Scenarios and Uncertainties: Role of IAMs (and Other Methods)

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ENERGY MODELING FORUM

Workshop on Climate Change Impacts and Integrated Assessment (CCI/IA)

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Three Uses of Scenarios

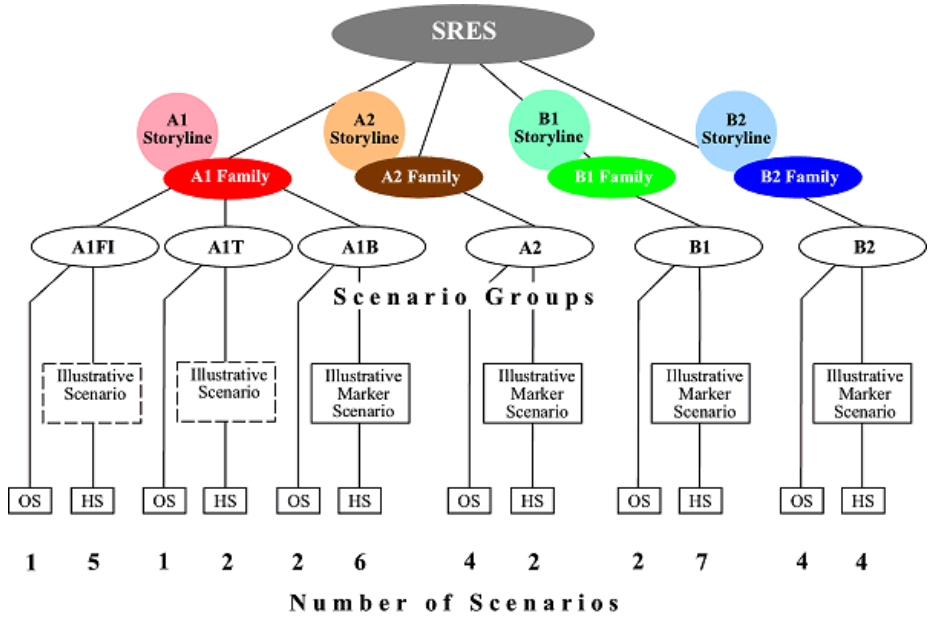
Scenarios are not predictions but are descriptions of alternative futures and can be an effective means of:

1. Coordinating interdisciplinary science and assessment
2. Evaluating implications of uncertainty for decisions
3. Informing decisions and communicating with stakeholders and decisionmakers

Context matters: Scenario users

Two types of users, two types of scenarios

- **Decision makers** ➔ Scenarios can be tailored to the specific decision context
- **Intermediate users** (analysts, scientists, contributors to assessments) ➔ Scenarios for strategic exploration of futures



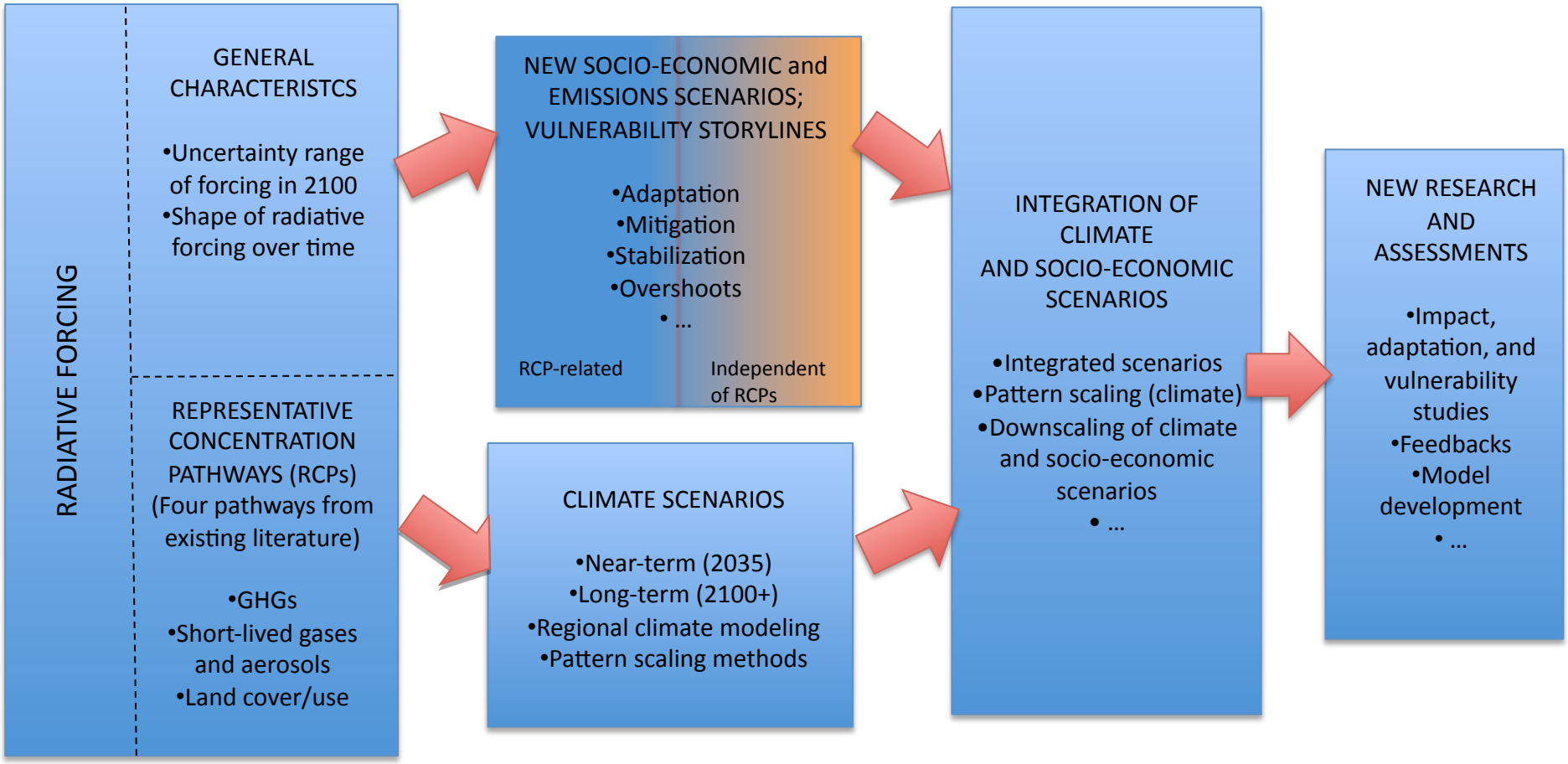
Source: Elmar Kriegler

Elmar Kriegler, Brian O'Neill, Stephane Hallegatte, Tom Kram, Rob Lempert, Tom Wilbanks: Socio-economic Scenario Development for Climate Change Ana;ysis

1. Scenarios to Coordinate Interdisciplinary Research and Assessment

- Different types of scenarios (socio-economic, emissions, climate, environmental) have typically been used in a sequential fashion to coordinate research and link sets of studies
- A new process (IPCC 2007; Moss et al., 2010) was developed to alter this process so that climate and socioeconomic scenarios (including for VIA analysis) could be developed in parallel with climate scenarios
- The process rests on the observation that many different socioeconomic futures can be associated with a particular climate future
- The process encourages development of exploratory socioeconomic scenarios nested within the broader bounding context provided by a set of "Representative Concentration Pathways"

Context: "Parallel Process"

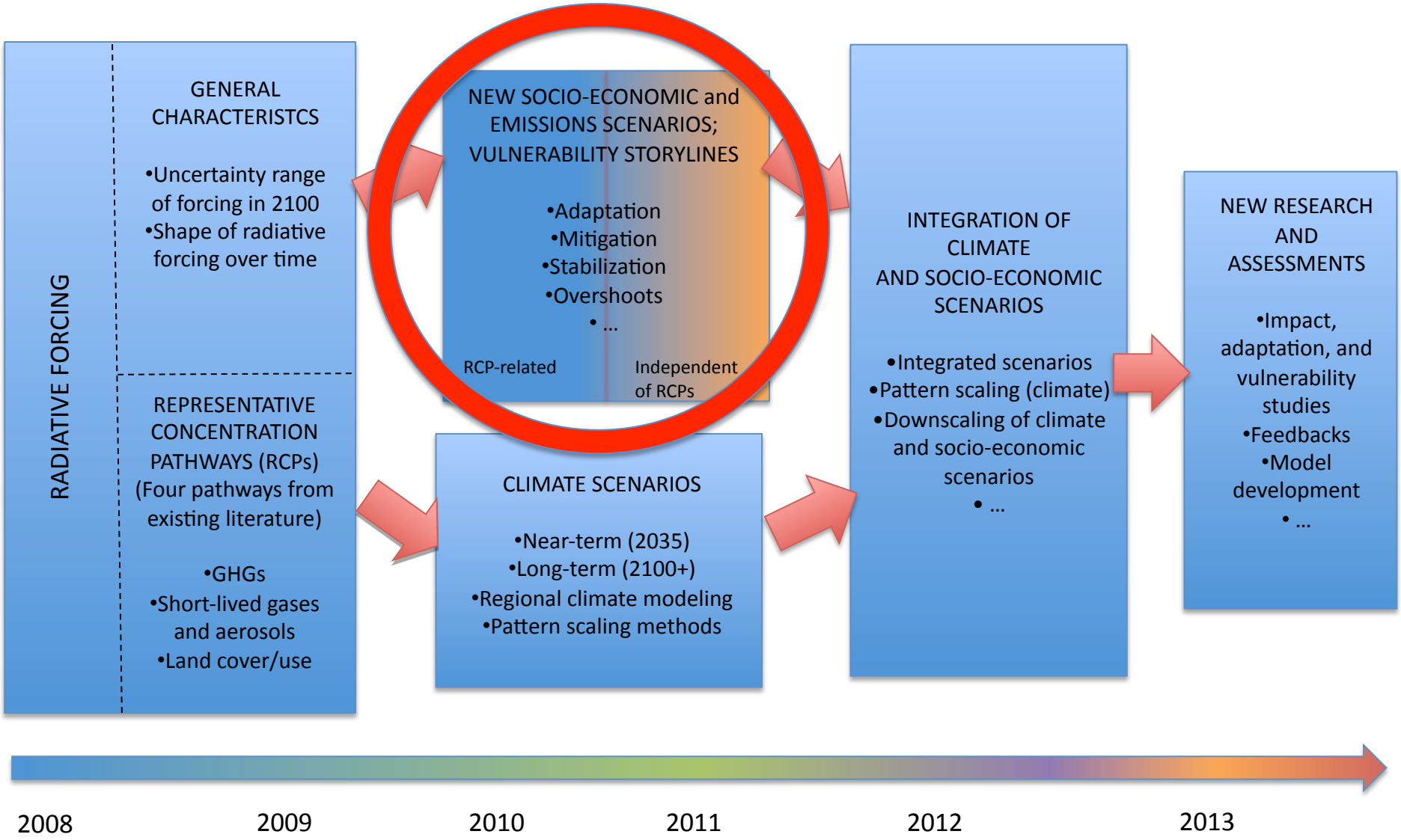


Source: Moss et al. 2010

RCP-Based Climate Scenarios

- Long term scenarios to 2100+
  - For all RCPs
  - 1° to 2° resolution
- Near-term scenarios to 2035
  - "Decadal prediction" (research issue)
  - Higher resolution (0.5° to 1°)
  - Additional information on extremes
  - RCP4.5
- Pattern scaling using simple models forced with different scenarios (research issue)

Context: "Parallel Process"



Source: Moss et al. 2010

Socioeconomic Narratives and Scenarios

- RCP-related
  - IAMC, EMF, RECIPE, ADAM, RoSE, Asia Modeling Exercise, EU framework projects are encouraging work in this area
  - Need narratives and scenarios to explore a wide range of futures (especially related to VIA)
  - Questions explored during CCI/IA day 1:
    - What does it mean to be part of a family of RCP-related scenarios?
    - What factors to include?
      - Relationship of global and regional/local conditions for VIA?
      - How detailed?
    - Time scales?
    - For IPCC, how to identify a workable number of socio-economic narratives and scenarios?
- New scenarios unrelated to the RCPs are also being developed to explore alternative stabilization levels, higher overshoot pathways, etc.

Describing Socio-Economic and Environmental Futures for Climate Change Research and Assessment

February 4-5, 2010 **Washington, DC**

Organized by the US National Research Council with sponsorship from DOE, NSF, NOAA, and NIES (Japan)

Personal Reflections from the NRC Socioeconomic Scenarios Workshop

- Nonclimate events will be more important than climate events in the short term; for climate in the short term, focus on extremes
- For longer timescales, examine factors with large inertia such as education levels, income distributions, and urbanization
- There are too many drivers to include—focus on a few key drivers: governance and institutions, access to public-sector services, ecosystem services, urbanization, and globalization and trade
- Pursuing both adaptation and mitigation will create constraints—energy, water, and land use interactions
- Use non-governmental character of process to explore "worst-case" alternative baselines and policy narratives
- Identifying desired end points and developing scenarios by working backward from those states holds promise

Framework for Nested Scenarios

- The RCPs are consistent with a very broad range of socioeconomic futures
- A few "light touch" narratives and scenarios should provide a bounding framework into which scenarios for particular sectors, regions, or decisions can be developed
  - Bound key uncertainties at scale of globe and large regions
  - Should not attempt to determine regional/local conditions/trends with global data sets or models
  - Consider what processes are tightly and loosely coupled across scales
  - Potential for stakeholder engagement
- Technical guidelines and methods for developing local scenarios for testing out specific decisions nested within the RCPs and RSPs would also be useful (see, e.g., Zurek and Henrichs, 2007)
  - E.g., are there combinations of socioeconomic factors unlikely to occur under specific RCPs?
  - Encourage application of diverse methods and approaches
- It was questioned whether the community is organized to do all of what is needed on timescales needed by the AR5

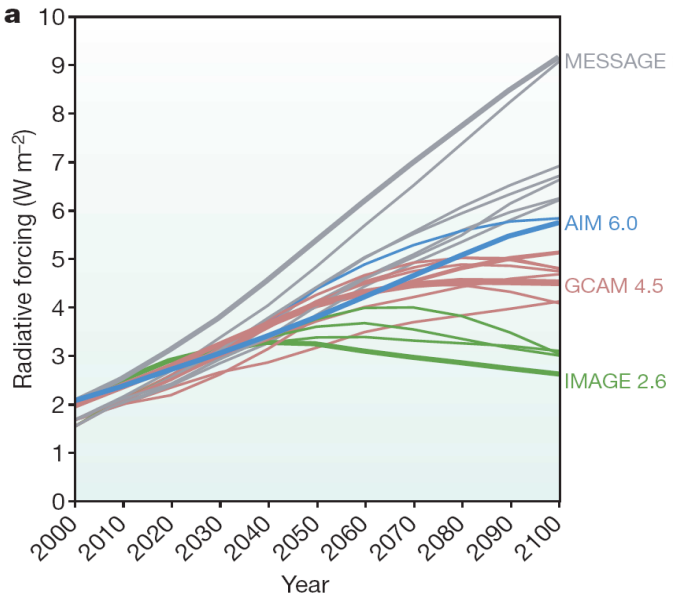
2. Scenarios to Evaluate Uncertainty

By spanning ranges of uncertain variables or outcomes, scenarios can be used in analysis to assess the robustness of options to a range of possible futures

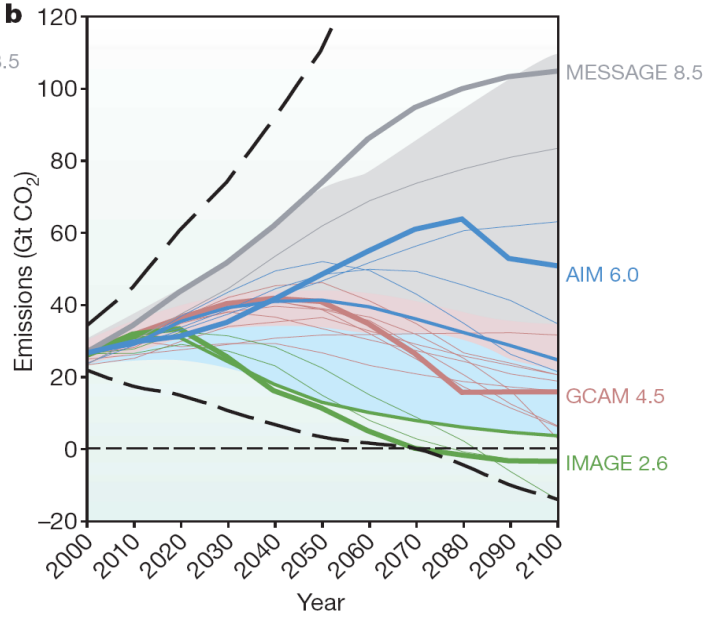
ppmv*	CO_2eq*
950	1430
670	790
520	650
410	450

*in 2100

Span RF scenarios



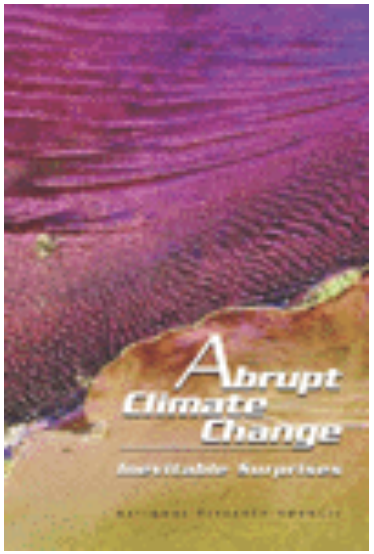
Represent 10-90th emissions



Sources: Detlef VanVuuren, Jae Edmonds

Still Need to Incorporate "Inevitable" Surprise

- Large shifts in climate that persist for years or longer over a widespread area
- Slow-down or cessation of ocean circulation due to influx of fresh water
- Melting of the Greenland Ice Sheet
- Carbon Cycle Feedbacks
- Potential for Extreme Extreme Events



Uncertainty in Complex Regional Models

nature

www.nature.com/nature

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Validation required

Transparency and quality control are essential in the highly uncertain business of assessing the impact of climate change on a regional scale.

Climate scientists are engaged in a lively debate about how — or whether — the Intergovernmental Panel on Climate Change (IPCC) should reform itself (see *Nature* 463, 730–732; 2010). At a minimum, the panel needs to hold itself to the highest possible standards of quality control in future assessments.

But so do climate scientists themselves — especially those who study the links between global climate change and its potential regional effects on factors such as weather patterns, ecosystems and agriculture. Governments faced with the need to make difficult, disruptive and politically fraught decisions about when and how to respond to climate change are understandably eager for certainty. But certainty is what current-generation regional studies cannot yet provide. Researchers need to resist the pressures to overstate the robustness of their conclusions, and to be as open as possible about where the uncertainties lie.

As an example of the scientific challenges involved, imagine a regional authority wanting to plan for water resources in a river basin over the next four decades. An applicable study might be probabilistic in approach. It could take into account a range of global greenhouse-gas-emission trajectories, and involve multiple runs of global climate models using different values for a number of parameters. However, such models cannot reproduce some important atmospheric phenomena such as circulation trapping, and cannot be validated against real climate behaviour over decadal timescales. The multiple runs will produce a probability distribution of precipitation which itself will contain intrinsic uncertainties. These outcomes then need to be fed into a catchment model with its own range of parameters and limitations of knowledge, and which in turn needs to be coupled to models of water demand as local housing and populations change over the period (M. New *et al. Phil. Trans. R. Soc. A* 365, 2117–2131; 2007, and other papers in that issue).

Climate projections at the national level are crucial for such efforts. One such study was published last year, when the UK Met Office produced its climate projections of the next eight decades, including analysis down to a resolution of 25-kilometre squares (http://ukclimateprojections.defra.gov.uk). The British government is now conducting a national climate-change risk assessment, due for completion in early 2012, that uses the projections. But such an application could well be problematic: it is likely that the projections reflect the limitations of the models and analyses as much as probabilities intrinsic to the real world. Yet regional planners and others might easily miss the detailed discussions of uncertainties, and misguidedly seize on these projections as a solid basis for investment decisions. And depressingly for decision-makers, the more the uncertainties are explored, the greater the ranges in the projected possible outcomes are likely to become.

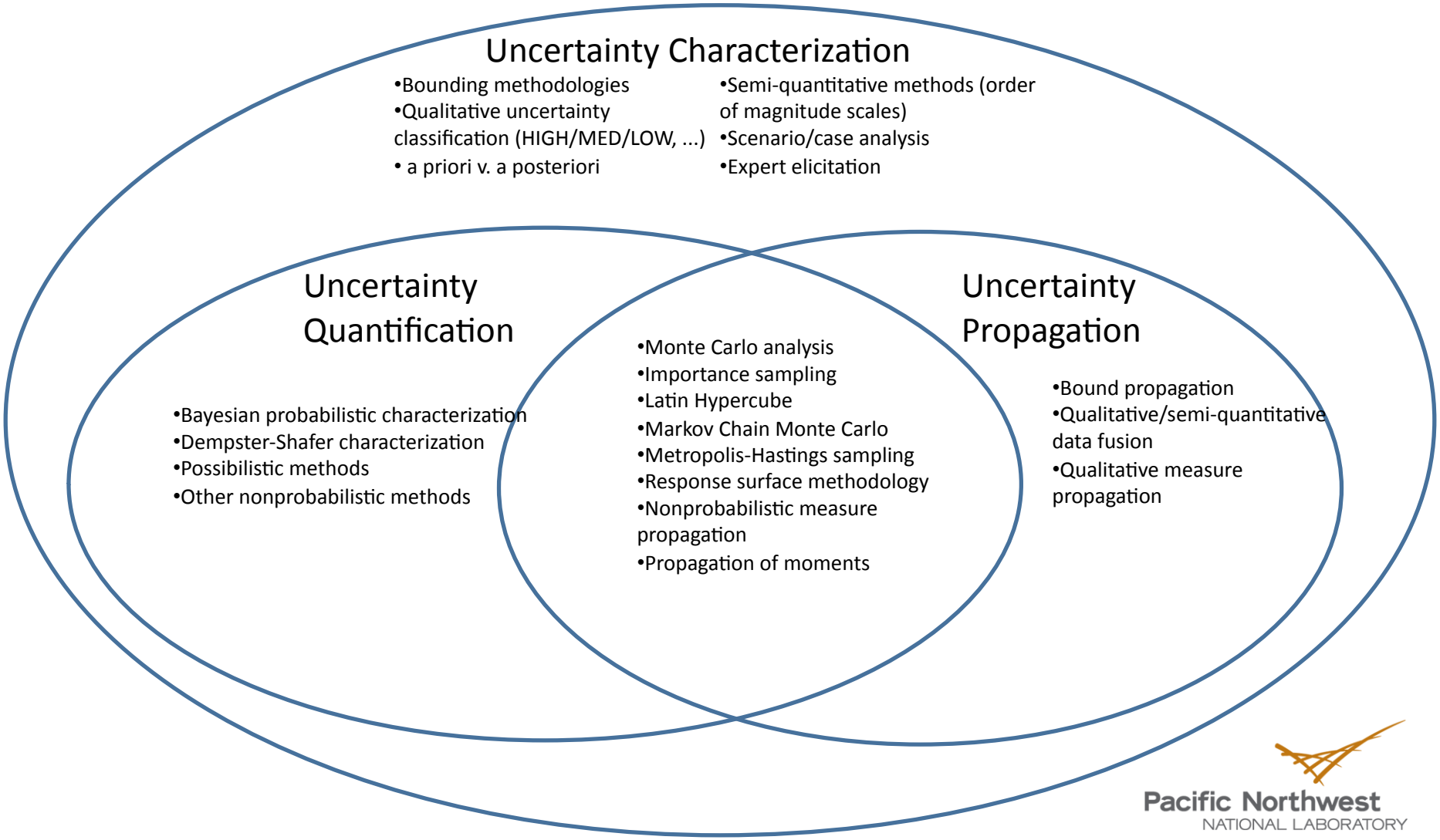
This combination of projections and risk analysis is one way in which an over-reliance by decision-makers on modelling may be setting up the scientific community for a loss of trust. What is more, like regional-impact studies, such analyses often appear not in peer-reviewed journals but in 'the grey literature' — in reports, or on websites. Yet they are no less important in representing the outputs of climate science, and need to be included in the IPCC assessment. For these reasons, such grey studies should be transparently peer reviewed as a part of their commission.

"Grey-literature studies should be transparently peer reviewed as a part of their commission."

Uncertainties about future climate effects do not undermine the case for action to reduce greenhouse-gas emissions. But there is a long way to go in the science before regional-impact studies provide a suitable basis for detailed planning. Whatever the pressures, statements by scientists and government agencies about such studies need to be well qualified, and policies based on them need to be kept as flexible as possible. It is intrinsic to this research, after all, that scientists' best judgements will be subject to change. ■

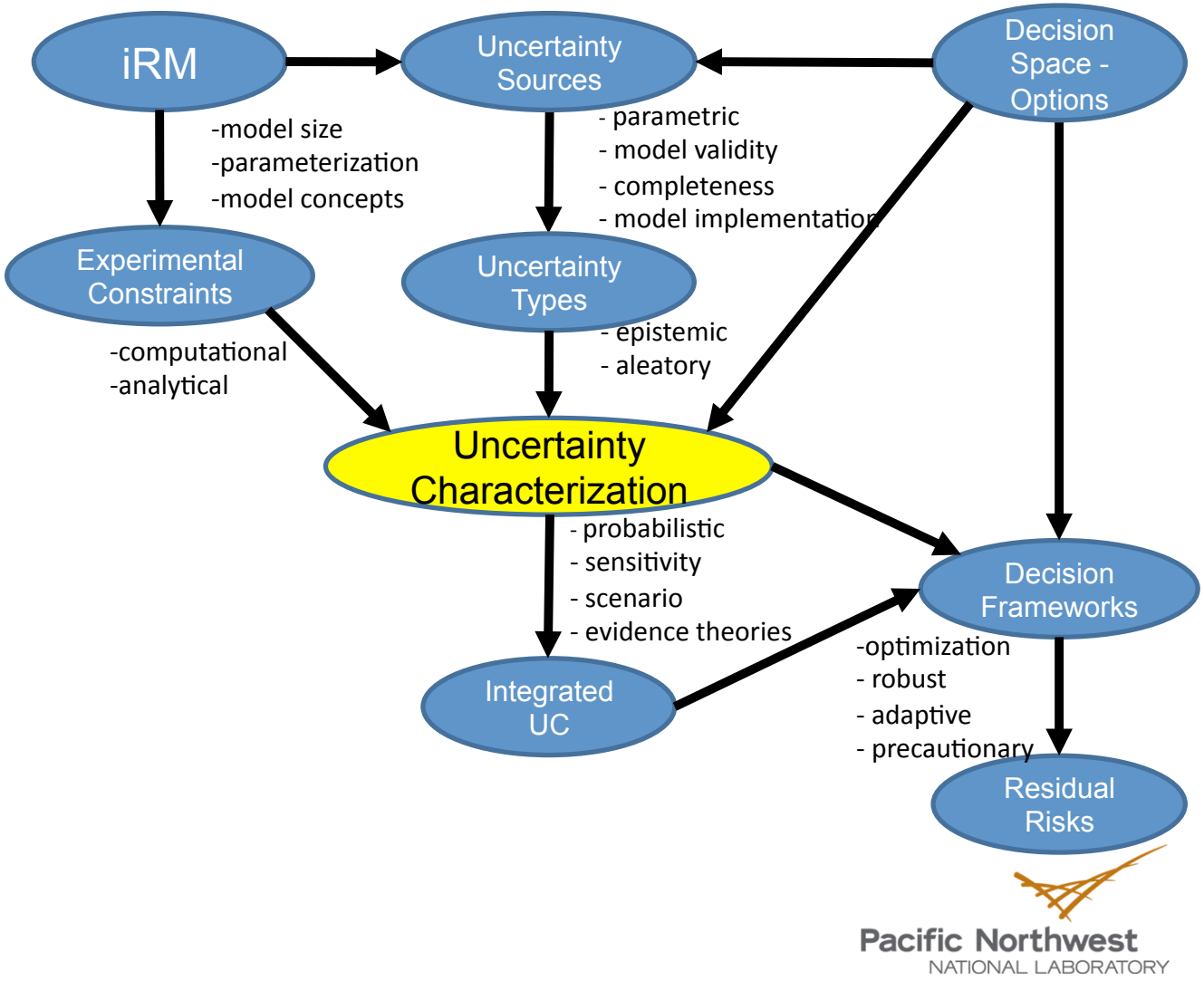
- "…it is likely that the projections reflect the limitations of the models and analyses as much as probabilities intrinsic to the real world. "
- "…the more the uncertainties are explored, the greater the ranges in the projected possible outcomes are likely to become."
- "…an over-reliance by decision-makers on modelling may be setting up the scientific community for a loss of trust."

Scenarios Are Just One of Many Approaches to Characterize Uncertainty



Source: S. Unwin

Example: Uncertainty Characterization Within an Applied Modeling Project



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3. Scenarios to Inform Decisions and Communicate with Stakeholders

- Traditional integrated assessment is plagued by the lack of thorough integration of social and institutional domains
- Participatory integrated assessment (PIA) framework (Robinson et al., 2009) can connect climate change mitigation and adaptation decisions to broader development priorities and decisions

The Challenge…

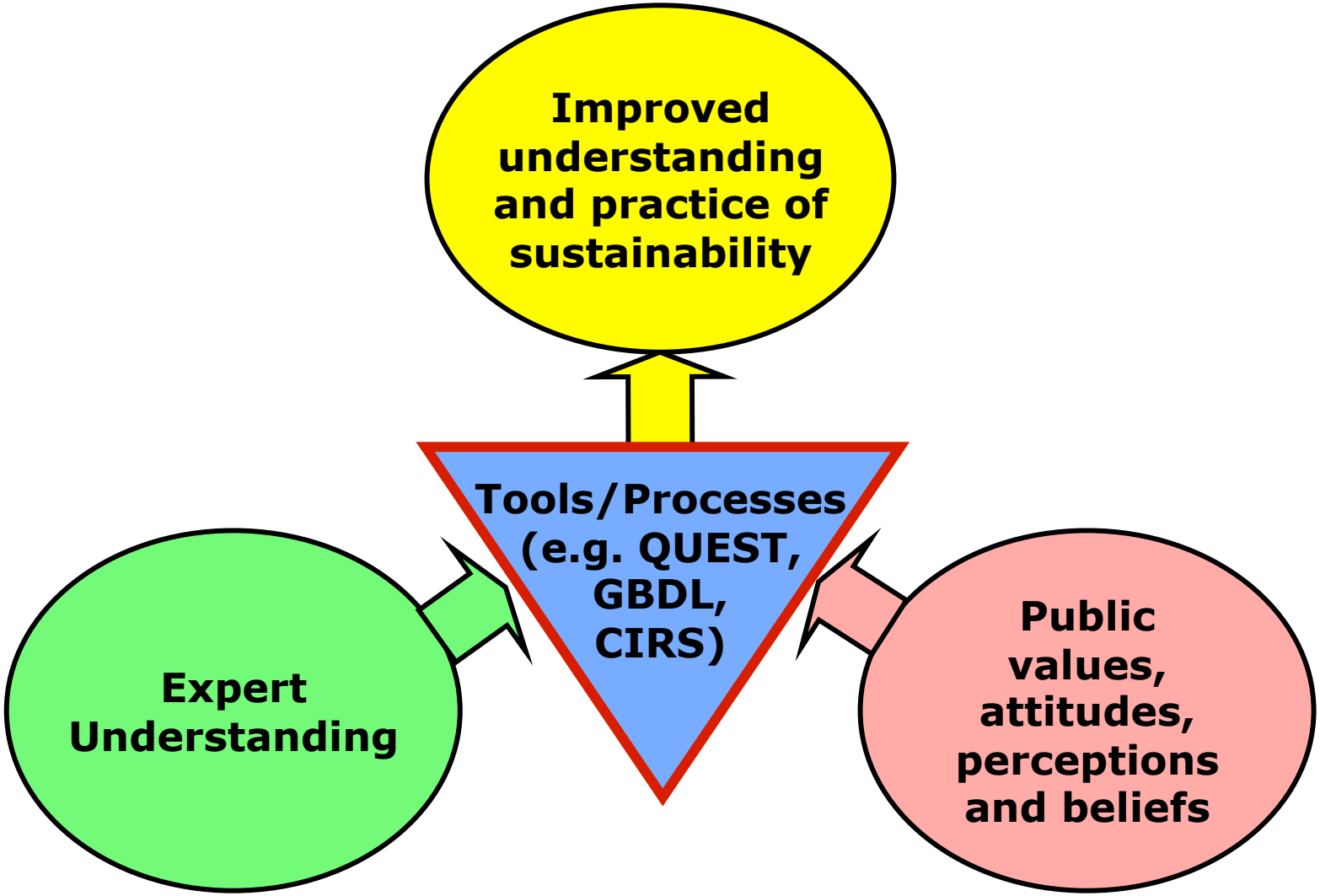
"the real purpose of modeling is not to describe the world but to change the mental models in the heads of users" Pierre Wack, Harvard Business Review, 1985

"most people in our culture are alienated from large systems… because most of it is noise to them. …people lack the mental models that would allow them to convert that noise to useful information" John Hiles, 1995

"information is the garbage of the nineties" Neil Postman, Technopoly, 1992

Source: John Robinson, UBC

Knowledge Synthesis



Source: John Robinson, UBC

MetroQuest Workshops

Discussing Priorities

Making Choices

Reviewing Scenarios

Discussing Implementation


MetroQuest GO TO 2040 - Landing Page - Windows Internet Explorer
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Chicago Metropolitan Agency for Planning
GO TO 2040
imagine that...
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AND AFFILIATES
VISIT 2040
ENTER
Take a quick tour.
Change the future through a couple of choices and spend a little time in 2040!
(Best with speakers on)
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INVENT 2040
ENTER
Get creative.
Make choices about the future and see maps and graphs showing what life might be like in 2040. Send feedback on issues you care about and get your friends involved!
COMPARE 2040
ENTER
Go even deeper.
Dig into the GO TO 2040 scenarios and see how they stack up against each other and scenarios you build yourself.
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Population in metropolitan Chicago is expected to reach nearly 11 million by 2040. To accommodate 2.8 million new residents, our region has urgent decisions to make in the very near future. GO TO 2040 is the Chicago Metropolitan Agency for Planning (CMAP) campaign to guide development and investment decisions to accommodate our region's growth.
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About MetroQuest
Use the tools above to create your own growth scenarios and compare them to others. Experiment with trade-offs regarding transportation, housing, economic development, open space, the environment, and other quality-of-life issues.
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Metroquest kiosk
Sears Tower, Chicago, 2009

Final Points

- Scenarios are a useful method for examining the implications for decisions of uncertain future conditions
- A new parallel process for developing scenarios to integrate interdisciplinary and multi-scale assessments is creating new opportunities and demands – new research and support institutions are still needed to develop the process
- In addition to scenarios, a variety of uncertainty characterization techniques is needed for evaluating parameter, model, and systemic uncertainty and the implications of uncertainty for decisionmaking
- Assessments of climate change adaptation and mitigation should take advantage of participatory scenario development techniques to integrate expert knowledge and public attitudes/desires in development of acceptable response strategies

Thank You!

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