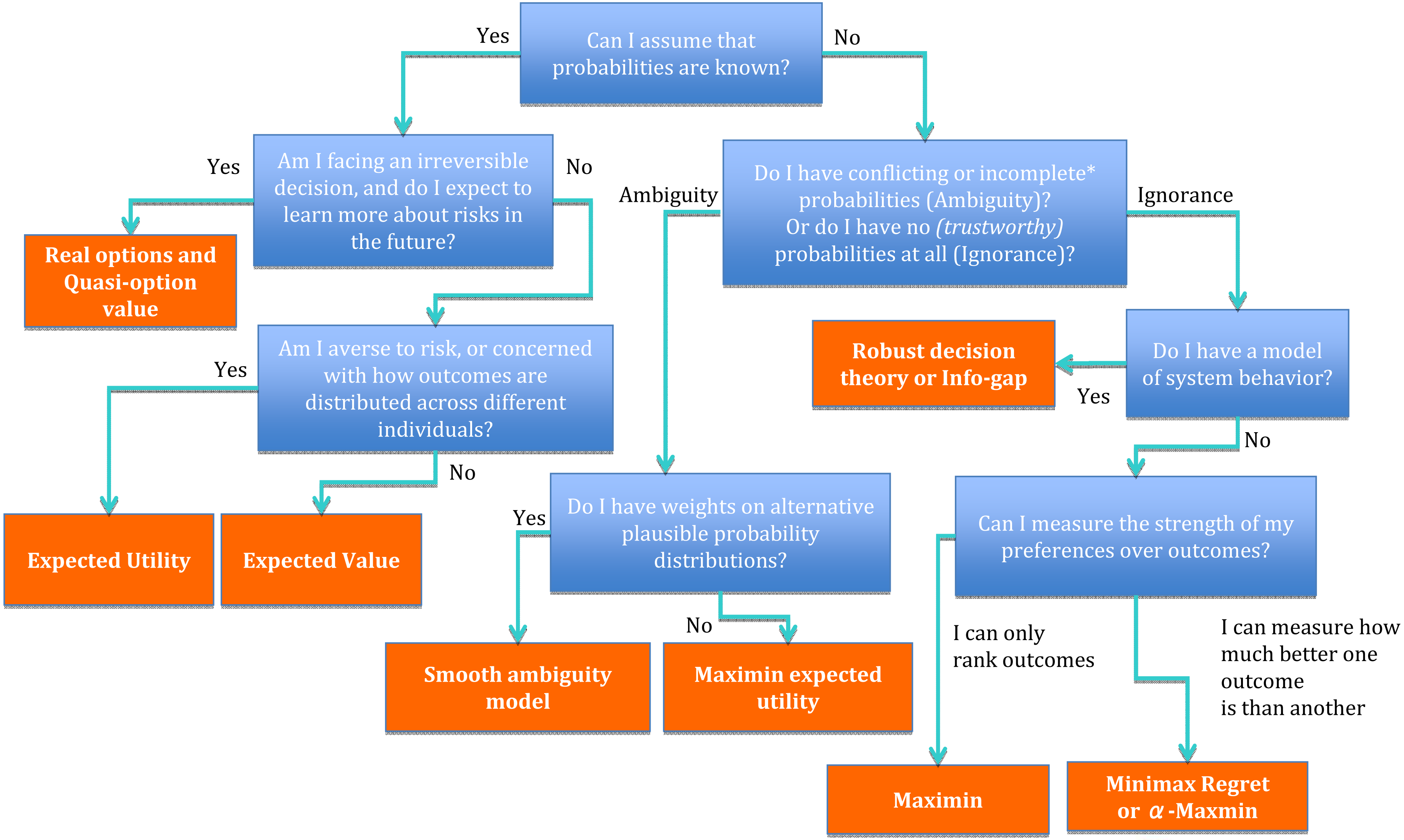
Decision methods and climate information



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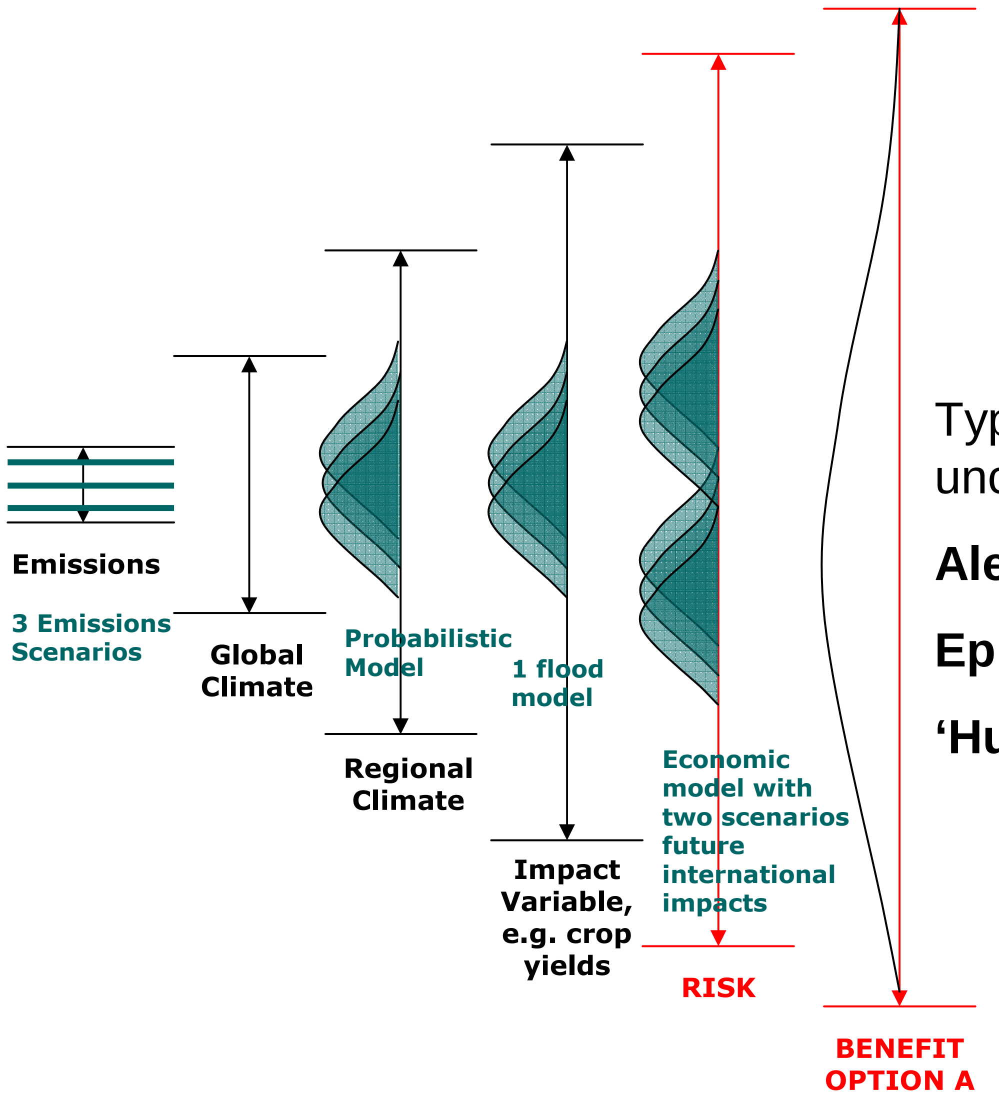
A climate of deep uncertainty

Why are projections so deeply uncertain?

Sources and types of uncertainty differ at each step and crucially, not all can be quantified with confidence
(Stainforth et al. 2007 and Dessai et al. 2009)



Types of uncertainty:

Aleatory

Epistemic

'Human'

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