JBA consulting

Recommendations for filling current gaps in climate information

Climate Information to Support UK Decision-making

July 2022

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UK CLIMATE RESILIENCE PROGRAMME

UK Research and Innovation

Met Office

JBA Project Manager

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Revision History

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Revised draft / 4th July 2022	Addressed Met Office review comments	Zorica Jones, Simon Brown, Jason Lowe (Met Office)
Final / 12th July 2022	Changes approved	Zorica Jones, Simon Brown, Jason Lowe (Met Office)

Contract

This report describes work commissioned by the Met Office on 1st March 2021. The Met Office's representative for the contract was Simon Brown.

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Purpose

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Acknowledgements

We appreciate the help and support provided by the Met Office and members of the UK Climate Research (UKCR) Steering Committee in supporting the research that has informed this report and attended the workshop. We are also very grateful to the climate information providers that completed the elicitation survey between December 2021 and February 2022.

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Abbreviations

AMOC	Atlantic Meridional Overturning Circulation
CCRA	Climate Change Risk Assessment
CCRA3	Third UK Climate Risk Assessment
CPM	Convective Permitting Modelling
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
ECMWF	European Centre for Medium Range Weather Forecasts
ETH Zurich	Eidgenössische Technische Hochschule Zürich (a public research university in the city of Zürich, Switzerland)
GCMs	Global Circulation Models
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Institute for Climate and Society, USA
JBA	Jeremy Benn Associates, trading as JBA Consulting
NCAR	National Centre for Atmospheric Research (Colorado, USA)
NCAS	National Centre for Atmospheric Science
NERC	Natural Environment Research Council
PMP	Probable Maximum Precipitation
SEPA	Scottish Environment Protection Agency
SMHI	Swedish Meteorological and Hydrological Institute
TCFD	Task Force on Climate-related Financial Disclosure
UEA	University of East Anglia
UKCP	UK Climate Projections
UKRI	UK Research and Innovation
UNSEEN	UNprecedented Simulation of Extremes with Ensembles (Met Office)
WMO	World Meteorological Organisation

1 Introduction and context

1.1 Introduction

This project falls within the wider Met Office and UK Research and Innovation (UKRI) supported UK Climate Resilience (UKCR) Programme which aims to bring together fragmented climate research and expertise to undertake robust, multi-and interdisciplinary climate risk and adaptation research to build UK capacity for resilience to climate variability and change.

1.2 Definition of climate information

Climate information is defined as data, models, forecasts and projections relating to the observed historical, or current, climate as well as the simulated future climate over different time horizons and spatial scales. Climate information is provided in numerical or graphical format, based on observations or model simulations for different spatial and temporal resolutions over different time horizons and geographical domains. Derived products such as the Environment Agency's climate change allowances for flood risk assessments are not included within this definition, nor are impact assessments, such as the UK Climate Change Risk Assessment (CCRA) or reporting required by the Task Force on Climate-related Financial Disclosure (TCFD). These are defined as products that use climate information.

Climate information is used to support decision-making about near, medium, and long-term risks across a wide range of sectors, and products based on this information can be attributed with different levels of confidence due to uncertainties in the data and production methods. However, whilst climate information is used regularly across UK public and private sectors for risk management, a changing mean climate state, as well as current and projected increases in extreme events, present a major challenge to organisations that provide guidance on risk and its management (e.g. environmental or infrastructure consultancies as well as public regulatory bodies).

1.3 Purpose of this report

This report forms the final project deliverable and the key output from Step 4 of the project, as set out below:

- Step 1: User assessment of the current needs for climate information (March – June 2021)
- Step 2: Production of a climate science 'ask' (June – August 2021)
- Step 3: Development of options (August 2021 – March 2022)
- Step 4: Prioritisation of options (March - June 2022)
    - Workshop with Steering Committee
    - Deliverable 4: set of recommendations

Informed by the previous steps of the project, this report concludes with a set of recommendations relating to the provision of climate information. Drawing on the insights and experience of the UKCR Steering Committee as representatives of a broad user community, in this final step, the options for the provision of climate information (from Step 3) have been prioritised.

We refer readers to the Development of Options report for more information regarding the approach taken to determine the set of options for climate information provision during Step 3. However, it is important to note that these options were informed by a survey which elicited the views of climate information providers on priorities for the production of climate information, hereafter referred to as the Provider Survey. We recognise that other options for the provision of climate information may exist and therefore this list should not be considered as exhaustive.

2 Expert Group Workshop

2.1 Workshop design

Aim The aim or the workshop was to inform the development of future datasets for characterising current and future weather and climate risks in the UK and overseas by understanding what a range of existing user requirements might imply for providers of future UK climate information.

Participants The UKCR Steering Committee[1] itself represents a broad range of users and so it was agreed that it would be both effective and efficient to hold the final workshop with the Steering Committee rather than convene another group. This had the additional advantage of the group already being aware of the project and engaged in the wider programme. We recognise that while there is a broad range of expertise on the group it should not be considered as a representative or unbiased sample of the full UK community.

Agenda Following in-depth consultation, a Workshop Development Team developed a workshop agenda as shown in Appendix A.

Activities The workshop included:

- A statement on UK Government User Needs (see Appendix B).
- Breakout rooms for two groups to discuss in greater depth a series of pre-defined, user-focused topics.
- A 'conceptboard' function that allowed multiple users to enter textual information in response to a range of questions. The output from this conceptboard is provided in Appendix C.

[1] https://www.ukclimateresilience.org/about/management/steering-committee/

Provider Survey highest priorities

Workshop user needs topics

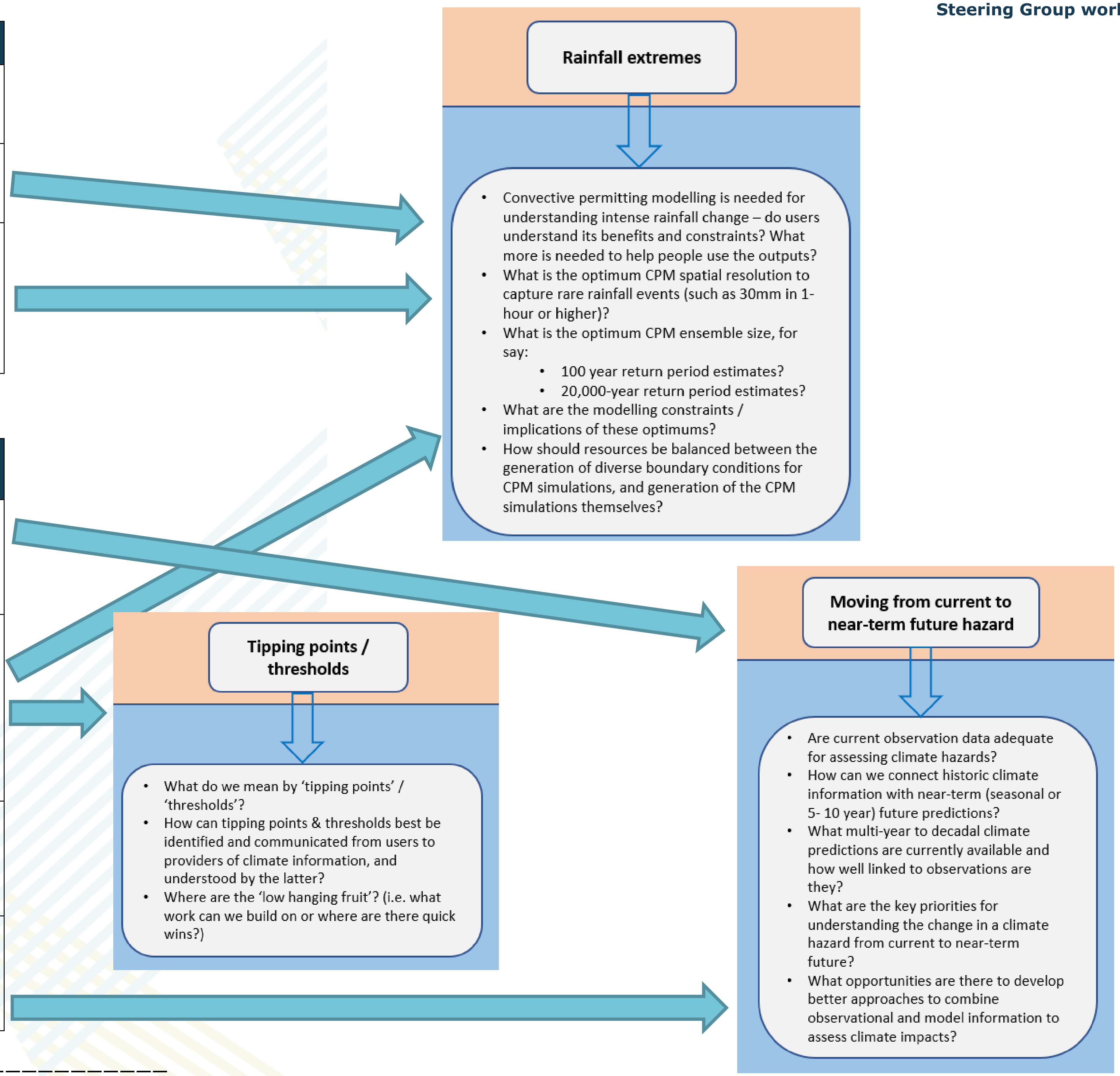
Figure 2-1 Illustration of how high priority recommendations from the Provider Survey relate to discussion topics at the UKCR Steering Group workshop

Table 2-1 Preferred options related to model development

Model development preferred option	Justification
Produce 'better' models to improve understanding of the climate system	Rated highest (4.1) overall by 19 respondents
Large ensembles	Rated second highest (3.9) overall by 19 respondents – large ensembles will serve to give the best estimates of climate extremes, especially for high impact low probability events.
Ultra-high resolution local runs	Although not a stand-out high score overall (3.2), we propose that this is highly important to understand impacts due to rainfall intensity, particularly surface water flooding, rapid-response catchment flooding, urban pollution management and probable maximum precipitation (PMP) estimation[2] (when combined with sufficiently large ensemble size).

Table 2-2 Preferred options related to use of models

Model development preferred option	Justification
Model and data providers should focus on demonstrating how the data can be used.	Rated joint highest (4.1) overall by 19 respondents. We recognise there is strong support for this but also recognise and support comments that this might be a role for 'science translators' or should be done through co-development between users and information providers.
Production of compound parameters e.g. combined precipitation and temperature projections (especially in relation to high impact events)	Rated joint highest (4.1) overall by 19 respondents. While this is well supported, we recognise the importance of co-development in defining the parameters and how the model information is produced. Users need to define the parameters, and important thresholds[3] for these. As well as compound flood risk parameters, combined temperature and humidity parameters are important for heat stress.
Using existing models and model data	Rated joint second highest (3.9) overall by 19 respondents. Important from an economic and science perspective, summed up by "*Existing models should be exhaustively tested and assessed to better understand model sensitivities before new experiments are planned.*"
Transient simulations that run from present day to some point in the future (e.g. 2050 or 2100)	Rated joint second highest (3.9) overall by 19 respondents. Overall, benefits seen to outweigh negatives and can support multiple needs: coastal and marine environments, socio-economic modelling or facilitating projections at industry-set time horizons.



[2] An on-going project for the Environment Agency is developing new estimation methods for PMP and PMF (Probable Maximum Flood) – engineering estimates used for reservoir safety and other highly vulnerable infrastructure: https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/improving-probable-maximum-precipitation-pmp-and-probable-maximum-flood-pmf-estimation-for-reservoir-safety

[3] For example, a temperature threshold related to public health, or a precipitation threshold related to a specific return period meaningful to flood risk or water utilities community

2.2 User needs topics

The workshop explored three user needs topics recognised (from Step 1) as important user needs for climate information: (1) tipping points/ thresholds; (2) extreme rainfall and Convective Permitting Models (CPM); and (3) transitioning from current to future projections.

Figure 2-1 shows how these user needs topics relate to the outcomes of the Provider Survey. Questions posed to attendees of the workshop are indicated also in this figure under the three topic headings. A summary of these three topics areas is provided below.

2.2.1 Tipping points / Thresholds

In discussions with users (during Step 1), a key area of interest was in the prediction of tipping points or thresholds that result in step changes in impacts as these become key decision points for adaptation. One example from Step 1 was to understand when the current approach for managing wildfires (e.g. width of fire breaks in forests, or use of fire breaks at all) might need to change as a result of climate change. Other examples were referred to in the workshop by JBA relating to heatwaves, extreme floods and rainfall amounts giving rise to pollution from urban drainage systems – each of which recognise specific thresholds that give rise to step changes in impacts.

We acknowledge that there is potential for confusion in the term tipping point used in this way. To distinguish between this term and the official definition of tipping point by the IPCC definition[4] we subsequently refer to this user need as 'User impact thresholds'.

2.2.2 Extreme Rainfall and CPM/UKCP Local[5]

This discussion topic focuses on the need for better understanding of rainfall intensity and convection-related rainfall in the future, informing understanding of extremes over a range of scales (e.g. from 50% to 5×10^{-5} % annual exceedance probability[6]). While rainfall extremes are not the only extreme climatic change of importance for the UK, they have relevance to many of the identified climate risks within the Climate Change Risk Assessment (CCRA)3, as detailed in the Development of Options report in this project.

The user needs relating to extreme rainfall and convection-permitting modelling discussed under this theme relate to three of the highest priority model areas identified by climate information providers, as shown in Figure 2-1.

2.2.3 Transitioning from current to future climate projections

This topic focuses on connecting historic, near-term and decadal climate projections to longer range projections, for example to the end of the century. The driver behind this need is an understanding of the change in risk from current to future periods and the avoidance of discontinuities or 'step changes' in the climate information with time. Members of the UKCR Steering Committee recognise this need for 'seamless' information through the time continuum as important when communicating impact messaging. There is also an acknowledgement that there remains significant uncertainty about extreme events in the current climate that do not appear in observations – i.e. climate modelling can estimate current climate risks due to extreme events that are plausible but may not appear in observed records.

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[4] Tipping point: A large-scale change in the climate system that takes place over a few decades or less, persists (or is anticipated to persist) for at least a few decades, and causes substantial disruptions in human and natural systems (IPCC, https://www.ipcc.ch/sr15/chapter/glossary/)

[5] https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-factsheet-local-2.2km.pdf

[6] i.e. 2-year to 20,000 year probability

3 Recommendations drawn from workshop output

The following recommendations are drawn from the contributions of those attending the workshop and are organised within the three user need topics discussed. Final recommendations are provided in section 4.

The recommendations in this section are numbered sequentially to enable them to be linked to the final recommendations in Section 4.

A conceptboard output file containing anonymised workshop attendee inputs is included in Appendix C. The conceptboard information has been used to inform the recommendations in this section.

3.1 Recommendations related to user-focused thresholds:

1. Establish quantitative confidence limits in the tails of distributions for extreme events.
2. Understand user impact thresholds better and examine regional disparity in these. However, understanding of all user impact thresholds is not seen as realistic, or helpful (view of some members of the UKCR Steering Committee) – there are many thresholds and they change over time; but greater appreciation of the user need for information related to impact thresholds of importance to them is recommended. This could include drawing on members of the UKCP18 development and knowledge sharing network (DAKS) to extract more user-relevant information on thresholds.
3. Consider relevant data and climate experiments from the UK community including Met Office and academic sector; in particular, those which will explore possibilities for improved understanding of thresholds and extremes.
4. Examine the interaction of thresholds within systems – this could give rise to cascading impacts, where one impact triggers another from the same or different climatic hazard.

3.2 Recommendations related to extreme rainfall intensity

5. Provide better information on reliability / validity of CPM projections of rainfall – several views were expressed that there is a need for more extensive validation of the way the UKCP Local CPM simulates current climate. However, it should be noted that some useful validation has already been carried by the UKCP18 team following consultation with members of the UKCP18 Non-Government User Group[7].
6. Explore other ways derive rainfall extremes using validation e.g. climate analogues – prior projects have examined analogue approaches with varying levels of success[8].
7. Provide a narrative description of rainfall extremes from the model outputs[9].This would aid the understanding of the benefits of CPM modelling, including when CPM are useful, how they should be used and what uncertainties are associated with CPM. While the UKCP Local Fact Sheet[10] does this to some extent, information could be made simpler for a wider audience and less scientific for non-scientific users and decision makers, e.g. large-scale infrastructure owners.

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[7] The UKCP18 Non-Government User Group had a sub-group that provided guidance on user needs for CPM model output and 2.2km resolution was selected as it gave better agreement with observations than 4km while was at a resolution that could have a sufficiently meaningful ensemble size (12-member).

[8] Climate analogues were used within a UKWIR project in 2014-15 involving a research team from Newcastle University. Results were published in: Dale et al (2015) New climate change rainfall estimates for sustainable drainage. Proceedings of the Institution of Civil Engineers Engineering Sustainability http://dx.doi.org/10.1680/jensu.15.00030

[9] This has been addressed in part through the UKCR / UKRI project FUTURE-DRAINAGE project and its outputs, e.g. https://artefacts.ceda.ac.uk/badc_datadocs/future-drainage/FUTURE_DRAINAGE_Guidance_for_applying_rainfall_uplifts.pdf and Environment Agency climate change allowances for flood risk: https://environment.data.gov.uk/hydrology/climate-change-allowances/rainfall

[10] https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-factsheet-local-2.2km.pdf

3.3 Recommendations related to transitioning from current to future climate projections

8. Assess the probability of past observed extreme events. Historic events provide users with a wealth of information about what happened (e.g. heavy rainfall) and the impact that it had and provide an invaluable reference for planning responses/ adaptations should such events become more likely as a result of a changing climate. Therefore, increasing confidence in the calculation of the probability of an historic event occurring again in the future, given current (and future projected) climate conditions, could increase the benefit of using historic events as important case events for assessing risk and resilience. Historic events could be characterised within a distribution of possible outcomes and users could see whether they fall near the centre or tail of the distribution to understand risk better.
9. (As for thresholds recommendations) Examine the interaction of user-focused thresholds within systems – this could give rise to cascading impacts, where one impact triggers another from the same or different climatic hazard.
10. Understand better the UK's and sectors' vulnerability and exposure to combined hazards and events increasing in frequency through historic to current to future timescales. How this should happen depends on future collaboration between climate information user and provider groups (discussed in section 4.2).
11. Conduct research into potential sources of, or mechanisms which could lead to, high impact 'surprises', either because of unexpected changes in climate or because of poor understanding of current and future changing vulnerability/exposure.
12. Develop statistical methods for estimating instantaneous probabilities of extremes in a non-stationary climate[11][12].
13. Use a large ensemble of transients that resample past variability and transition through the present into the future. To enable improved understanding of climate risks in the current climate and how this has changed from historic (past) climates.
14. Assess the skill in seasonal to decadal predictions to aid decision-making using information from decadal forecasts.

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[11] For flood risk, work is on-going in this area and new guidance from the Environment Agency is available: https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/development-of-interim-national-guidance-on-non-stationary-fluvial-flood-frequency-estimation#full-publication-update-history

[12] UKCP18 probabilistic extremes products are another example of how this can be done, with 20, 50 & 100 year return levels estimated for every year between 1950 and 2100. See: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp-probabilistic-extremes-report.pdf

4 Final recommendations

4.1 Recommendations to inform future datasets for characterising current and future weather and climate risks and wider research gaps

The recommendations below have been drawn from information from the Provider Survey and the workshop. These are summarised in the table below. For ease of reference, in the second column, the user needs recommendations from section 0 have been mapped to seven broader recommendations.

Recommendation	Relevant user need discussion recommendations
Need: To better understand extremes and the transition along the continuum from historic through current to future climate. Addressed by: Continued use of large ensembles.	4, 9, 12, 14
Need: Validate CPM projections, especially of rainfall extremes at short (e.g. 1- 6-hour or shorter)and long (e.g. 24-hour +) durations, against observations. Addressed by: Validation to provide confidence limits in estimates of current and future projections.	2, 6, 7, 9, 12
Need: Better understanding of important compound parameters, to identify and provide estimates of current and future likelihood of extremes and 'threshold breaking' events Addressed by: Interaction between users and providers of climate information.	3, 5, 10, 12
Need: Estimate very extreme (i.e.>100-year return period) and probable maximum precipitation values in current and future climate across the UK, needed for highly vulnerable locations e.g. reservoir safety and other vulnerable infrastructure Addressed by: Use of CPM modelling, possibly with UNSEEN[13] approaches, to estimate these high extremes better.	4, 6, 9, 11
Need: Understand user impact thresholds better. Addressed by: Ensuring ongoing, close engagement between users and providers of climate information as well as 'science translators'. Science translators are key intermediaries who can translate climate science for appropriately for users and also inform providers of evolving user needs that might inform future science.	1, 3, 11, 16
Need: Clearer information on the skill in seasonal to decadal climate predictions[14]. Addressed by: Closer collaboration between users and providers to extract decision-relevant information from these.	14
Need: Maximising use of existing models and model outputs. Addressed by: Exhaustively testing and assess existing models to better understand model sensitivities before new sets of climate integrations designed to inform adaptation planning are initiated.	(Provider Survey)

[13] https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/wcssp/unseen-infographic.pdf

[14] Skill in such forecasts is available from the Met Office but it may be that improved or clearer information on skill and appropriate decisions that can be taken (e.g. low regrets decisions) would be useful.

4.2 Wider recommendations for the provision of new climate information

It has become clear through this project that there is significant opportunity for improving understanding of climate information needs by encouraging and enabling further collaboration between climate information providers and users.

Many of the responses from the Provider Survey, the workshop participants and participants in the July 2021 workshop have pointed to a strong need for these groups to work together more. JBA considers that the UKCR programme, and any subsequent evolution of the programme, would be a good vehicle to facilitate this. The benefits of closer collaboration would include:

- Increased understanding by information providers of:
  - the decisions users need to make with climate information
  - the thresholds that impact certain sectors that could encourage climate science and modelling to focus on better estimates of these threshold conditions
  - the uncertainties that the users understand to exist and their tolerances of different uncertainty levels, noting that these vary across and within both sectors and organisations
- Increased understanding by users of information about:
  - Modelling and science limitations – what is and isn't possible to predict or have projections for and why not
  - What climate model output is available to inform the decision they need to make
  - The role 'science translators' can play in using the climate information within tailored models or systems that provide user-oriented decision-support, (Science translators are also termed 'boundary managers' in recent research15.

An illustration of why we recognise this need for greater collaboration is shown in Figure 4-1. When posed with a question about what might be an optimum spatial resolution for CPM to estimate rainfall extremes, one comment (from a user) indicates this is for climate scientists and the other (from a provider) says scientists need to be informed by users. To gain the best answer to this question, relevant users and CPM model information providers need to work together, potentially with a 'science translator' who can help explain concepts, language etc., to arrive at the optimum spatial resolution. This is just one example in one technical area. There are many such cases for other climate information sources and for many other user sectors.

[15] Suhari, M. Dressel, M. Schuck-Zoller, S. Challenges and best-practices of co-creation: A qualitative interview study in the field of climate services. Climate Services. Volume 25, January 2022, 100282 https://doi.org/10.1016/j.cliser.2021.100282

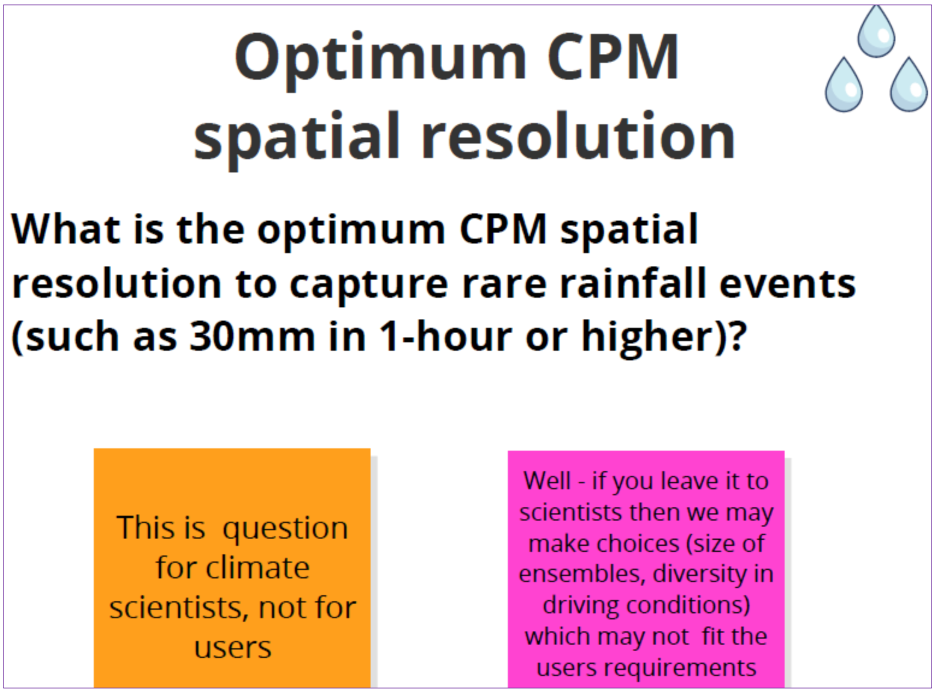


Figure 4-1 Excerpt from the Workshop conceptboard output exemplifying the need for closer user-provider collaboration

In this project, there has not been the opportunity to explore in depth how closer collaboration between users and providers of climate information might occur. Previously in this project the image in Figure 4-2 was developed to highlight a 'twin track' concept in which users and providers each have priorities and needs. The central part of this diagram, highlighted in the red box, proposes that increased collaboration between users and providers of climate information should be 'periodic and strategic'. This is because we see benefit in the interaction being structured and occurring with a periodicity that is practical (not too frequent) as well as sufficient (frequent enough) to have the most benefit for both communities. Strategic interaction implies that it occurs when there is an accepted important user need that should be discussed, or when there is a known 'step change' in the science and modelling information that is likely to impact decisions users will take compared to what they would decide using existing climate information.

There are also considerations such as which body should coordinate the interaction (if it needs formal coordination), which user and provider groups should be involved (ideally all, being as inclusive as possible), whether funding would be needed to promote and establish the interaction and how interaction is recorded and outcomes shared. To make effective use of public money, we would recommend that this be initiated by a publicly funded, cross sector body.

We recognise this an important recommendation in this project and one meriting more detailed analysis.

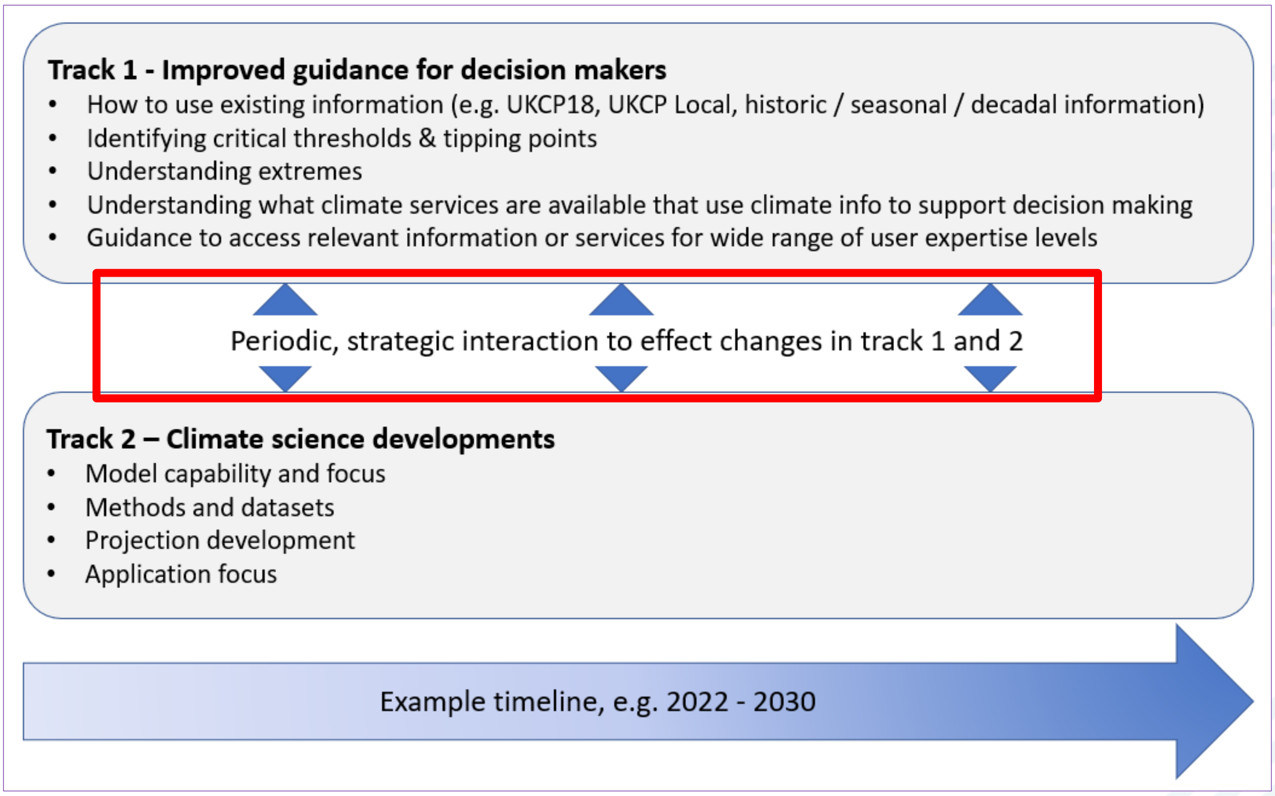


Figure 4-2 Graphical illustration of the user and provider 'tracks', and interaction

Appendices

A Workshop Agenda

CLIMATE INFORMATION TO INFORM UK DECISION MAKING

24th May 2022 Workshop: Climate information for the next decade: how to draw together climate information provider priorities and climate information user needs

Workshop Agenda	Timing
1. Participants joining	0930 - 0935
2. Explanation of the purpose of the workshop - what are we trying to achieve?	0935 - 0945
3. A statement on Government user needs from Katy Peat (Defra)	0945 - 0955
4. A statement on provider priorities drawn from online survey	0955 - 1005
5. Questions and answers	1005 - 1015
6. 5-minute break	1015 - 1020
7. Breakout discussions #1– exploring one user need area and questions (see second page) Explanation of task – each group will be allocated to one user need area (participants will be allocated to one user need area) • User need 1: tipping points and thresholds • User need 2: rainfall extremes • User need 3: moving from current to near-term future hazard After answering user need questions, consider the following two questions: • What specific activities are needed to address the three user needs discussed? (Including who should lead, rough timescales) • What should the funding mechanisms be to meet deliver these activities? Output: • Detail to inform future datasets for characterising current and future weather and climate risks in the UK and overseas • Identification of wider research gaps for provision of climate information for the UK • Specific activities that could be undertaken for the provision of a large UK ensemble • Views on potential funding mechanisms	1020 - 1120
8. 10-minute break	1120 - 1130
9. Breakout discussions #2– exploring user needs areas and ways to meet them As for breakout session #1, addressing a second user need (participants will be allocated to one user need area)	1130 - 1215
10. Plenary from second breakout session: derive lessons learnt from both / all groups	1215 - 1235
11. Workshop wrap-up: a. Summary of outcomes b. Project next steps c. Questions & answers from participants	1235- 1245
12. Workshop end / allowance for remaining discussion	1245 - 1300

Recognised, important user needs for climate information

Tipping points / thresholds

Rainfall extremes

Moving from current to near-term future hazard

Discussion points to address user needs

Tipping points / thresholds

- What do we mean by 'tipping points' / 'thresholds'?
- How can tipping points & thresholds best be identified and communicated from users to providers of climate information, and understood by the latter?
- Where are the 'low hanging fruit'? (i.e. what work can we build on or where are there quick wins?)

Rainfall extremes

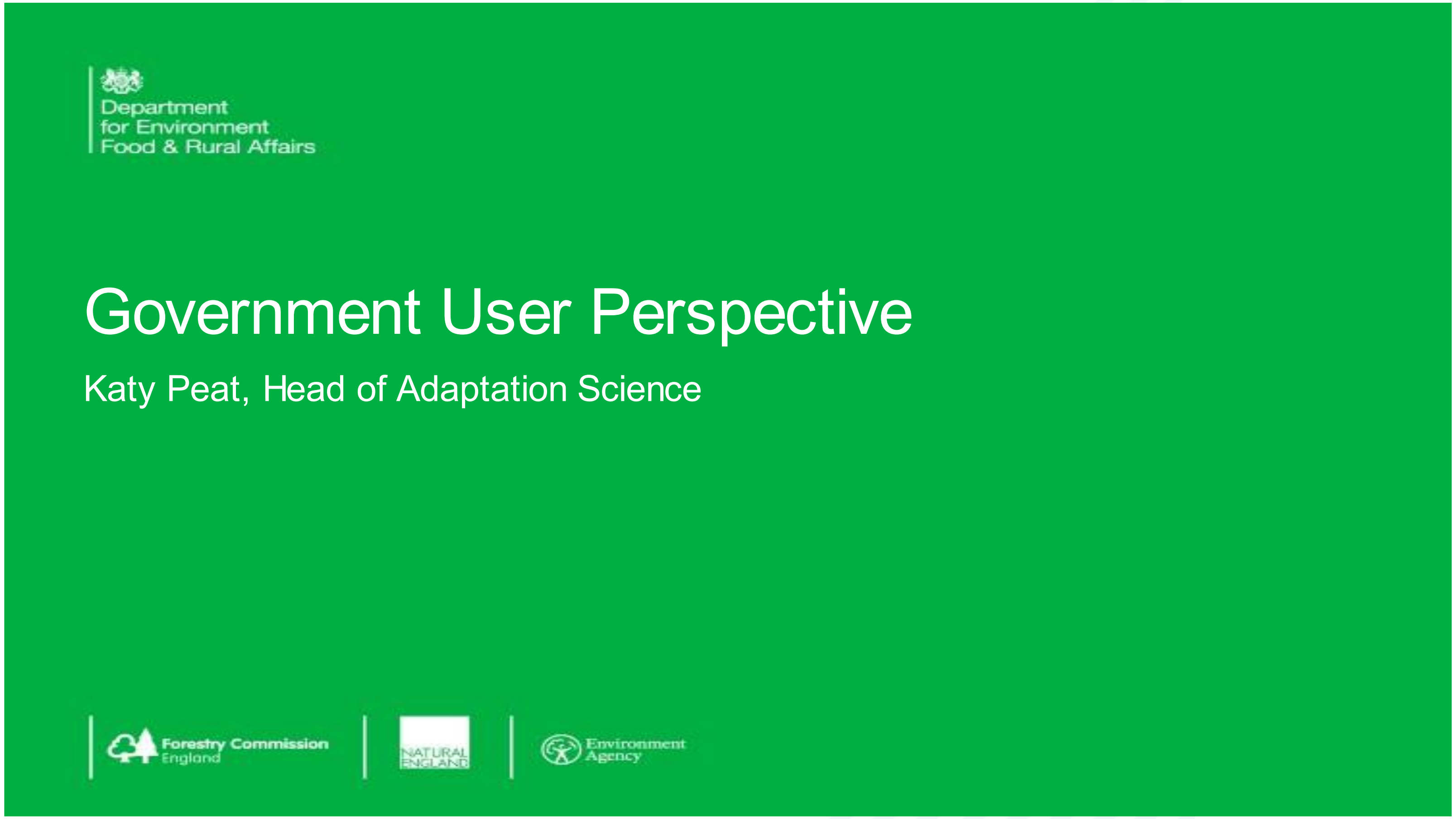
- Convective permitting modelling is needed for understanding intense rainfall change – do users understand its benefits and constraints? What more is needed to help people use the outputs?
- What is the optimum CPM spatial resolution to capture rare rainfall events (such as 30mm in 1-hour or higher)?
- What is the optimum CPM ensemble size, for say:
    - 100 year return period estimates?
    - 20,000-year return period estimates?
- What are the modelling constraints / implications of these optimums?
- How should resources be balanced between the generation of diverse boundary conditions for CPM simulations, and generation of the CPM simulations themselves?

Moving from current to near-term future hazard

- Are current observation data adequate for assessing climate hazards?
- How can we connect historic climate information with near-term (seasonal or 5- 10 year) future predictions?
- What multi-year to decadal climate predictions are currently available and how well linked to observations are they?
- What are the key priorities for understanding the change in a climate hazard from current to near-term future?
- What opportunities are there to develop better approaches to combine observational and model information to assess climate impacts?

Other user needs of importance that should be addressed outside this project:
Coastal means & extremes
Other hazard extremes (e.g. heatwaves, droughts)

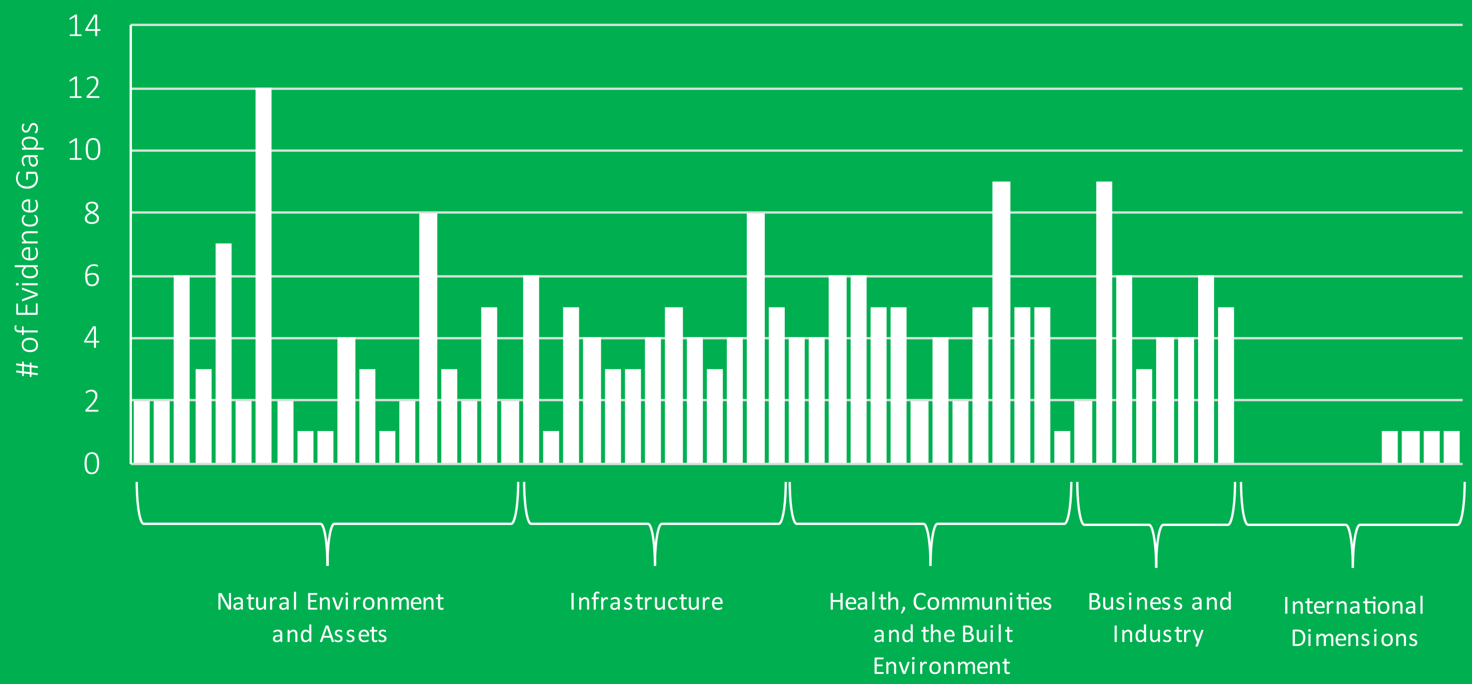
B UK Government user need information (presented by Katy Peat, Defra, 24th May 2022)



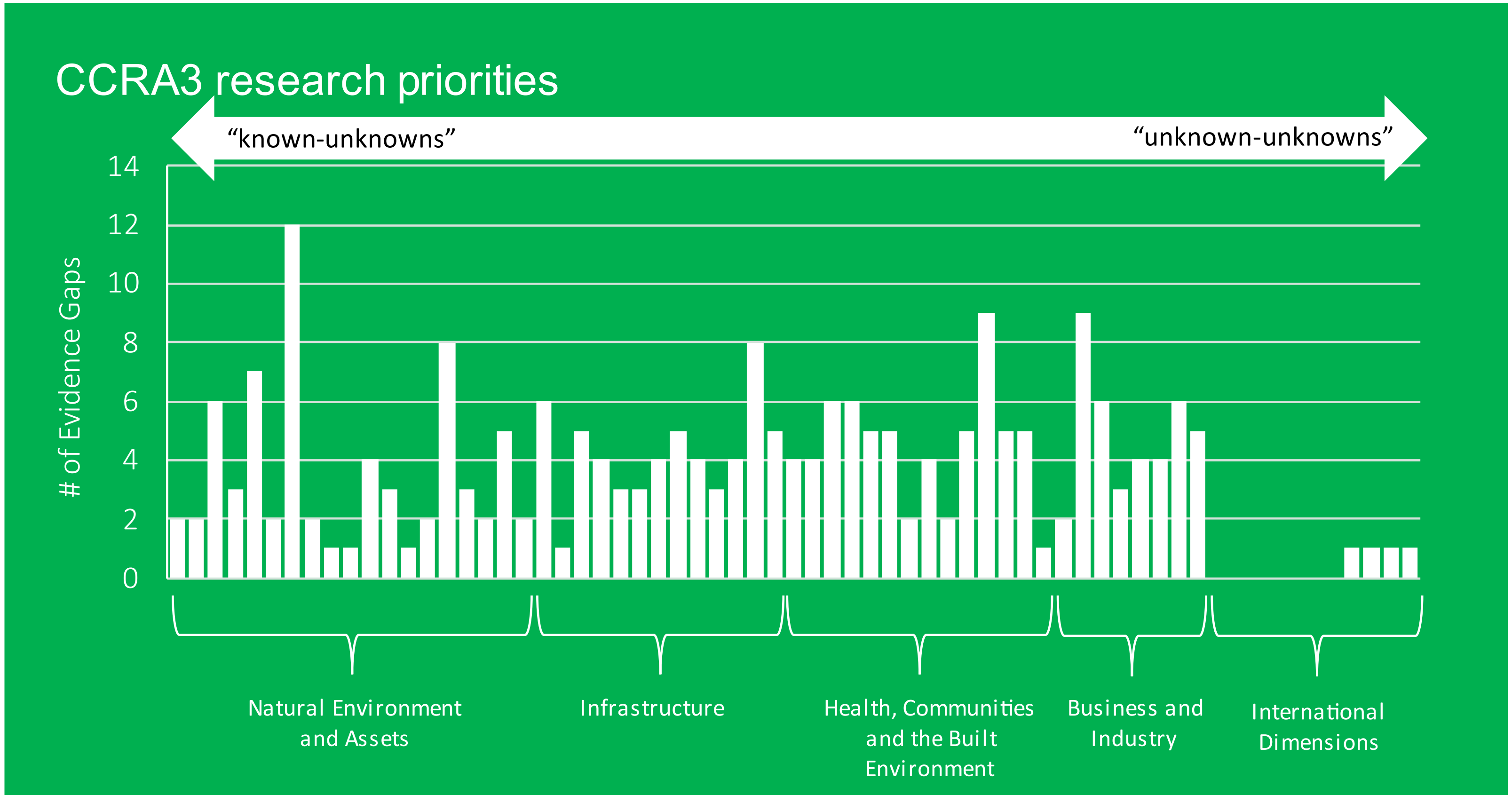
UKCP18 Development and Knowledge Sharing (DaKS) network

Knowledge Sharing	Improving Understanding	Improving Access	Additional datasets (low-medium)	Additional datasets (high)
Co-authored guidance with decision trees	Starter's guide/product summary	UX Testing of web pages	Rainfall event frequency/ distribution	Extremes indices e.g. based on State of the UK Climate Report
Peer-to-peer sharing seminar series	Guidance on use, e.g. factsheets on data products	UX Testing of User Interface	Storm severity and frequency	Downscaled CMIP5

CCRA3 research priorities



Number of research priorities outlined in CCRA3 organised according to sector and risk.



Number of research priorities outlined in CCRA3 organised according to sector and risk.

Adaptation R&I Framework

Scoping (Spring/Summer 2022)

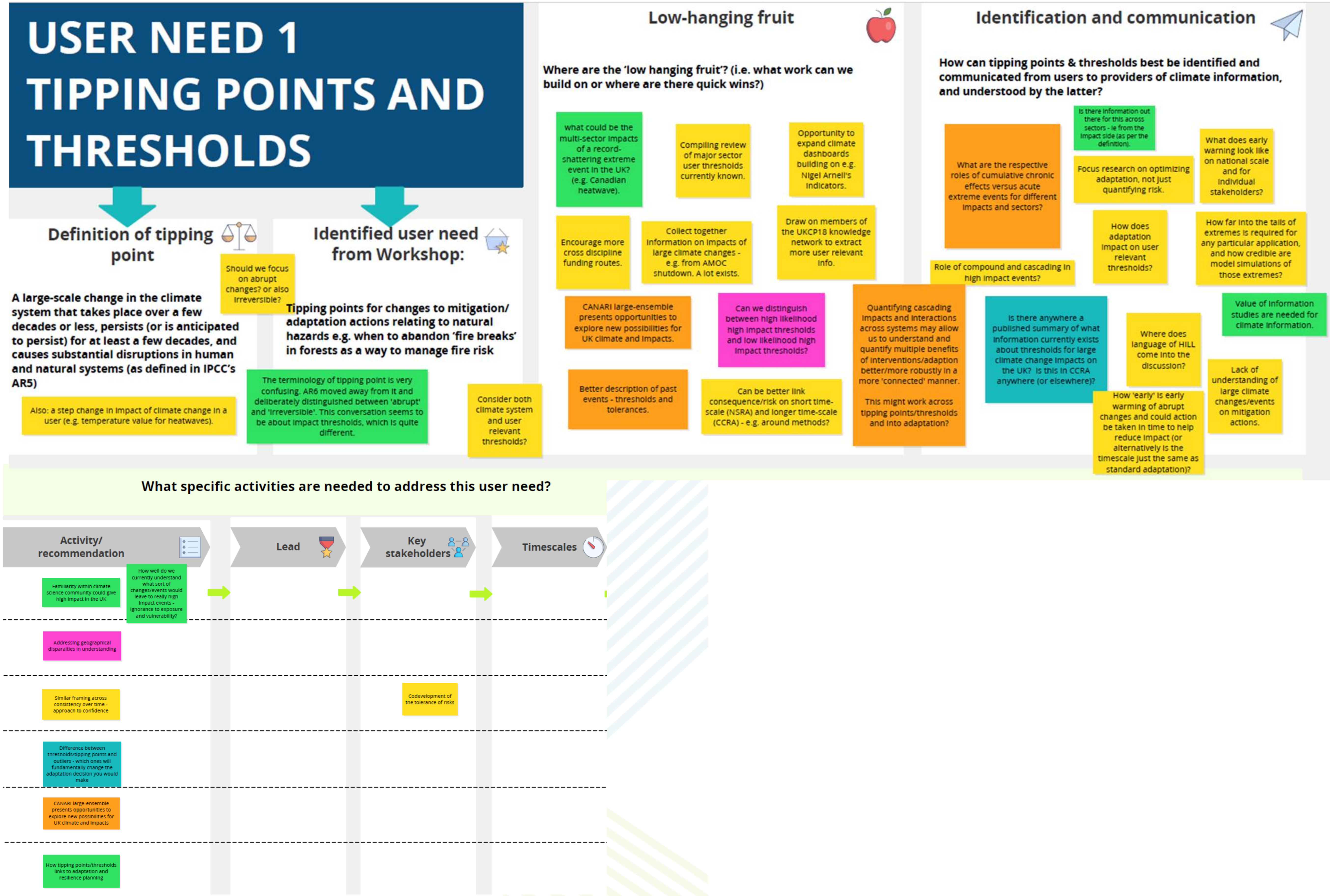
Consultation (Autumn 2022)

Drafting (Winter 2022)

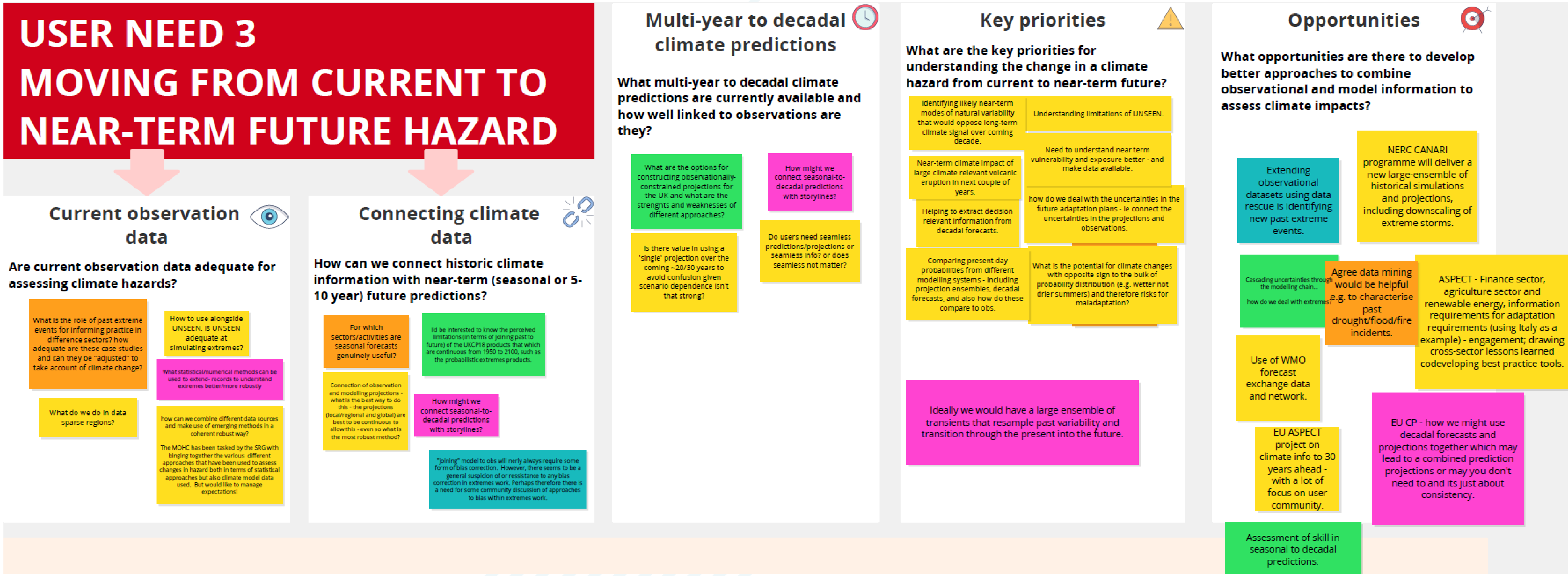
Iteration with NAP3 (Spring/Summer 2023)

Considering CCRA4

- How can we better include:
  - Spatial considerations
    - How does risk vary regionally/locally?
    - How should a national assessment incorporate local risk?
  - Economic analysis
    - Can we compare cost-benefit analysis across risks and sectors?
    - How do we measure the cost effectiveness of interventions?
    - How do we value mid to longer term benefits of adaptation?
- How effective are adaptation actions?
- How can we maximise the utility of the CCRA?


USER NEED 1
TIPPING POINTS AND THRESHOLDS
Definition of tipping point
A large-scale change in the climate system that takes place over a few decades or less, persists (or is anticipated to persist) for at least a few decades, and causes substantial disruptions in human and natural systems (as defined in IPCC's AR5)
Should we focus on abrupt changes? or also irreversible?
Also: a step change in impact of climate change in a user (e.g. temperature value for heatwaves).
Identified user need from Workshop:
Tipping points for changes to mitigation/ adaptation actions relating to natural hazards e.g. when to abandon 'fire breaks' in forests as a way to manage fire risk
The terminology of tipping point is very confusing. AR6 moved away from it and deliberately distinguished between 'abrupt' and 'irreversible'. This conversation seems to be about impact thresholds, which is quite different.
Consider both climate system and user relevant thresholds?
Low-hanging fruit
Where are the 'low hanging fruit'? (i.e. what work can we build on or where are there quick wins?)
What could be the multi-sector impacts of a record-shattering extreme event in the UK? (e.g. Canadian heatwave).
Compiling review of major sector user thresholds currently known.
Opportunity to expand climate dashboards building on e.g. Nigel Arnell's indicators.
Encourage more cross discipline funding routes.
Collect together information on impacts of large climate changes - e.g. from AMOC shutdown. A lot exists.
Draw on members of the UKCP18 knowledge network to extract more user relevant info.
CANARI large-ensemble presents opportunities to explore new possibilities for UK climate and impacts.
Can we distinguish between high likelihood high impact thresholds and low likelihood high impact thresholds?
Quantifying cascading impacts and interactions across systems may allow us to understand and quantify multiple benefits of interventions/adaption better/more robustly in a more 'connected' manner.
This might work across tipping points/thresholds and into adaptation?
Better description of past events - thresholds and tolerances.
Can be better link consequence/risk on short time-scale (NSRA) and longer time-scale (CCRA) - e.g. around methods?
Identification and communication
How can tipping points & thresholds best be identified and communicated from users to providers of climate information, and understood by the latter?
Is there information out there for this across sectors - ie from the impact side (as per the definition).
What are the respective roles of cumulative chronic effects versus acute extreme events for different impacts and sectors?
Focus research on optimizing adaptation, not just quantifying risk.
What does early warning look like on national scale and for individual stakeholders?
Role of compound and cascading in high impact events?
How does adaptation impact on user relevant thresholds?
How far into the tails of extremes is required for any particular application, and how credible are model simulations of those extremes?
Is there anywhere a published summary of what information currently exists about thresholds for large climate change impacts on the UK? Is this in CCRA anywhere (or elsewhere)?
Where does language of HILL come into the discussion?
Value of information studies are needed for climate information.
Lack of understanding of large climate changes/events on mitigation actions.
How 'early' is early warning of abrupt changes and could action be taken in time to help reduce impact (or alternatively is the timescale just the same as standard adaptation)?
What specific activities are needed to address this user need?
Activity/ recommendation
Lead
Key stakeholders
Timescales
Familiarity within climate science community could give high impact in the UK
How well do we currently understand what sort of changes/events would leave to really high impact events - ignorance to exposure and vulnerability?
Addressing geographical disparaities in understanding
Similar framing across consistency over time - approach to confidence
Codevelopment of the tolerance of risks
Difference between thresholds/tipping points and outliers - which ones will fundamentally change the adaptation decision you would make
CANARI large-ensemble presents opportunities to explore new possibilities for UK climate and impacts
How tipping points/thresholds links to adaptation and resilience planning


USER NEED 2
RAINFALL EXTREMES
Convective permitting modelling
This is needed for understanding intense rainfall change – do users understand its benefits? Is more needed to convince them?
Yes users want projections of intense rainfall, but they want to know they can depend on it.
They understand the benefits in terms of rainfall extremes, but don't really understand how much more is needed.
Is this really a question of do users understand the consequences of asking for lots and lots of CPM data? as that will mean there is less other information (differnt warming levels or characterising modelling uncertianty for example) so in the users perspective is the cost of the CPM worth the benefits.
Historical empirical adequacy of CPM needs to be demonstarted.
Optimum CPM spatial resolution
What is the optimum CPM spatial resolution to capture rare rainfall events (such as 30mm in 1-hour or higher)?
This is question for climate scientists, not for users.
Well - if you leave it to scientists then we may make choices (size of ensembles, diversity in driving conditions) which may not fit the users requirements.
Optimum CPM ensemble size
What is the optimum CPM ensemble size, for say:
- 100 year return period estimates?
- 20,000-year return period estimates?
Applications for intense rainfall, e.g. surface water flooding, require lower return periods (e.g. 1:30) than floods and droughts (1:500 for the latter).
I wonder if this might be better posed by asking what is the level of uncertainty users can work with for their particular extreme level. Providers can then have a go at the uncertainty budget and see where the resources should be placed resolution/ensemble size/physics uncertainty.
Modelling constraints
What are the modelling constraints / implications of these optimums?
To access the full benefits of higher resolution to resolve circulation patterns, this needs to be run in GCMs.
Insufficient performance assessment in UKCP18 of the CPM modelling results with observations.
Do we understand the uncertainty budget along chain from global model, regional, local model of ppn to flooding, inundation and impact?
Balancing resources
How should resources be balanced between the generation of diverse boundary conditions for CPM simulations, and generation of the CPM simulations themselves?
More effort needs to be invested in validation in baseline conditions.
Related to another post - perhaps a better characterisation of the uncertainty budget for specific cases (eg urban drainage vs coastal defence vs heatwaves) would help guide this decision.
Maximise diversity, completeness and independence of sources of evidence (from climate information).
What specific activities are needed to address this user need?
Activity/ recommendation
Lead
Key stakeholders
Timescales
Improved validation
Exploration of a variety of methods to derive rainfall extremes: physical, statistical
narrative description of rainfall extremes from the different model outputs/ sources of evidence


USER NEED 3
MOVING FROM CURRENT TO NEAR-TERM FUTURE HAZARD
Current observation data
Are current observation data adequate for assessing climate hazards?
What is the role of past extreme events for informing practice in difference sectors? how adequate are these case studies and can they be "adjusted" to take account of climate change?
How to use alongside UNSEEN. Is UNSEEN adequate at simulating extremes?
What statistical/numerical methods can be used to extend- records to understand extremes better/more robustly
What do we do in data sparse regions?
how can we combine different data sources and make use of emerging methods in a coherent robust way?
The MOHC has been tasked by the SRG with binging together the various different approaches that have been used to assess changes in hazard both in terms of statistical approaches but also climate model data used. But would like to manage expectations!
Connecting climate data
How can we connect historic climate information with near-term (seasonal or 5-10 year) future predictions?
For which sectors/activities are seasonal forecasts genuinely useful?
I'd be interested to know the perceived limitations (in terms of joining past to future) of the UKCP18 products that which are continuous from 1950 to 2100, such as the probabilistic extremes products.
Connection of observation and modelling projections - what is the best way to do this - the projections (local/regional and global) are best to be continuous to allow this - even so what is the most robust method?
How might we connect seasonal-to-decadal predictions with storylines?
"Joining" model to obs will nerly always require some form of bias correction. However, there seems to be a general suspicion of or ressistance to any bias correction in extremes work. Perhaps therefore there is a need for some community discussion of approaches to bias within extremes work.
Multi-year to decadal climate predictions
What multi-year to decadal climate predictions are currently available and how well linked to observations are they?
What are the options for constructing observationally-constrained projections for the UK and what are the strenghts and weaknesses of different approaches?
How might we connect seasonal-to-decadal predictions with storylines?
Is there value in using a 'single' projection over the coming ~20/30 years to avoid confusion given scenario dependence isn't that strong?
Do users need seamless predictions/projections or seamless info? or does seamless not matter?
Key priorities
What are the key priorities for understanding the change in a climate hazard from current to near-term future?
Identifying likely near-term modes of natural variability that would oppose long-term climate signal over coming decade.
Understanding limitations of UNSEEN.
Near-term climate impact of large climate relevant volcanic eruption in next couple of years.
Need to understand near term vulnerability and exposure better - and make data available.
Helping to extract decision relevant information from decadal forecasts.
how do we deal with the uncertainties in the future adaptation plans - ie connect the uncertainties in the projections and observations.
Comparing present day probabilities from different modelling systems - including projection ensembles, decadal forecasts, and also how do these compare to obs.
What is the potential for climate changes with opposite sign to the bulk of probability distribution (e.g. wetter not drier summers) and therefore risks for maladaptation?
Ideally we would have a large ensemble of transients that resample past variability and transition through the present into the future.
Opportunities
What opportunities are there to develop better approaches to combine observational and model information to assess climate impacts?
Extending observational datasets using data rescue is identifying new past extreme events.
NERC CANARI programme will deliver a new large-ensemble of historical simulations and projections, including downscaling of extreme storms.
Cascading uncertainties through the modelling chain...
how do we deal with extremes?
Agree data mining would be helpful e.g. to characterise past drought/flood/fire incidents.
ASPECT - Finance sector, agriculture sector and renewable energy, information requirements for adaptation requirements (using Italy as a example) - engagement; drawing cross-sector lessons learned codeveloping best practice tools.
Use of WMO forecast exchange data and network.
EU ASPECT project on climate info to 30 years ahead - with a lot of focus on user community.
EU CP - how we might use decadal forecasts and projections together which may lead to a combined prediction projections or may you don't need to and its just about consistency.
Assessment of skill in seasonal to decadal predictions.

What specific activities are needed to address this user need?

Activity/ recommendation	Lead	Key stakeholders	Timescales
Thinking about more lines of evidence about the outlying results; Recognition we can't deal with determinism in the future and if we do it should be caveated (in the adaptation engineering space)			
Assess the physical probability - connection between past extreme events - how are they used and how should they be used? What alternatives should we offer?; To include why it is in the tail of distribution than just the central within the storyline approach			
Investigation into the cascade of the impacts - and with the change to electricity / net zero will have massive impacts			
Better understand our vulnerability and exposure and looking at combined hazards and repeated events			
systematic survey of and research into mechanisms that could lead to high impact "surprises" either because of unexpected changes in climate or because of poor understanding of current and future changing vulnerability/exposure			
Large ensemble of transients from past to future			
Statistical methods for estimating (instantaneous) probabilities of extremes in a non-stationary climate			

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