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Introduction to climate change risk assessment

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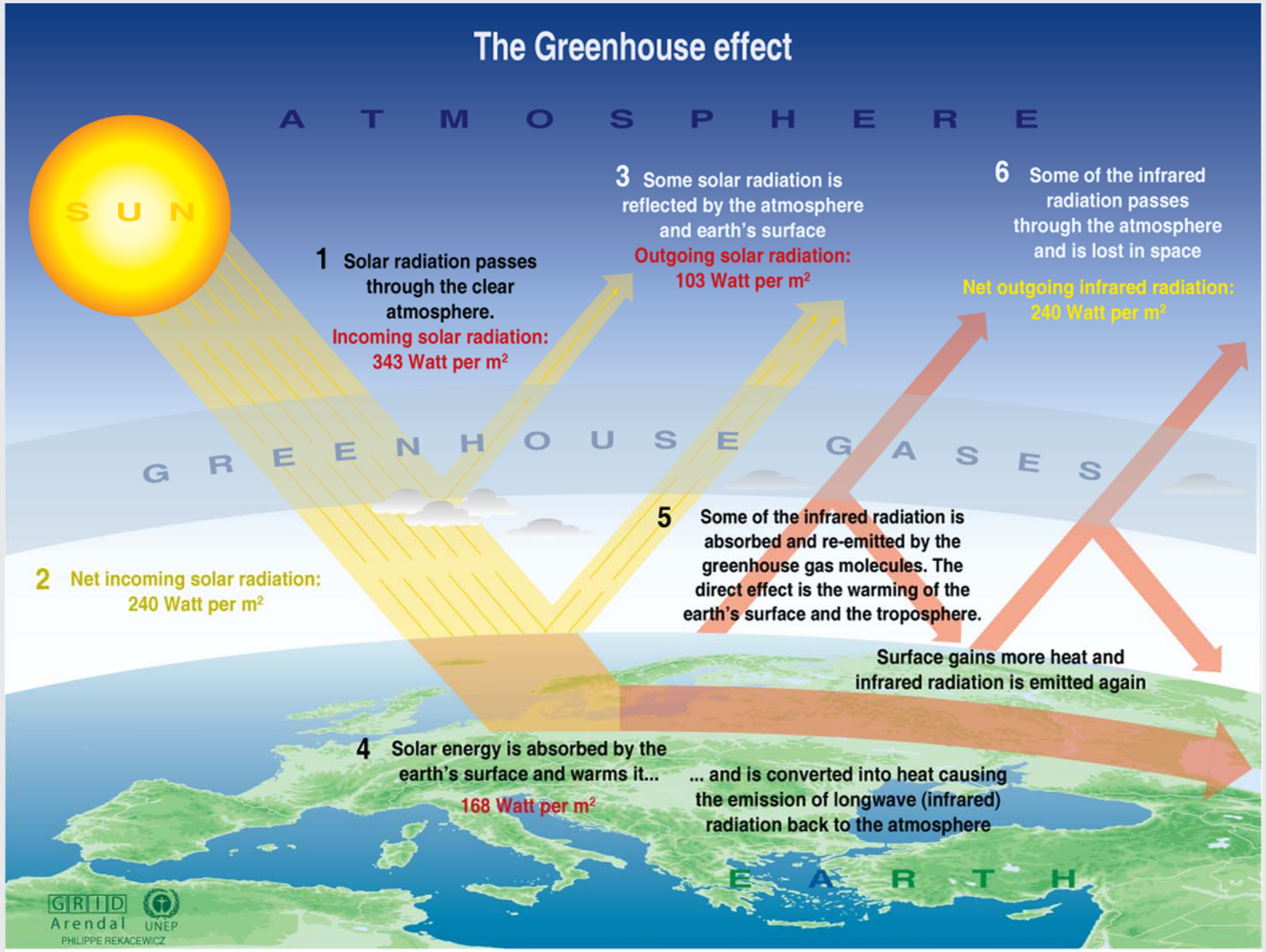
Outline

- Climate change background
- Climate change impacts in Mauritius
- Impacts, adaptation and vulnerability assessment methods
- Conclusions

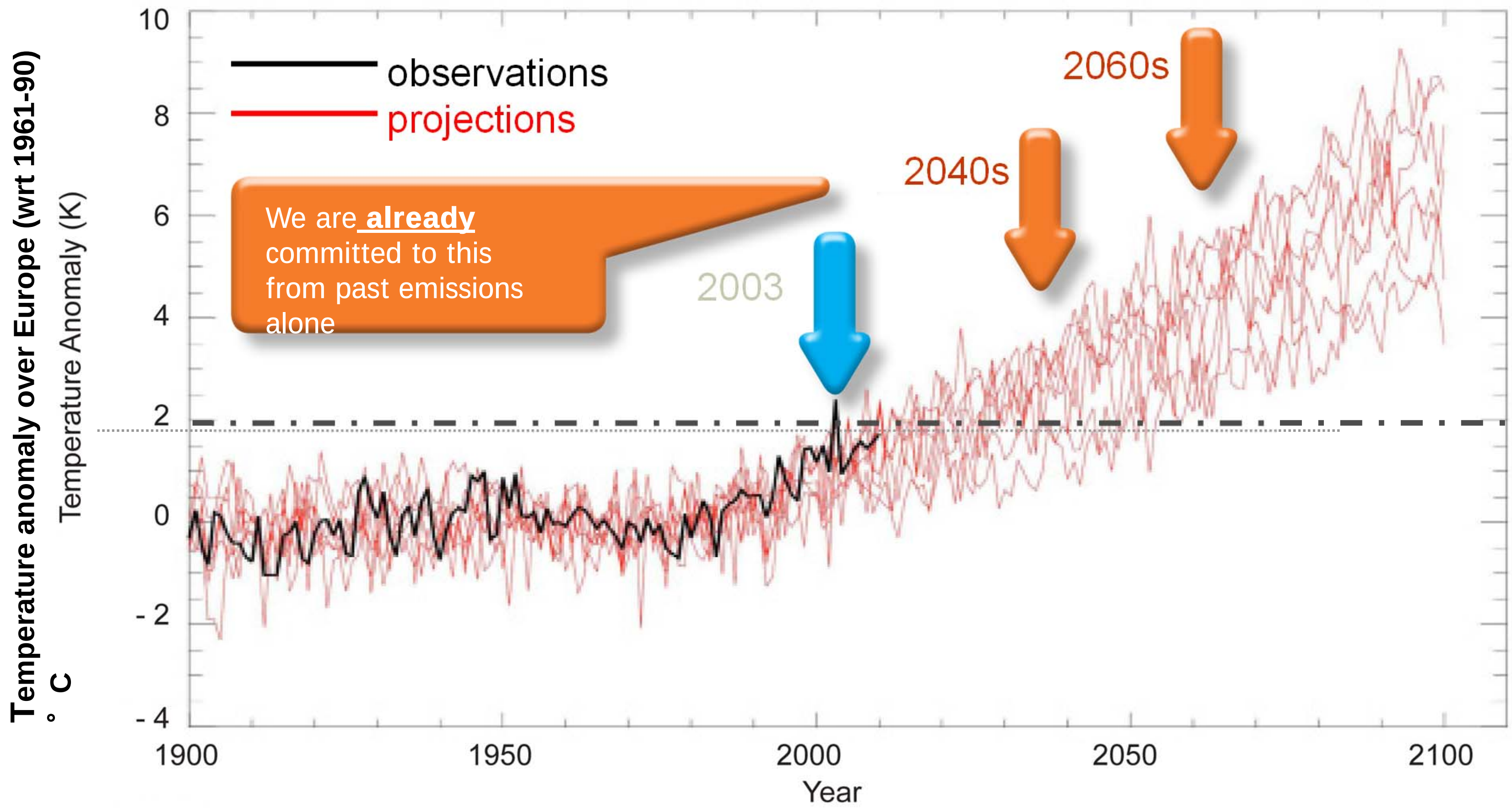
The greenhouse effect



Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.

http://maps.grida.no/go/graphic/greenhouse-effect

Mitigation is vital, but we need to prepare for inevitable climate change



Hadley Centre

Climate variability and change

Climate vs. weather

- > Climate describes long term (30-year) average conditions
- > Climate change assessments use baseline of 1961 to 1990
- > Weather is the daily variation in conditions

The Earth’s climate has changed in the past from “natural” causes e.g.

- > Variations in solar radiation (cycles, orbit …)
- > Atmospheric composition (volcanic activity)

Variability

Climate variability is large and complex

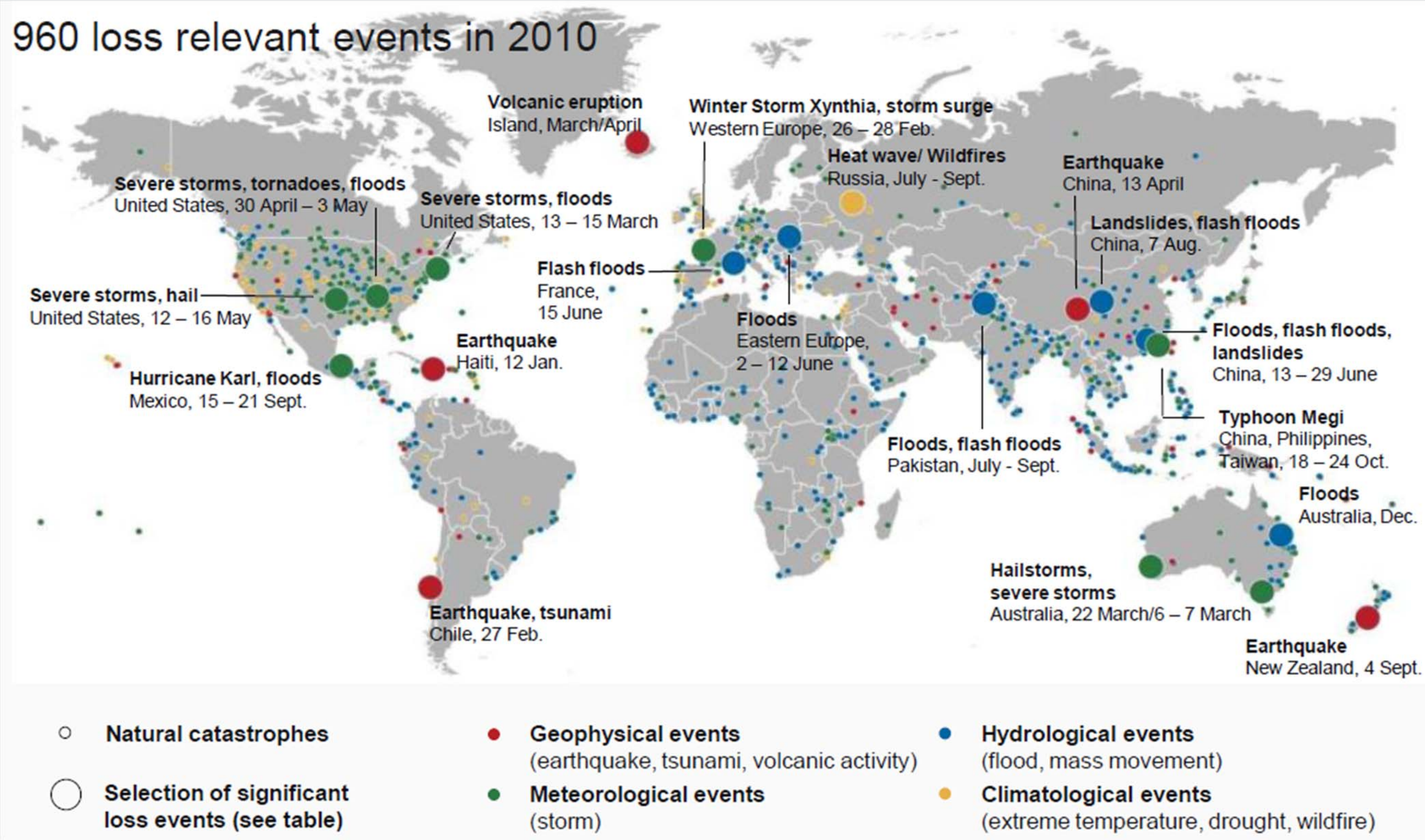
Detection

> There are clear trends in recent global temperature but less evidence for increased rainfall and river flows

Attribution

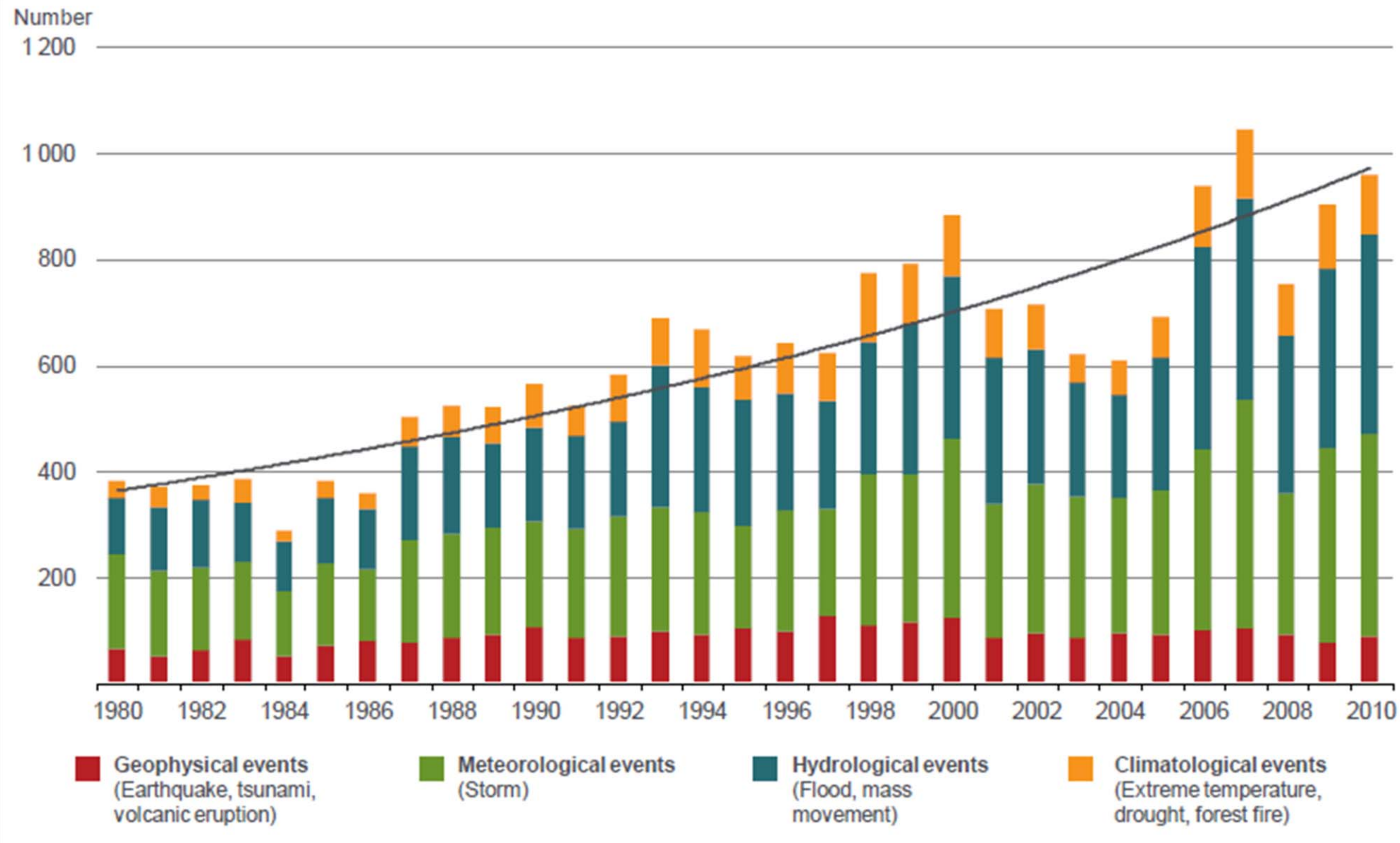
> We can not attribute individual extreme events to climate change but changing patterns of these events can be linked to warmer conditions (see IPCC SREX reports)

Natural catastrophes worldwide 2010



Natural catastrophes worldwide 1980 – 2010

Number of events with trend



The climate is changing

Scientific basis

> UN Inter-governmental Panel on Climate Change (IPCC)

> Peer-reviewed science

> Special report on emissions scenarios (SRES)

> 4^{th} Assessment Report 2007, 5^{th} AR in preparation

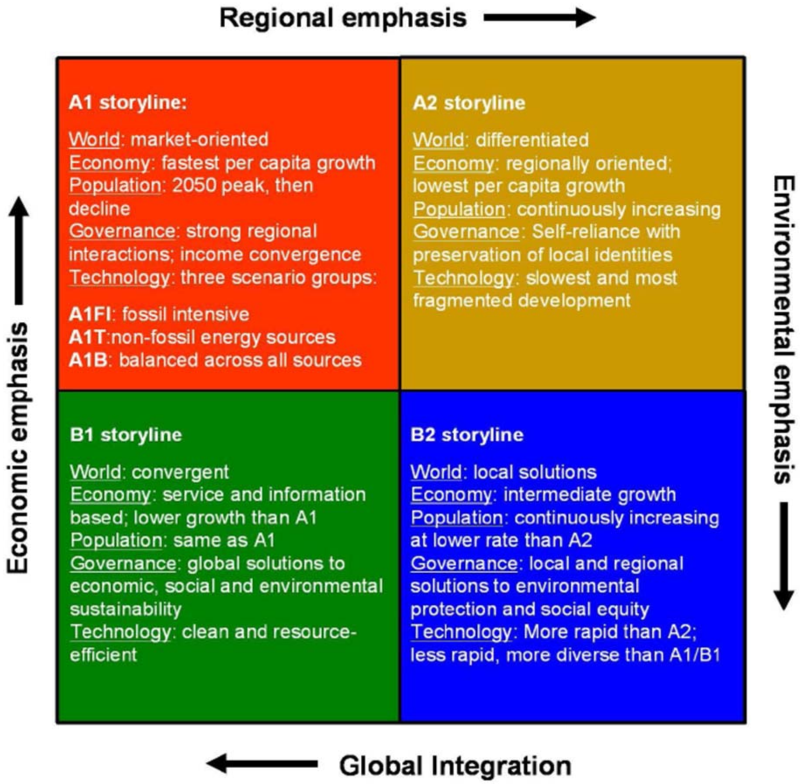
> IPCC WG2 Special Report on Extremes (SREX)

Political consensus

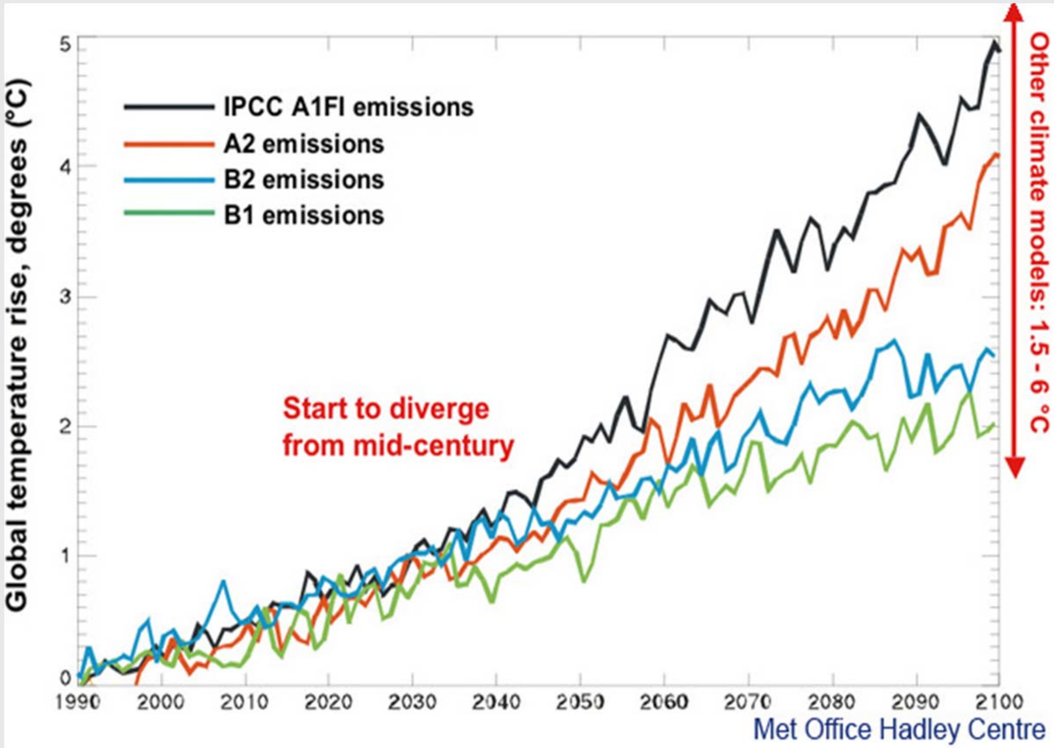
> UNFCCC, World Bank, African Development Bank ~promotion of climate change adaptation

> National commitments, e.g. UK Climate Change Act Mauritius climate change committee

Four SRES Climate scenarios: Summary characteristics



(Adapted from IPCC, 2007)



IPCC WG1 Summary (Feb 07)

Effect of human activity since 1750s has been one of warming

> very high confidence (9/10)

Increased rate of rise of global average sea level from C19th to C20th

> high confidence (8/10)

Atmospheric water vapour content over land and oceans has increased since 1980s, broadly consistent with the extra vapour warmer air can hold

Some projections: Table SPM-1

Trend for C21st SRES scenarios:

> Frequency / proportion of total rainfall in heavy precipitation events increases over most areas

- **Very likely (> 90%)**

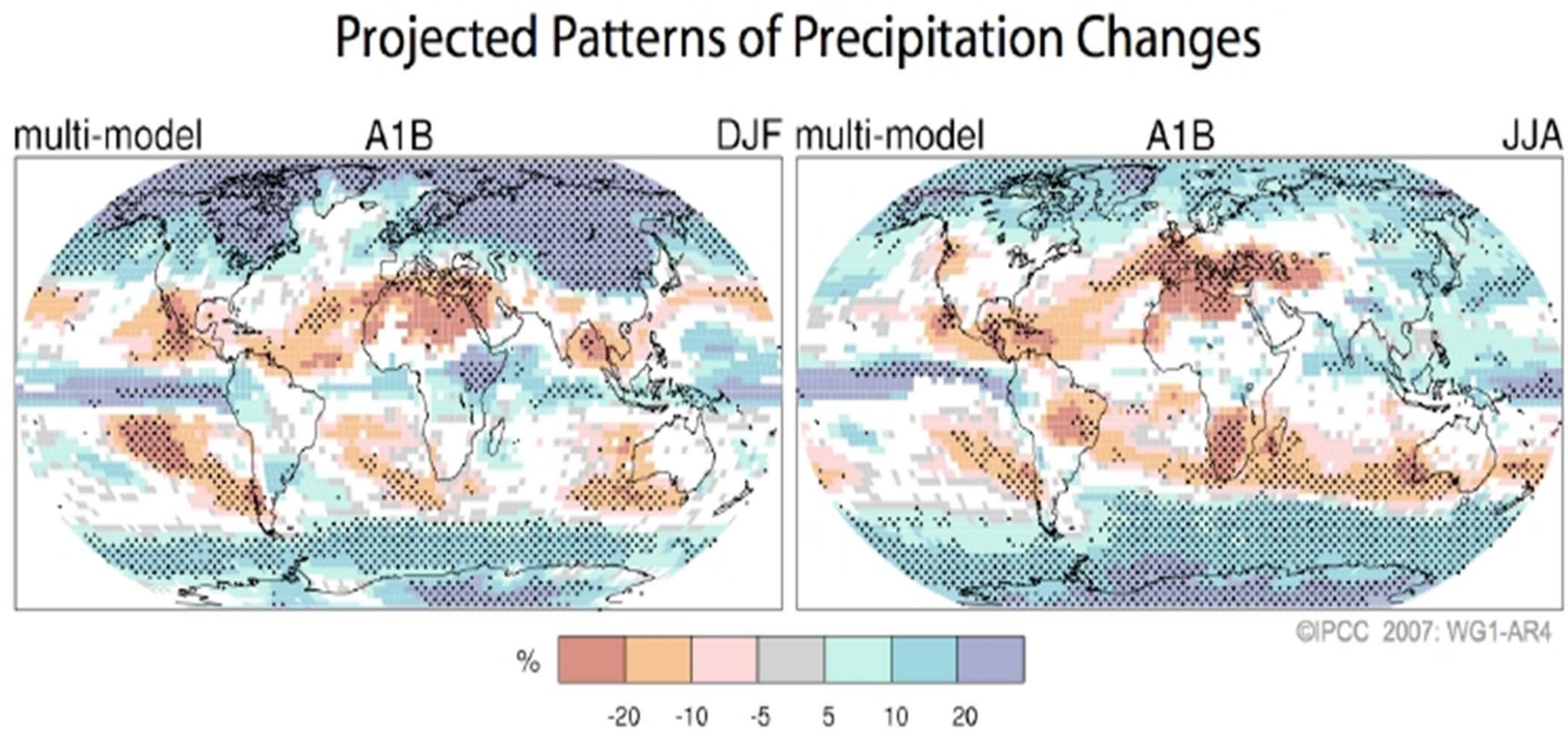
> Intense tropical cyclone activity increases

- **Likely (>66%)**

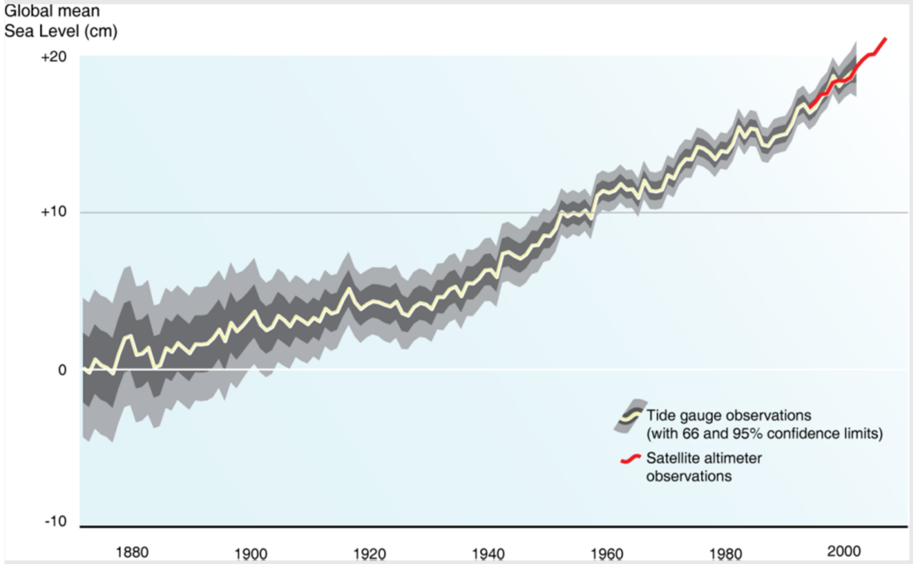
> Increased incidence of high sea levels

- **Likely (>66%)**

WG1 Summary Figure SPM-6



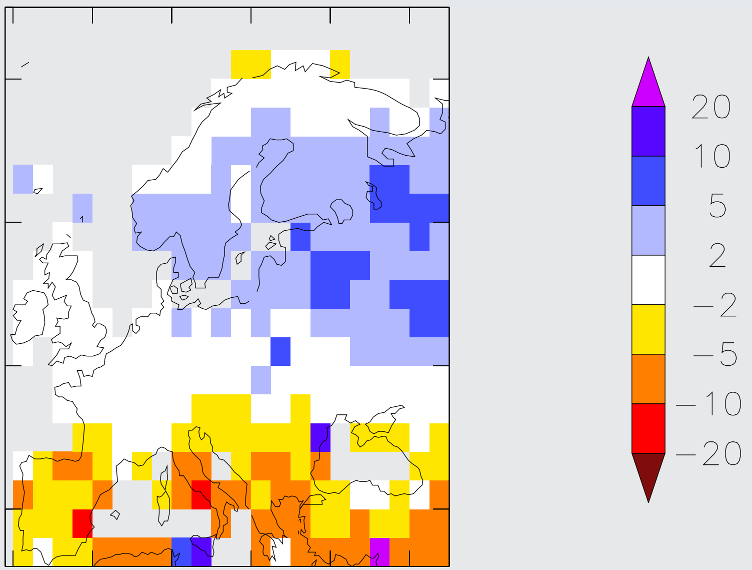
Trends in sea level



Source: Church, J.A. and White, N.J. (2006). A 20th century acceleration in global sea-level rise. Geophysical Research Letters, 33, L01602 – Figure: Hugo Ahlenius, UNEP/GRID-Arendal

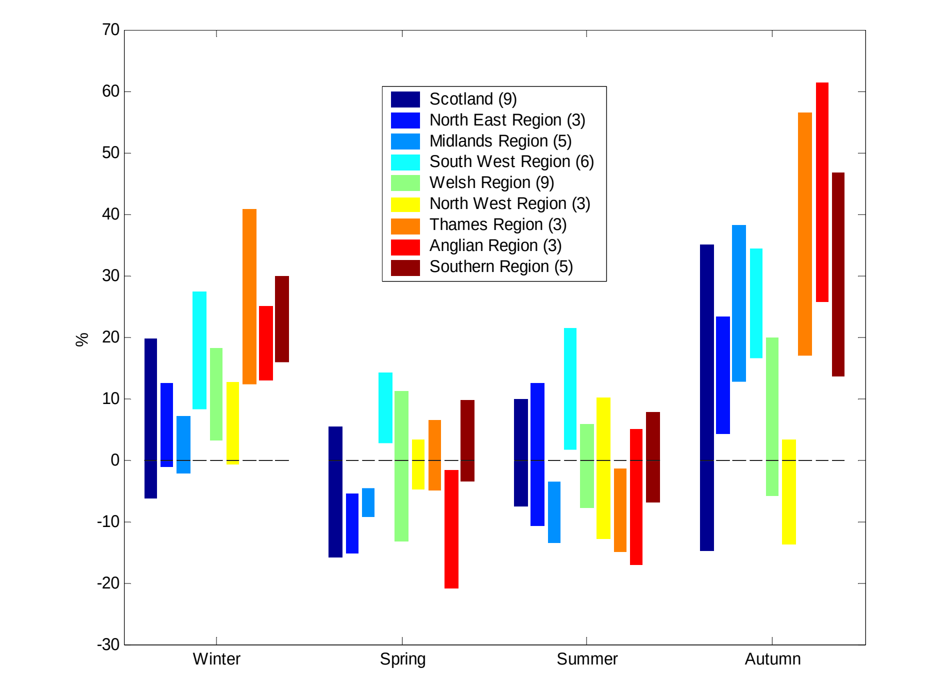
For Mauritius it has been estimated that the sea level is rising at a rate of 1.2 mm/year (comparable to global mean sea level increase of 1.0 to 2.0 mm per year during this century)

Impacts in Europe: Trends in river flows



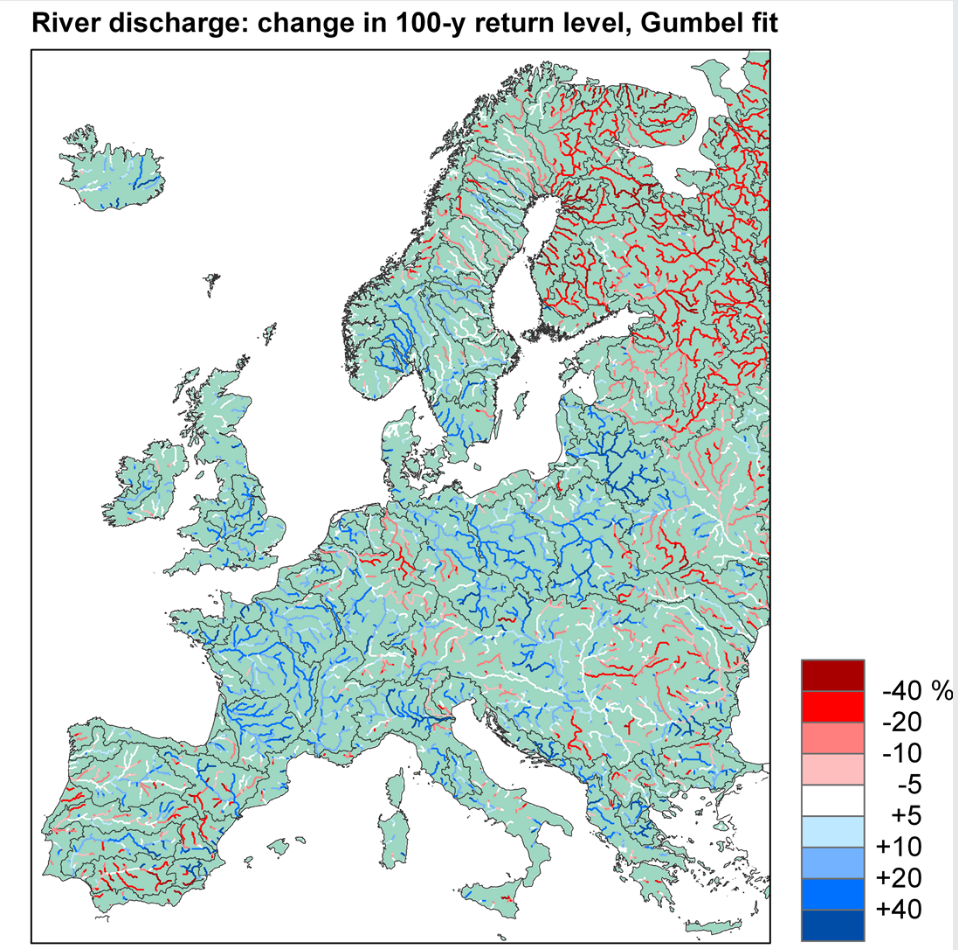
Relative change in runoff (%) during the twentieth century. Period

1971-1998 compared to 1900-1970. From Milly et al., Nature, 2005.



Percent change in average seasonal trend component from 1978 to 1990 and 1991 to 2003 for different regions. The number in parentheses is the number of sites used to determine the percent change interval. (Wade et al., 2006)

Impacts in Europe: Changes in river discharge



Source: Dankers and Feyen, 2008.

Changes in peak discharge in Europe (2071-2100, SRES A2)

Uncertainty *****

Natural variability

> reconcile summer flooding and winter drought

Flood risk

> what about pathways and receptors?

Projected average changes in peak flood flows in the UK

		Low estimate	Mid estimate	High estimate
River Thames, England		**p10**	**p50**	**p90**
2020s	Medium Emissions	0	7	23
2050s	Medium Emissions	0	14	**35**
2080s	Low Emissions	0	17	38
	Medium Emissions	0	22	50
	High Emissions	5	30	60*

Solway, Scotland		**p10**	**p50**	**p90**
2020s	Medium Emissions	6	15	24
2050s	Medium Emissions	11	22	**35**
2080s	Low Emissions	11	23	40
	Medium Emissions	11	27	50
	High Emissions	19	38	60*

Based on research completed by CEH (Reynard, *et al.*, 2009; Kay *et al.*, 2010).

Projected Climate Change in Mauritius

Trends

> Continue to get warmer

> Cyclones likely to become more intense; however, there are uncertainties regarding changes in frequencies

> Sea levels will continue to rise.

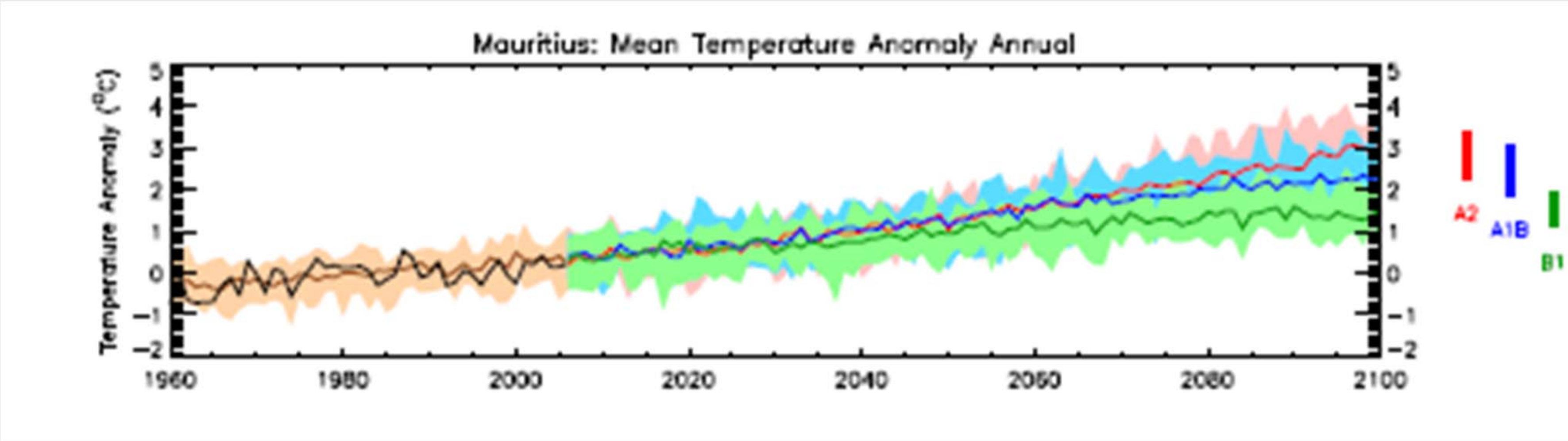
Extremes

> Some extremes become more common while others become less common

> more very hot days

> fewer very "cold" nights

UNDP Climate change scenarios: Profile for Mauritius



http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

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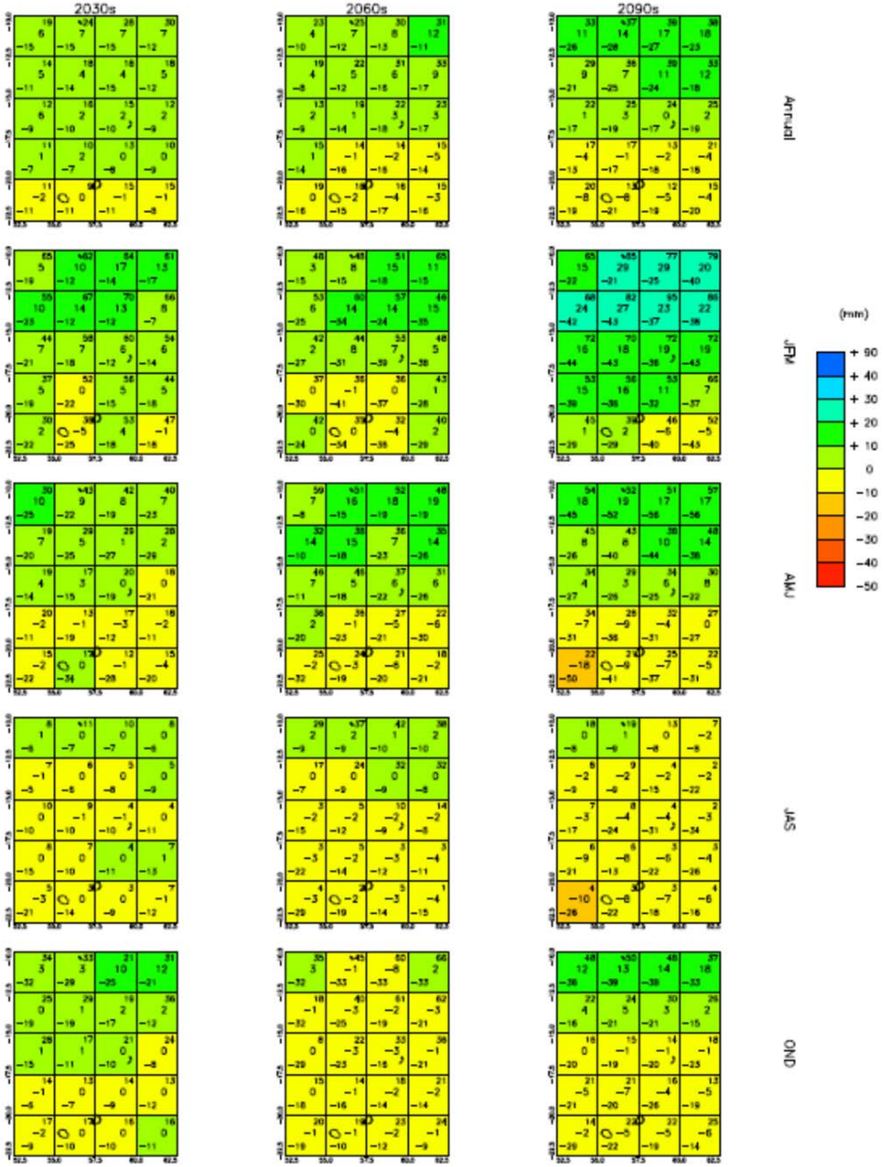
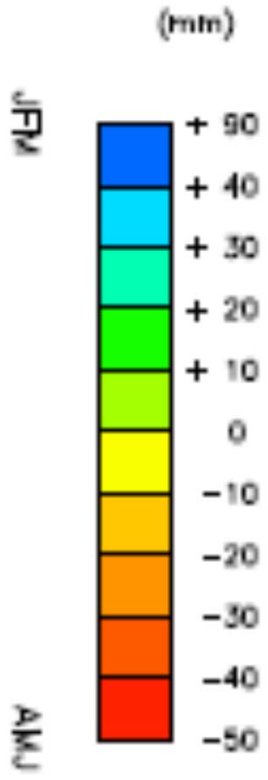
Changes in average precipitation





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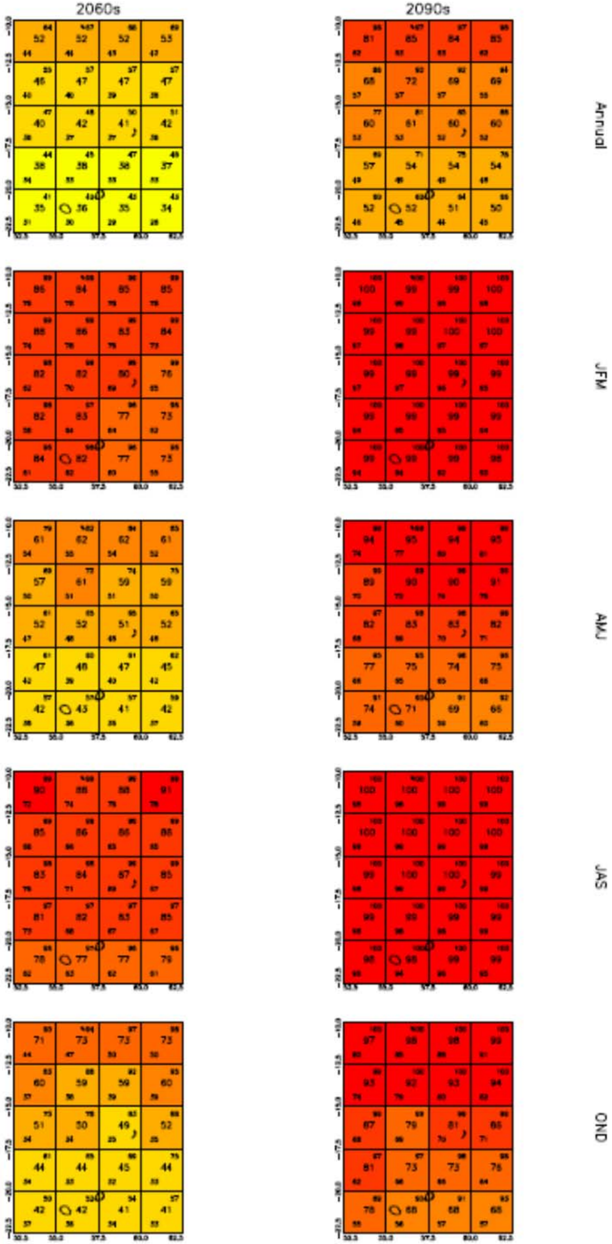
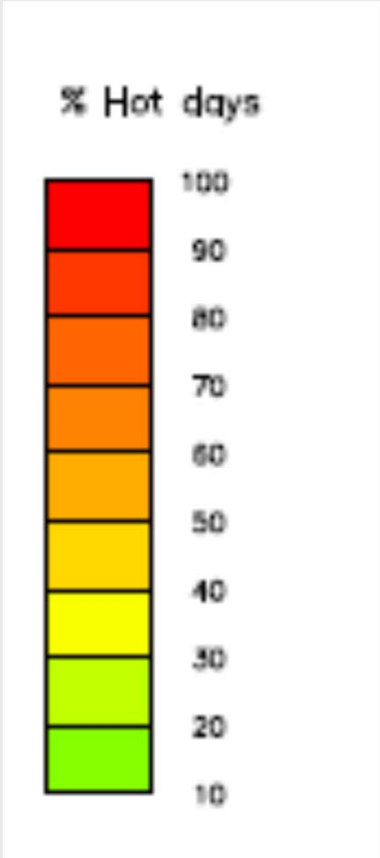
Changes in extremes





Changes in maximum daily rainfall of between -7 and + 26 mm for the 2090s (low confidence)

More detailed regional climate modelling or statistical downscaling is needed

Character of change

Average annual precipitation

Seasonality – precipitation, soil moisture deficits (SMDs), flow, recharge

Rainfall intensity

Extremes – rainfall, SMD, flow, recharge…………..

> Joint probability with pre-event conditions

Changes in Sources-Pathways-Receptors - coupling to other processes

> Vegetation and resistance

> Morphology

> Secondary influences of temperature (wetting and drying of earth embankments)

Considerable uncertainty in any risk assessment

> Scenarios, sensitivity analysis → probabilistic risk assessment??

Potential effects on structures

Bridges

- General scour exposes foundations
- Enhanced local scour from change in
  - **sediment load**
  - **planform and angle of attack**
- Increased potential for blockage

Embankments – changes in

- Velocity against embankment
- Planform leading to undercutting of toe
- Composition and resistance of natural protection
- Cracking of embankment soils
- Landslides

Potential effects on structures

Weirs and sluices

> Sedimentation upstream of weirs

> Energy dissipation at weirs and sluices (local erosion of bed and banks)

Dams

> Capacity of spillways (PMF / PMP)

> Wave overtopping (wind speed and direction)

Coastal protection

> Wave overtopping, eroison

Potential effects on road drainage

Quantity

> Increased flooding from existing systems

> Change in relative effectiveness of storage and infiltration solutions

> Erosion and landslide risks

> Reduction of dry weather flows = less dilution

Quality

> Increase in pollution from “first flush”

> Consequential impacts on water treatment requirements and receiving watercourses

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Conclusions

Climate change

> more intense hydrological cycle

> sea level rise

> impacts on flood risk – surface water, fluvial, groundwater, coastal

Understand natural variability

Consider hydrological processes

Need to manage risks and uncertainties

So in the future….

Use current best science available

Adaptation

> Ensure good design to cope with current extremes
> Design for unavoidable changes
> Test sensitivity for a wide range of changes
> Consider costs and impacts

Greater resilience

> Precautionary approach
> Design to reduce flood and erosion risk

Approaches and tools

Precautionary allowances

> Extreme rainfall

> Peak flow

Local climate impacts profiles – monitoring and recording weather impacts

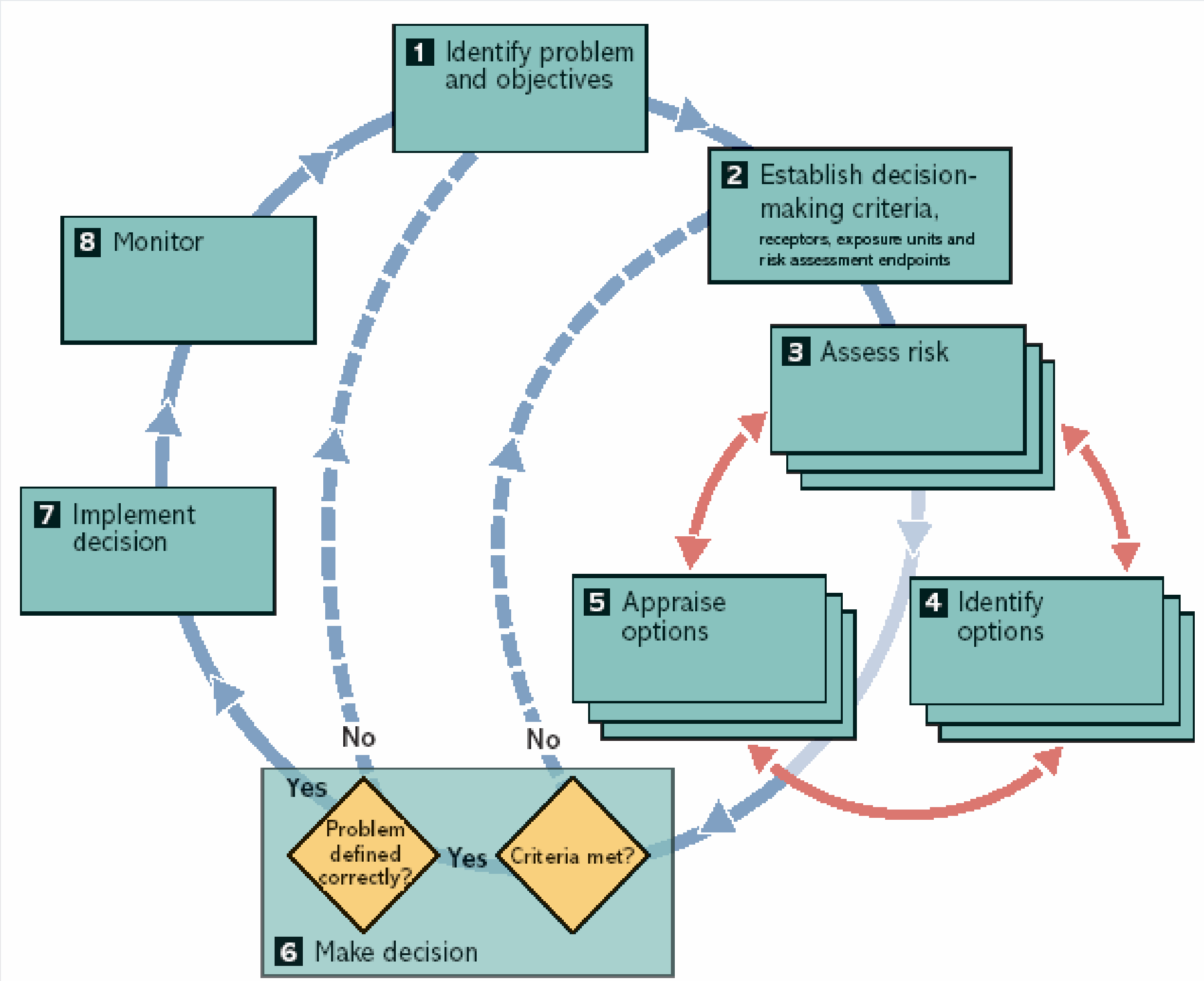
Risk screening and prioritisation of actions needed

Impacts and risk assessment

Guidance materials and methods for linking climate change to engineering design

Design codes and regulations (research needed first)

Decision making methods
UK Climate Impacts Programme Framework



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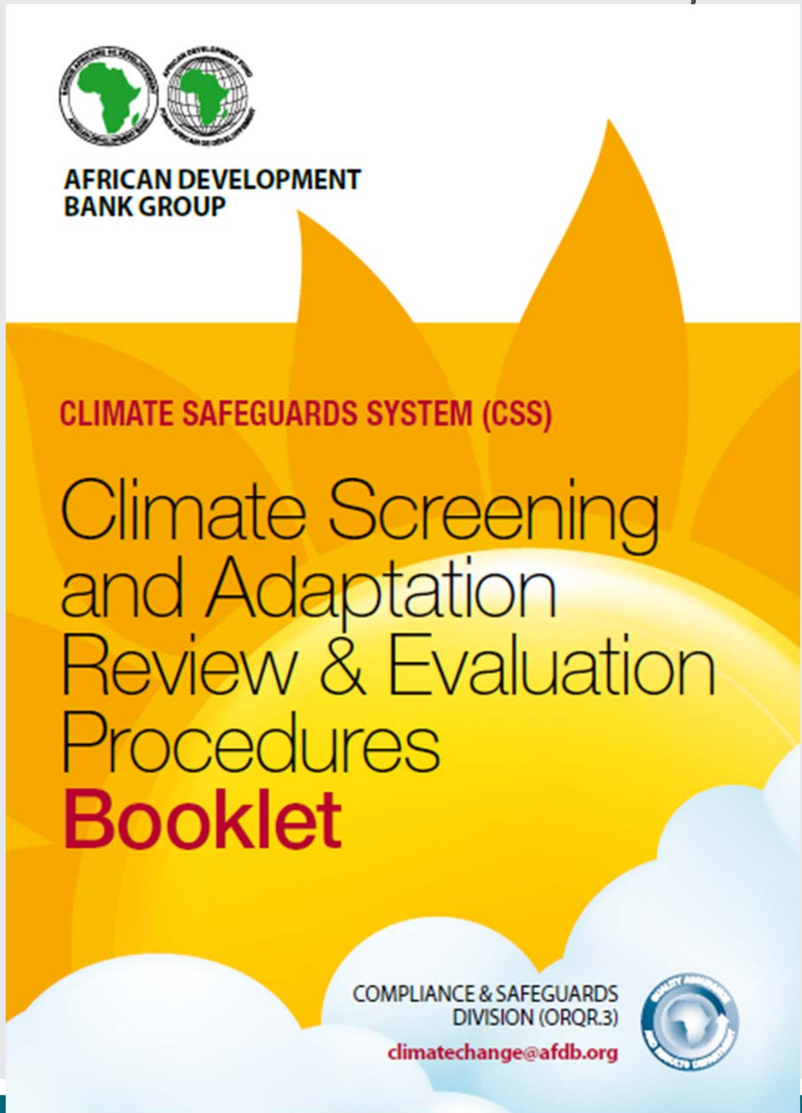
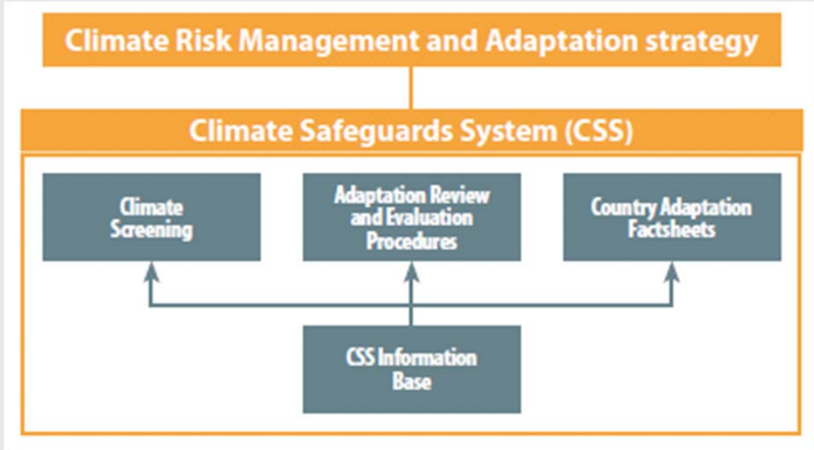
African Development Bank Climate safeguards system

http://www.climateadaptation.cc/download-center/





Questions and discussion

Understanding damages and losses due to climate change

Our economy, society and environment are all significantly affected by the climate, especially climate variability and extremes.

- Extreme events cause great social and economic disruption.
- We have cutting edge climate science, but surprisingly little good information on risks, i.e. how society, the economy and the environment will be affected.
- Knowing the risks helps us prepare and plan, i.e. to build resilience to climate risks into long-term decisions and so minimise future costs and disruption.

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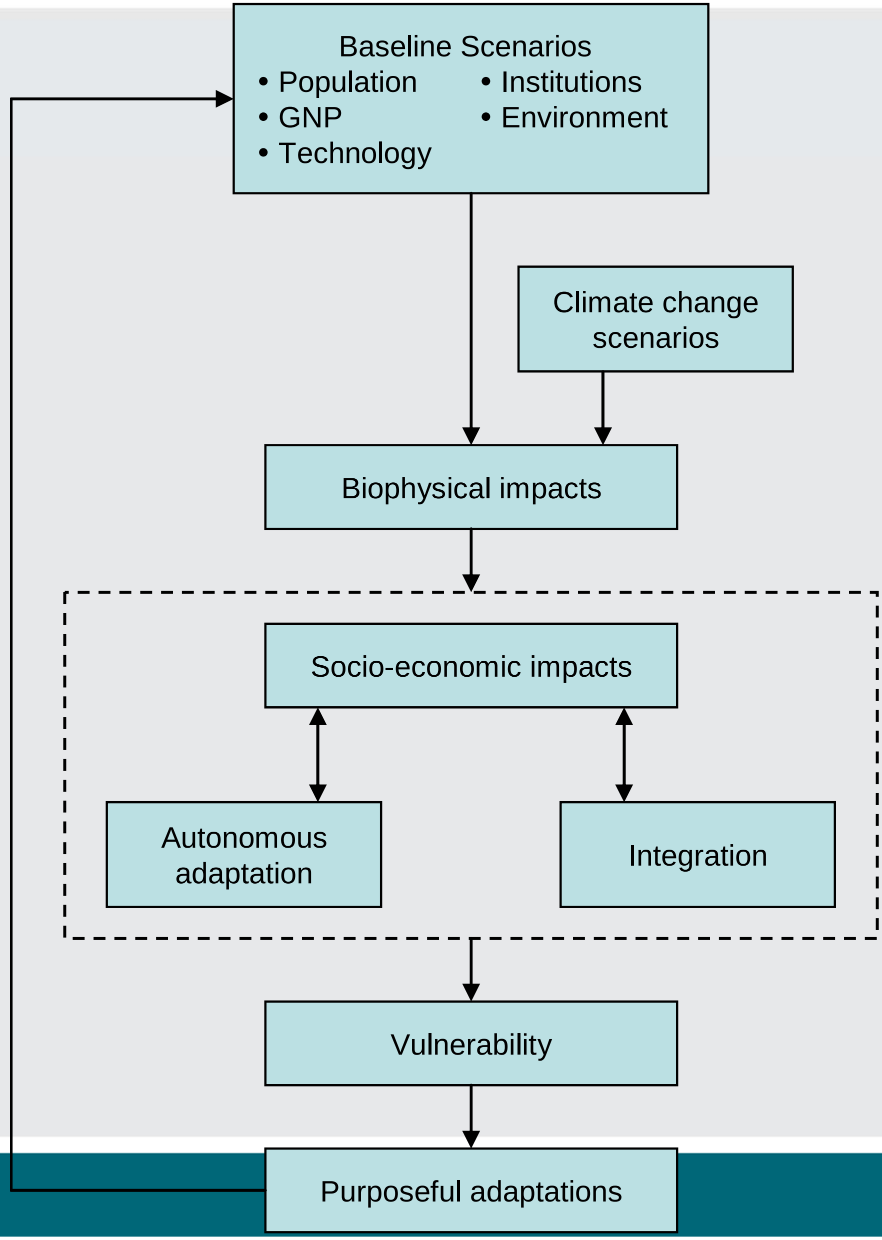
Methods

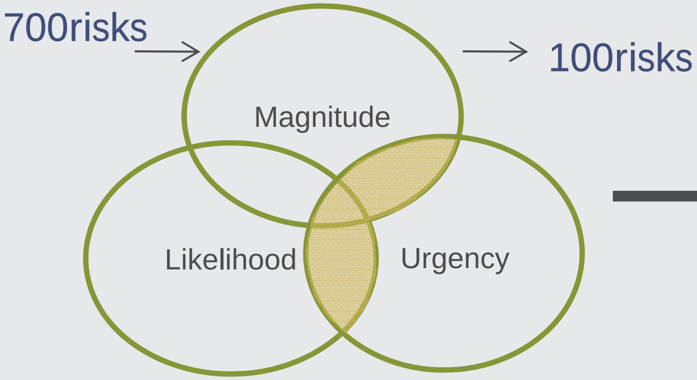
Approach				
	Impact	**Vulnerability**	**Adaptation**	**Integrated**
Scientific objectives	Impacts and risks under future climate	Processes affecting vulnerability to climate change	Processes affecting adaptation and adaptive capacity	Interactions and feedbacks between multiple drivers and impacts
Practical aims	Actions to reduce risks	Actions to reduce vulnerability	Actions to improve adaptation	Global policy options and costs
Research methods	Standard approach to CCIAV Drivers-pressure-state-impact-response (DPSIR) methods Hazard-driven risk assessment	Vulnerability indicators and profiles Past and present climate risks Livelihood analysis Agent-based methods Narrative methods Risk perception including critical thresholds Development/sustainability policy performance Relationship of adaptive capacity to sustainable development		Integrated assessment modelling Cross-sectoral interactions Integration of climate with other drivers Stakeholder discussions Linking models across types and scales Combining assessment approaches/methods
Spatial domains	Top-down Global → Local	Bottom-up Local → Regional (macro-economic approaches are top-down)		Linking scales Commonly global/regional Often grid-based
Scenario types	Exploratory scenarios of climate and other factors (e.g. SRES) Normative scenarios (e.g. stabilisation)	Socio-economic conditions Scenarios or inverse methods	Baseline adaptation Adaptation analogues from history, other locations, other activities	Exploratory scenarios: exogenous and often endogenous (including feedbacks) Normative pathways
Motivation	Research-driven	Research-/stakeholder-driven	Stakeholder-/research-driven	Research-/stakeholder-driven

Main elements of impacts framework (UNFCCC V&A assessment guidance)

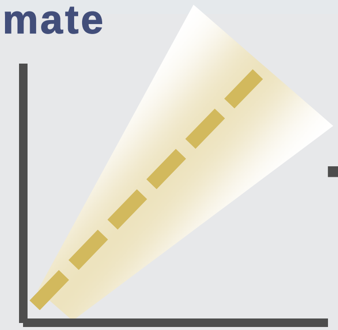


CCRA Method Overview

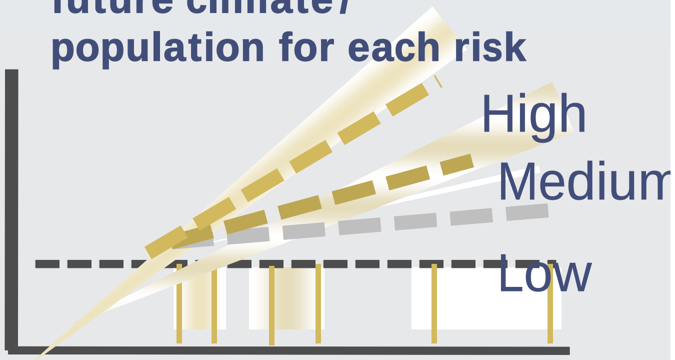
1. Choose priority risks



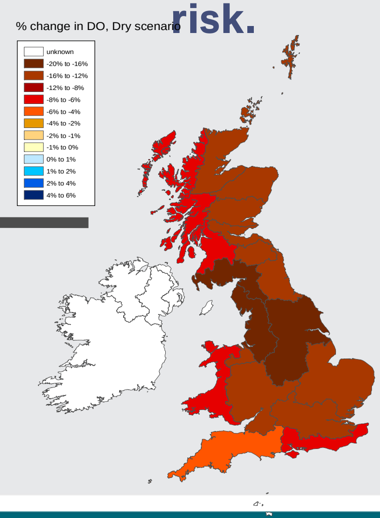
2. Assess sensitivity of each risk to current climate



3. Add projections of future climate / population for each risk



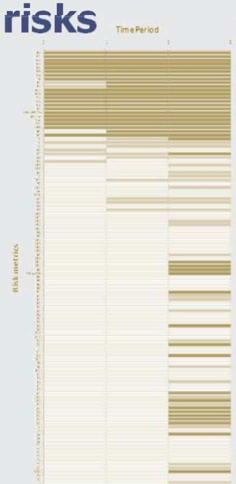
4. Compare by area for each risk.



5. Assign magnitude (logarithmic scale) and confidence scores to each risk

Magnitude	Low	Medium	High
Social	100s	1000s	Millions
Economic	£1 M	£10 M	£100 M
Env.	100km	1000km	10,000km

6. Compare scores of all risks



Stage 3: Assess Risks

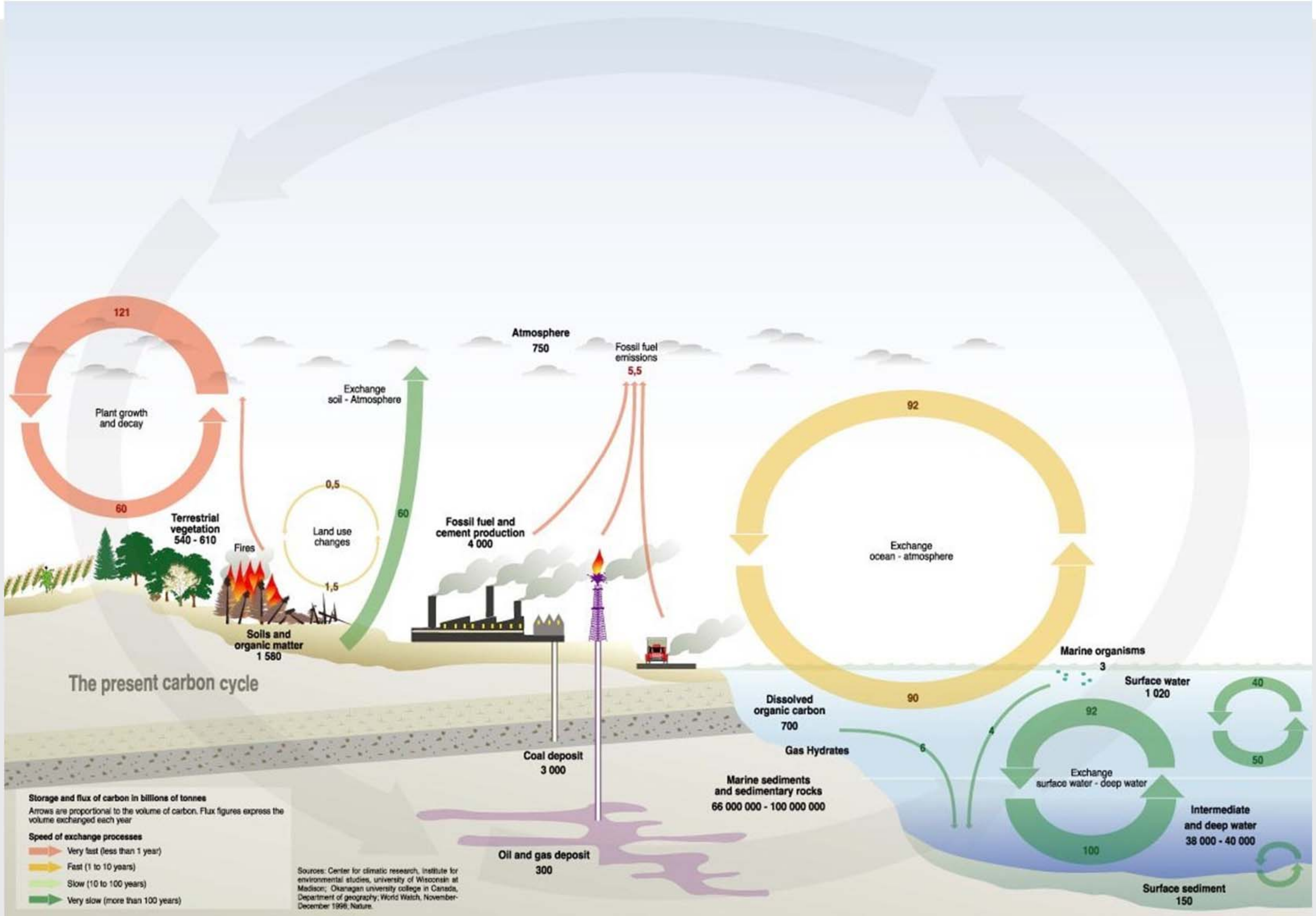
Scoping and selecting

Understanding sensitivity

Assessing future risks

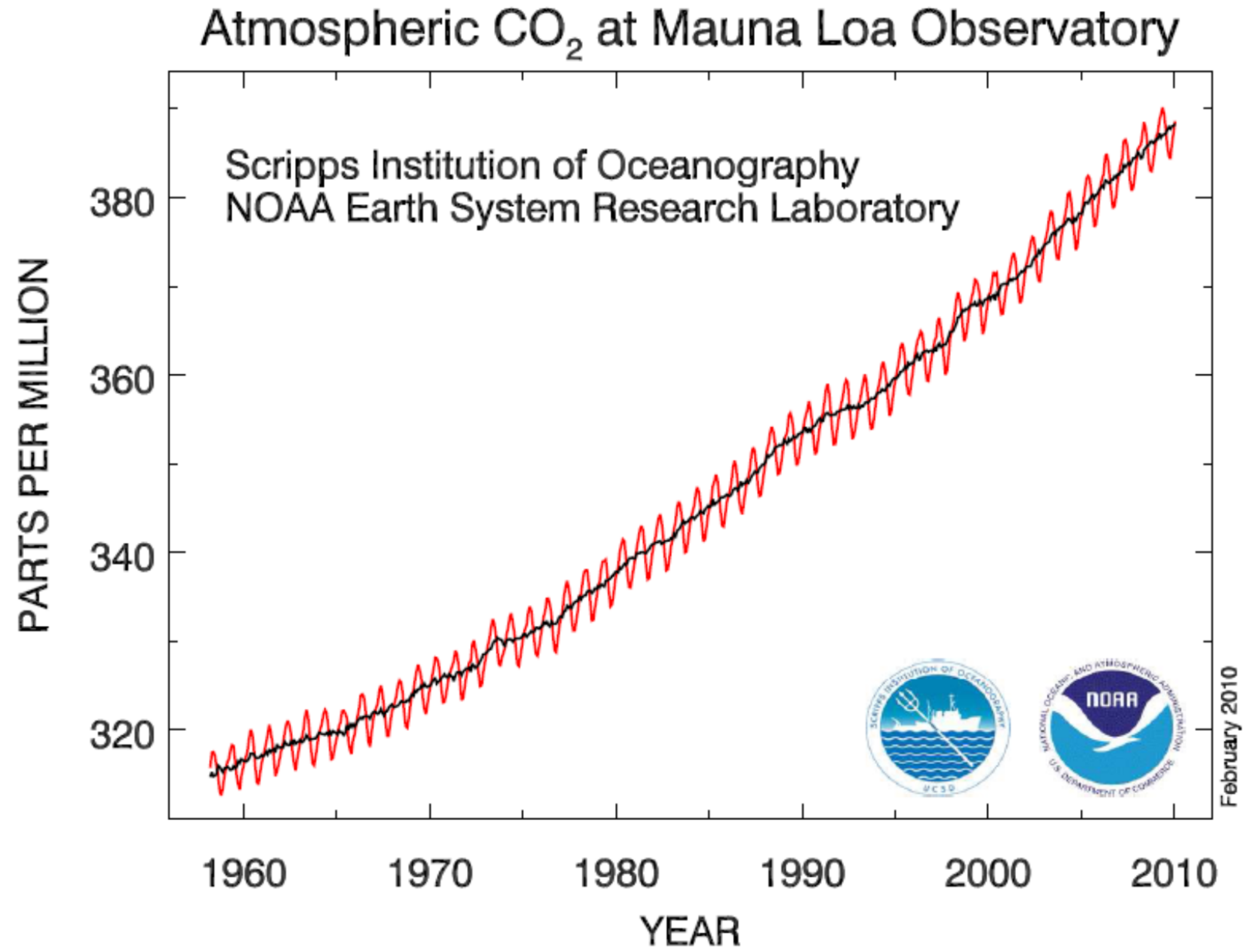
Reporting

Carbon Cycle

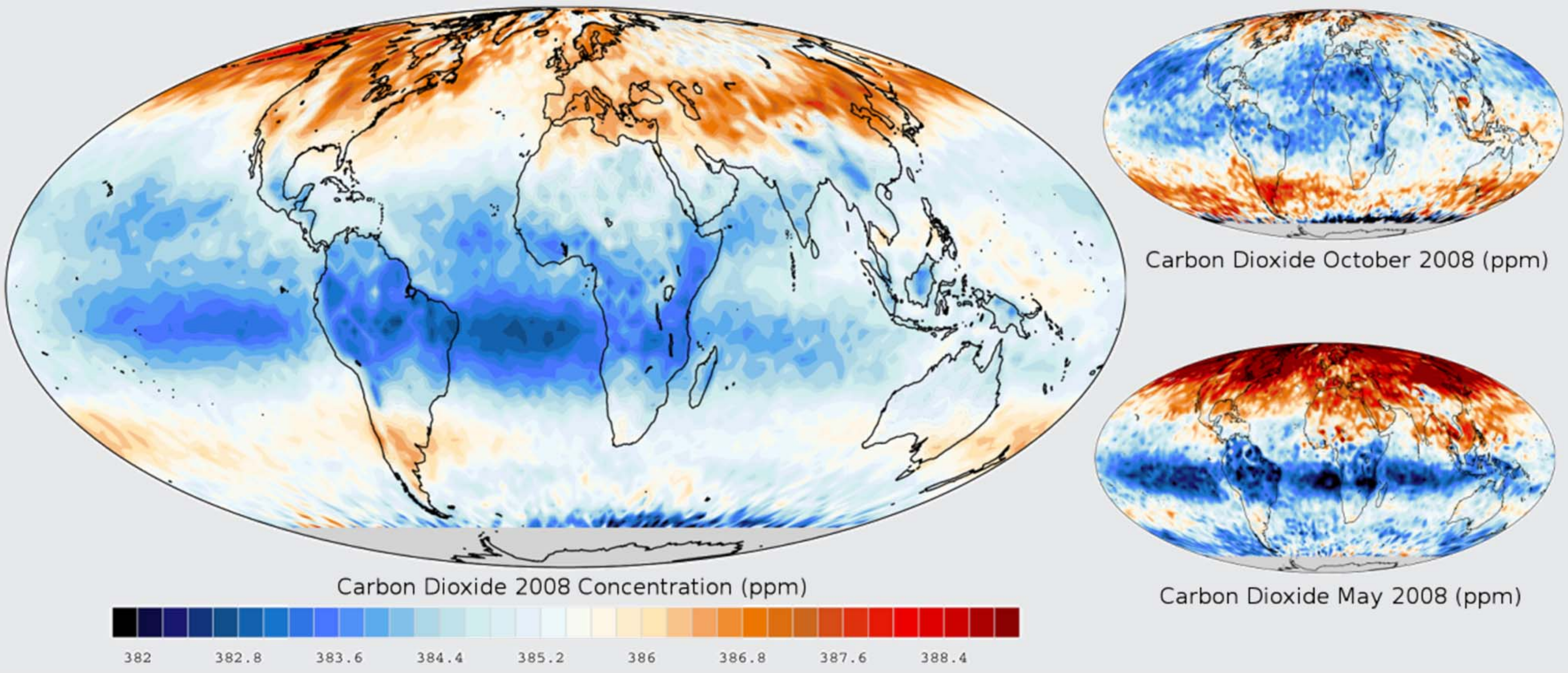


http://maps.grida.no/go/graphic/carbon_cycle

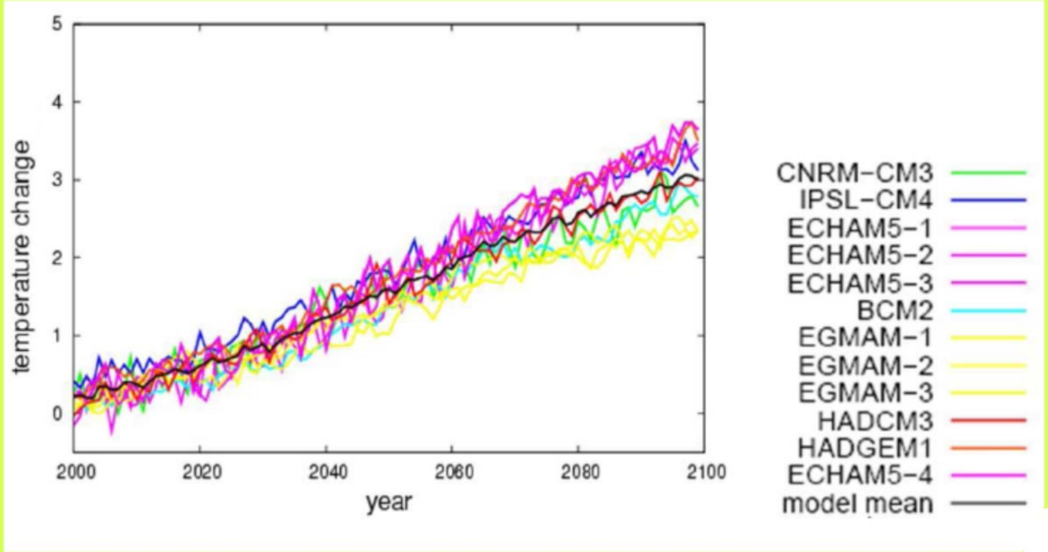
CO_2 Observations



CO_2 Distribution

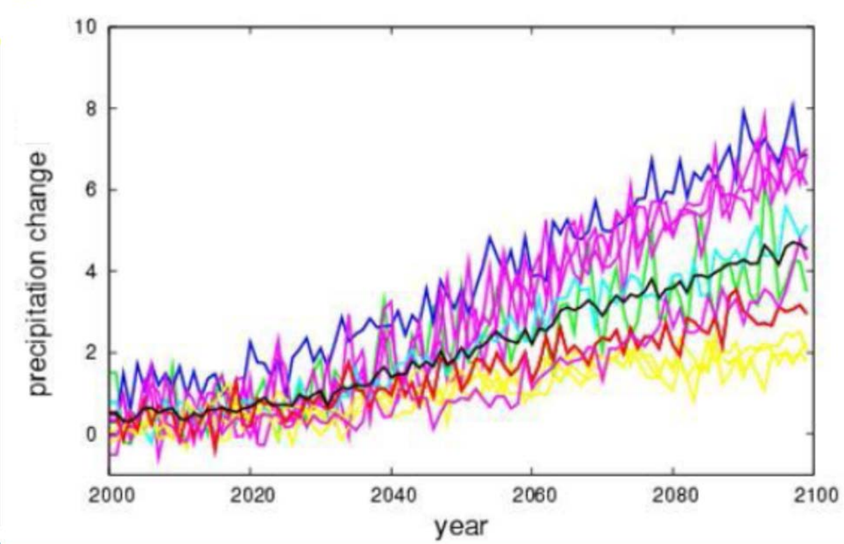


Global temperature change: EC Ensembles Project SRES A1B scenario



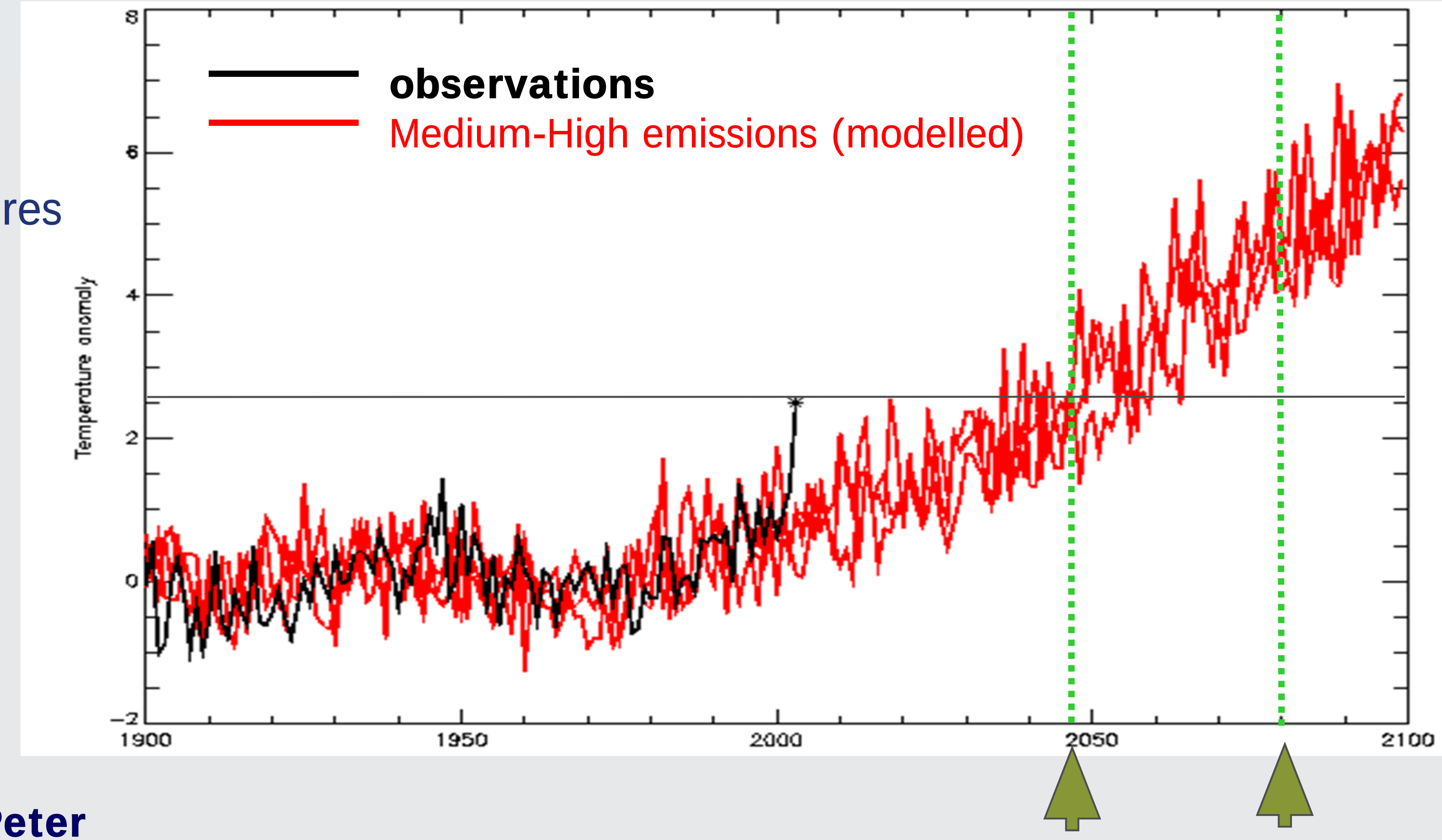
Warming leads to an intensification of the hydrological cycle

4 degrees roughly equal to 5 percent increase in precipitation



European Summer 2003 heat wave

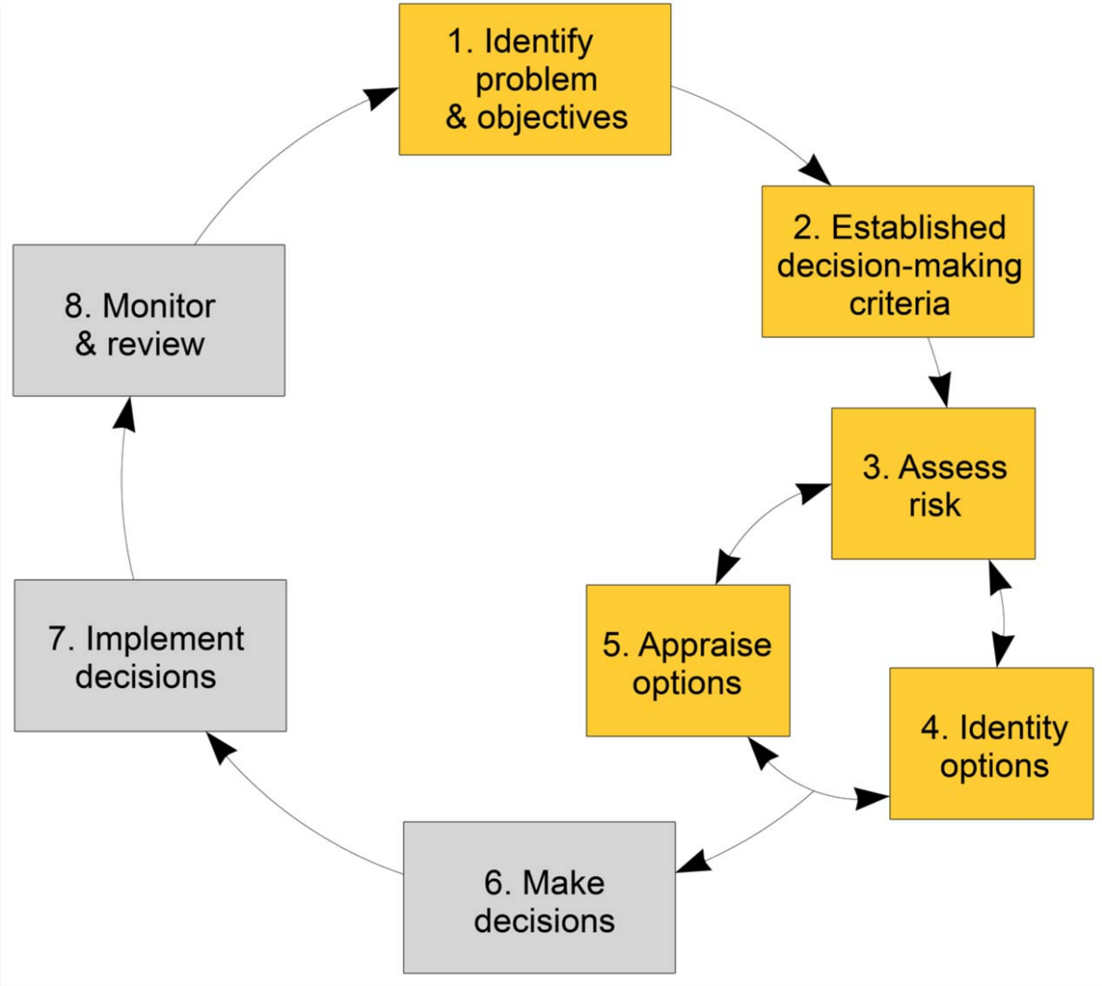
European summer temperatures



Source: Peter Stott, Hadley Centre

normal by 2040s: cool by 2080s

Overall approach



Analytical steps and supporting assessments