IMPC THEME C2:
Decision Making under Uncertainty and Non-stationarity

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Research Themes

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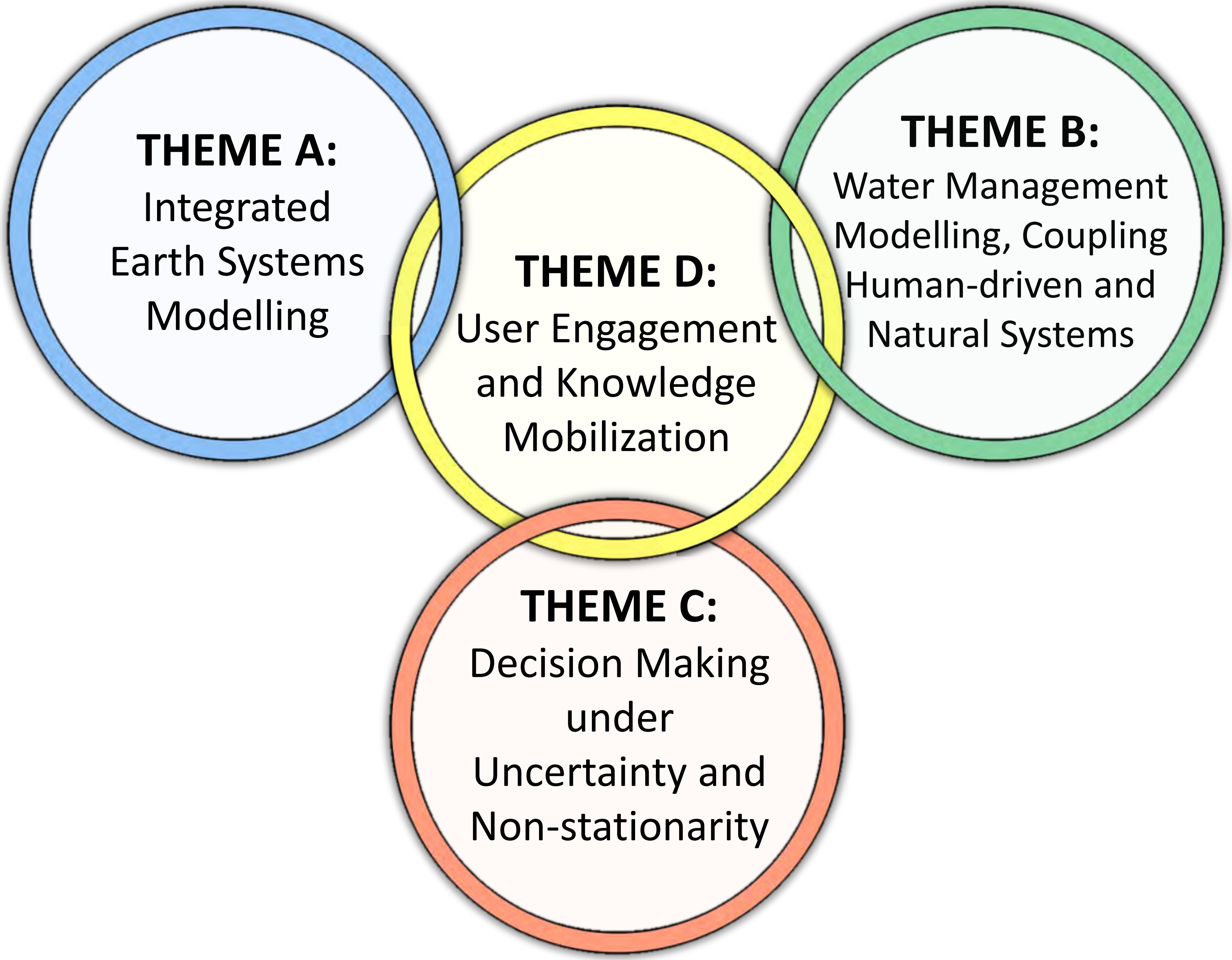

Grand Challenge: “Deep Uncertainty”

- Uncertainty in hydrologic (land surface water quality and quantity) modelling in most parts can be “adequately” characterized with the help of “probability theory”, however, …

- There are factors involved in decision making that are “deeply uncertain”. It is not practical to attempt to assign probabilities to some alternative future states, but “plausibility theory” is proving useful in this context.

“Cascade of Uncertainty” in Climate Projections …

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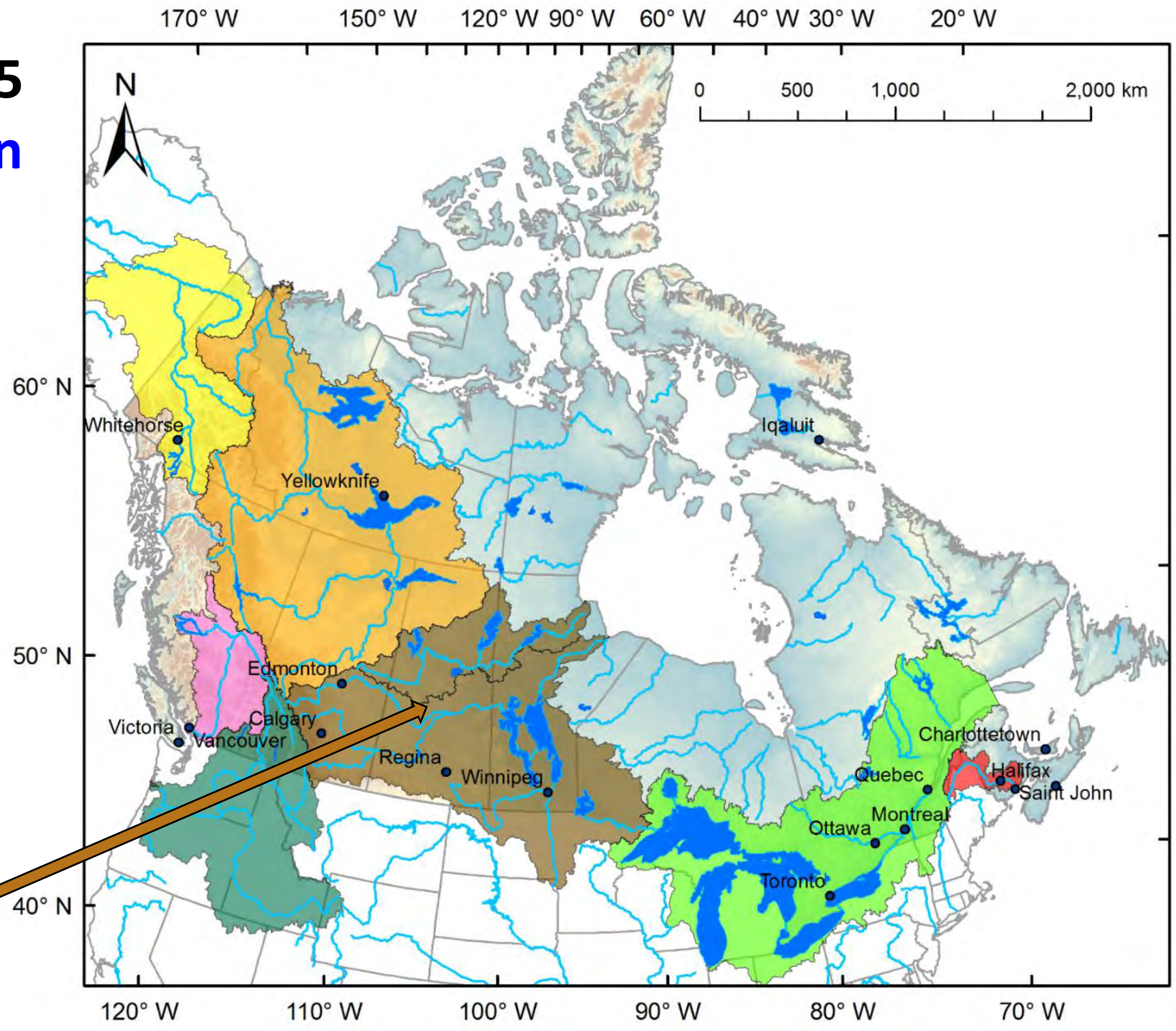
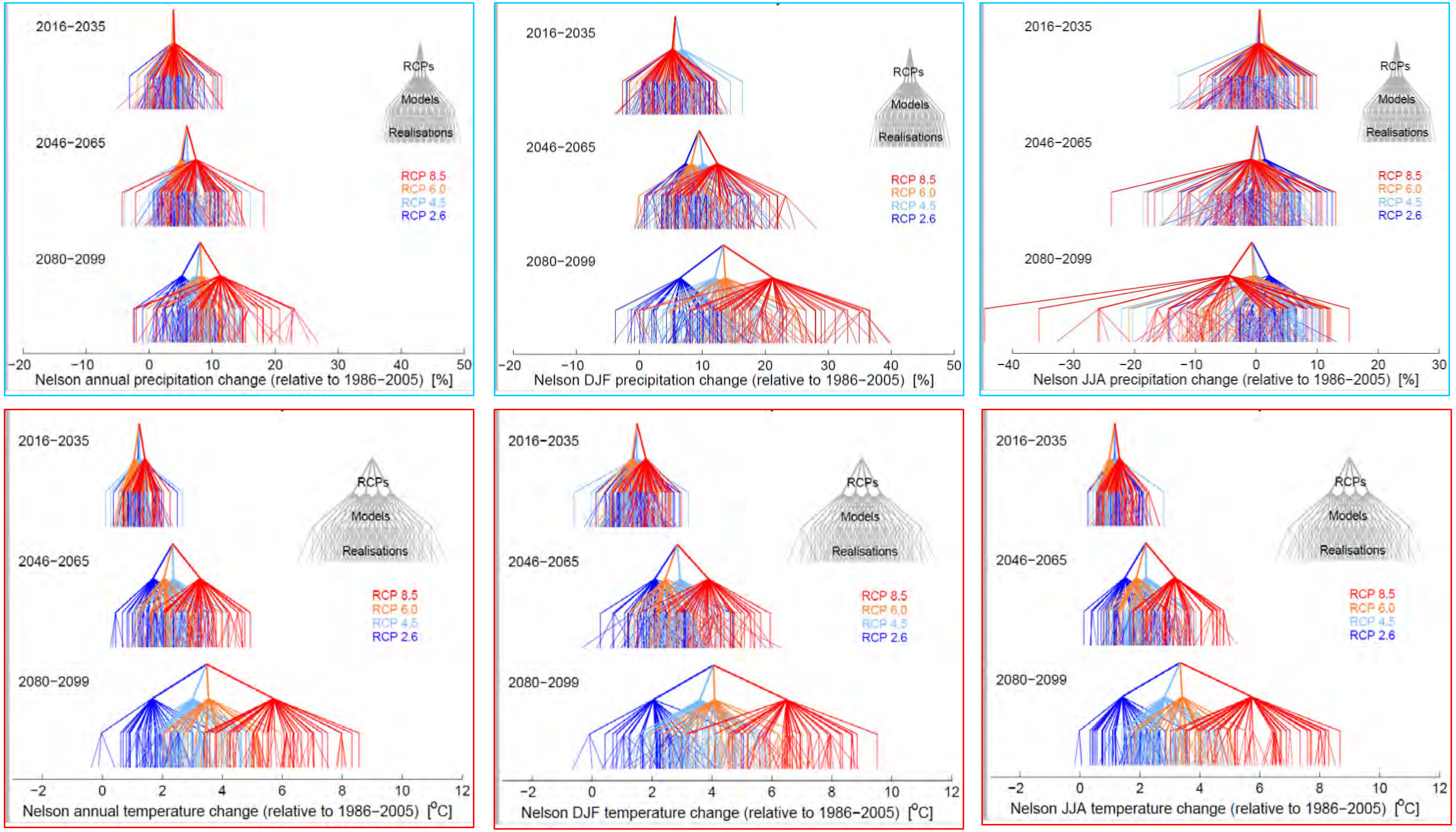
Cascade of uncertainty in CMIP5 projected change in precipitation and surface air temperature
(Elvis Asong et al.)



Nelson-Churchill

Nelson-Churchill River Basin: Example Results

Annual | **DJF (December-February)** | **JJA (June-August)**



For the near-term (2016-2035), the relative importance of the RCPs is far smaller than the uncertainty in the model response. However, at the end of the century, the RCP uncertainty tends to dominate more

Classic (Top-Down) Approaches Provide Only Limited Help and May Fail …

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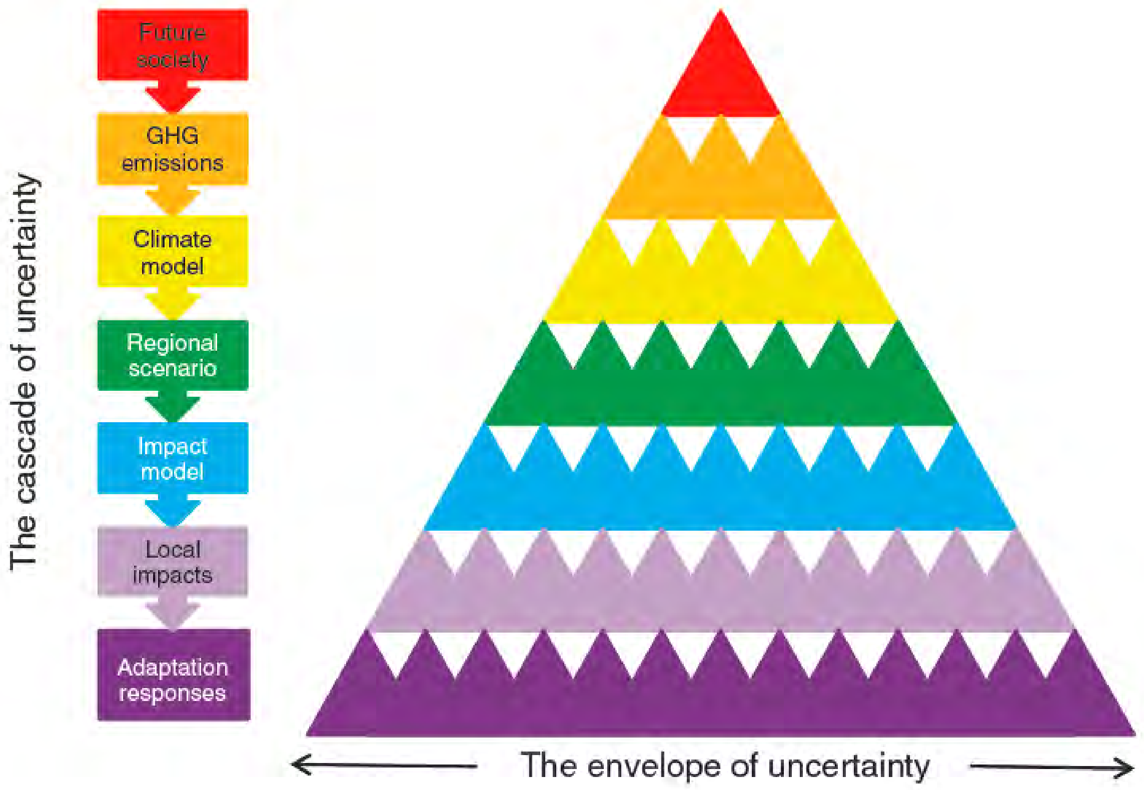
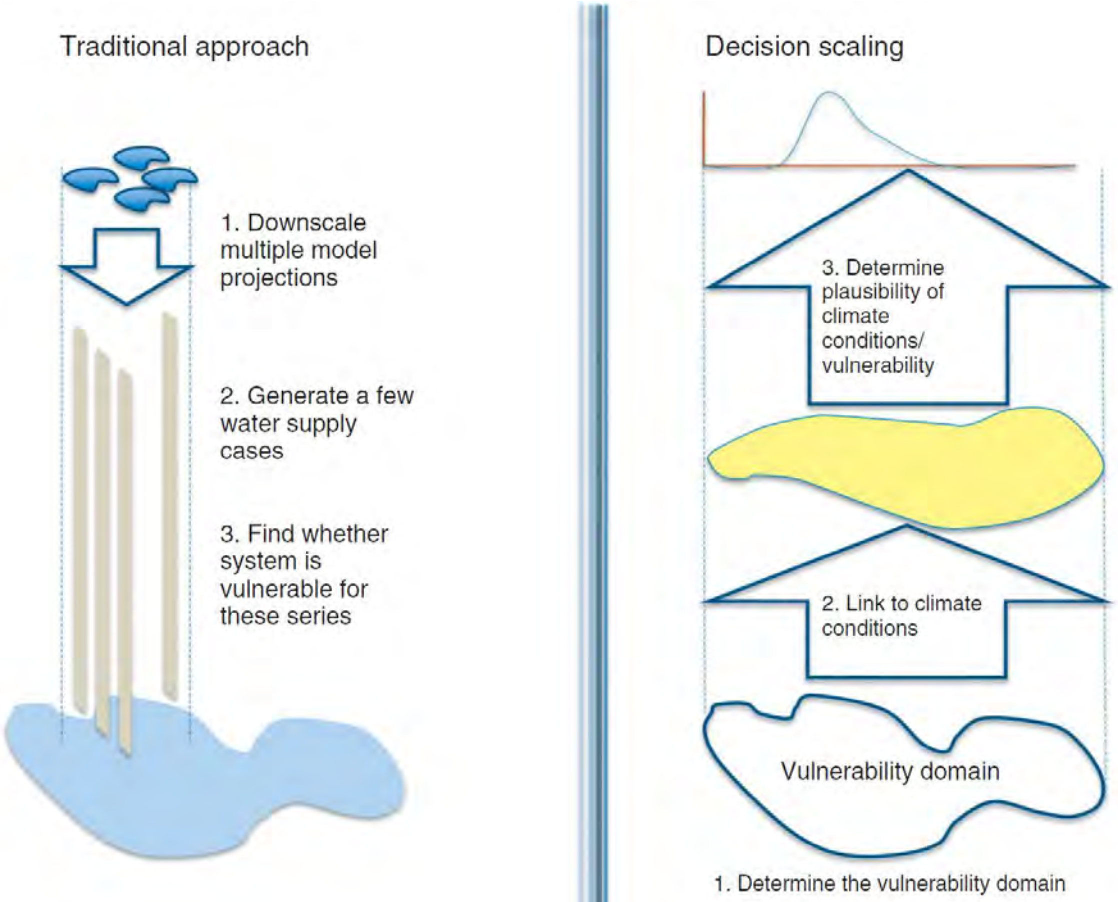
- The classic top-down (also called 'Predict-then-act') decision frameworks, where the best (or some) available predictions drive decision making at a give moment in time, are handicapped.
- The difficulty of getting diverse stakeholders to agree in advance on the predictions as the prerequisites for the decision.
- They tend to focus on parts with well-characterized uncertainty and ignore deep uncertainties and surprizes, highly relevant to policy questions.
- High uncertainty in predictions of ecological and socioeconomic factors and the deeply uncertain behaviour of future decision makers.
- Any decision is highly sensitive to the assumptions about which future is most likely (Weaver et al. 2013, WIREs).



Wilby & Dessai (2010, Weather)

Bottom-Up Perspectives and Robust Decision Frameworks are Essential …

- Need to shift the focus of policy design from seeking a single optimal solution under a future(s) to seeking a ‘robust solution’ which provides satisfactory performance across many plausible futures.
- The objective is to minimize regret under deep uncertainties and surprizes.
- Reduce sensitivity to broken assumptions about the alternative futures.
- Move backward from the decision context to technicalities, modelling, and problem formulation.
- Use models as a vehicle for “scenario discovery” and insight into the behaviour of complex systems.
- Rely heavily on participatory processes that bring together researchers and stakeholders to co-design the problem to ensure meeting stakeholder needs.



Brown et al. (2011, JAWRA)

Discovering Trade-offs: Multi-Objective Optimization

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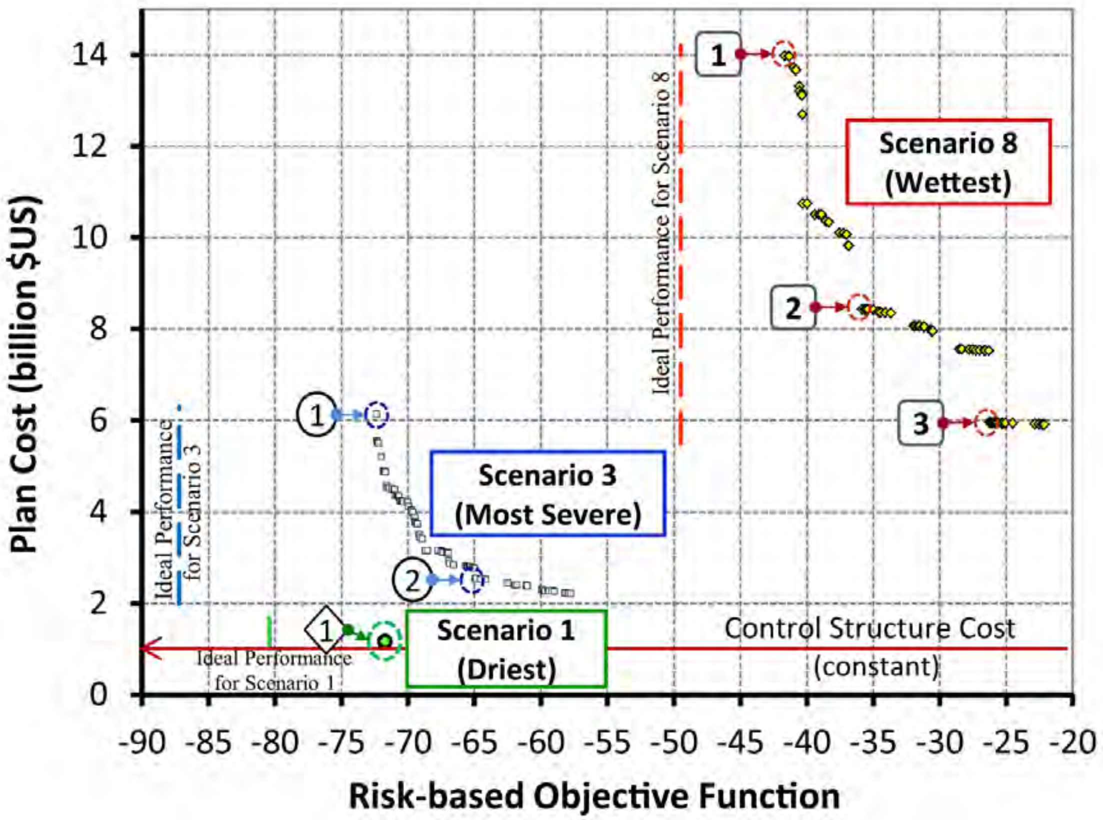
- Traditional "optimal expected utility" policy may eliminate many relevant policy pathways and often represent extreme perspective.

- There are diverse stakeholder groups that possess potentially conflicting preferences. No "one-size-fits-all" solution.

- Need for an explicit understanding of the trade-offs that emerge across different water policy options, to better inform negotiated compromises.

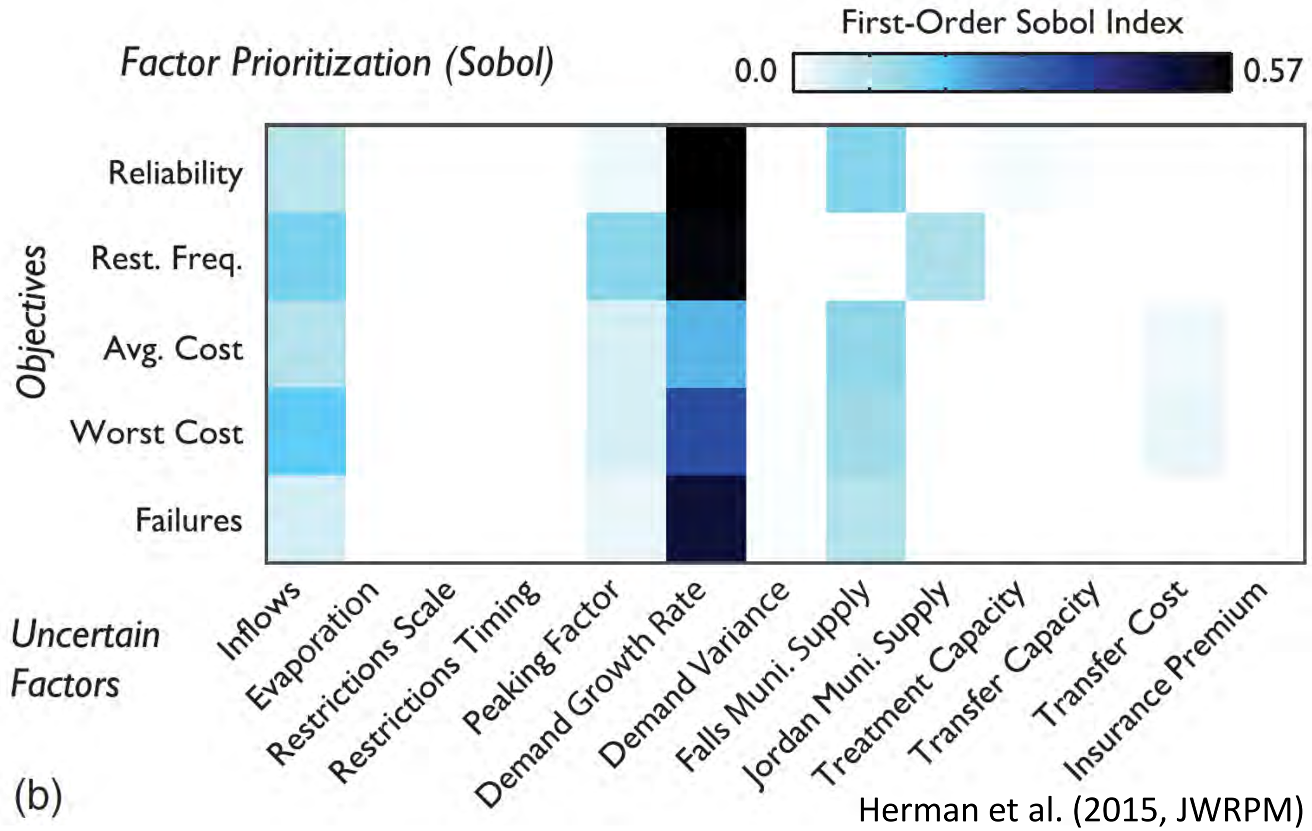
- Robust decision frameworks enabled with MO optimization can identify trade-off solutions
  - whose expected performance is optimal under certain scenarios, and
  - whose performance degrades minimally with errors in our assumptions for deeply uncertain factors.



Razavi et al. (2013, JWRPM)
International Upper Great Lakes Study

Identifying Controls of Uncertainty and Robustness: Multi-Criteria Sensitivity Analysis

- Identify and Isolate the deeply uncertain factors responsible for system vulnerabilities.
- Identify uncertain factors that are non-influential in the decision context of the problem (for problem reduction).
- Identify vulnerable ranges of uncertain factors regardless of the likelihood of future scenarios.
- Uncertainty Apportionment: Quantitative attribution of uncertainty in decision making to different factors.



Herman et al. (2015, JWRPM)

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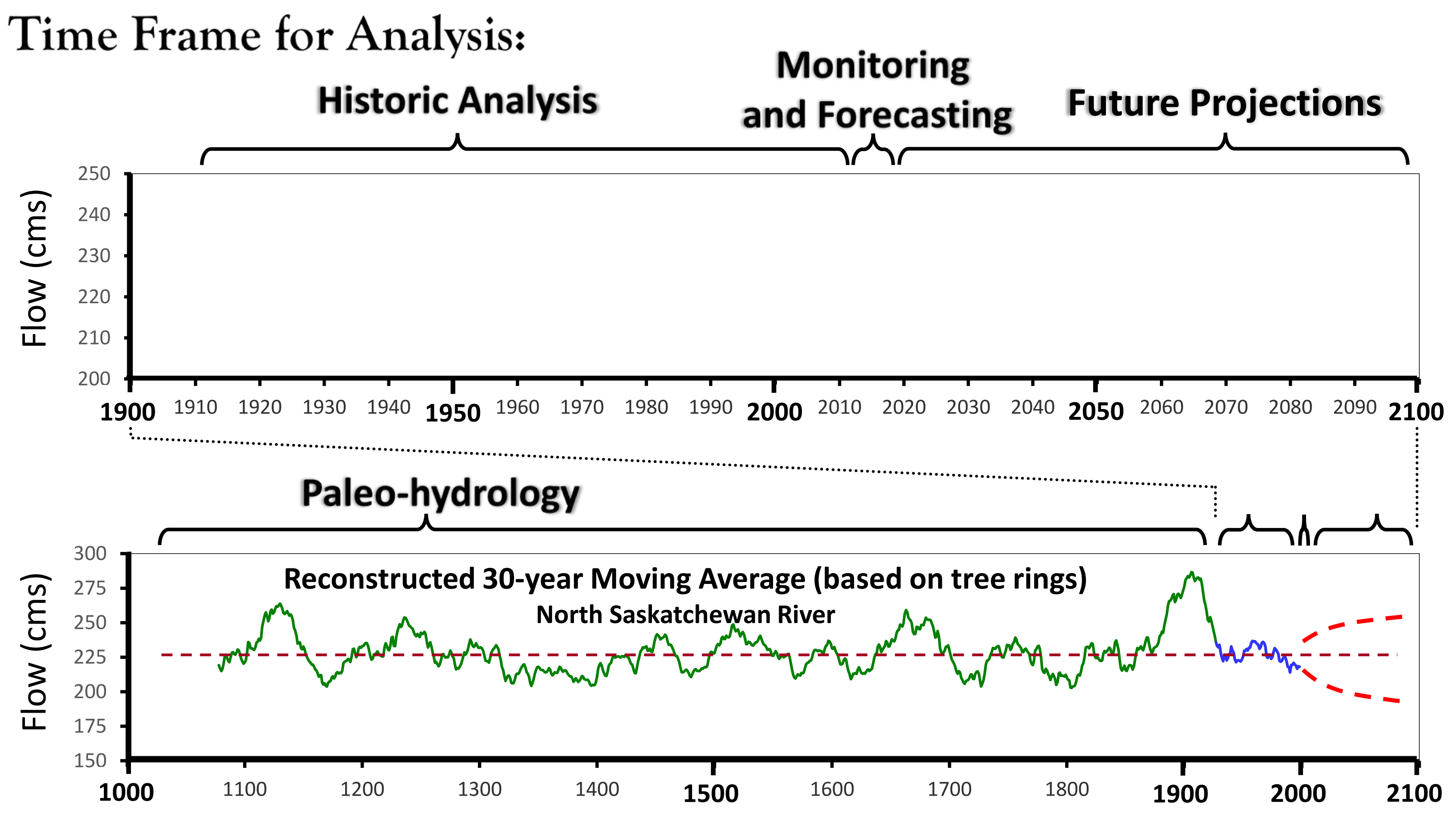
Lessons from Paleo-Hydrology …



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What's next?

- Develop a collaborative scenario-building exercise with stakeholders/users
  - To articulate alternative scenarios of the future for
    - (1) water policy;
    - (2) infrastructure development, including new reservoirs, diversions and irrigation systems and;
    - (3) water demand in agricultural, industrial, and domestic sectors.
  - With stakeholders in areas such as ecosystems, municipalities, hydropower, shipping industries, reservoir operation, recreation and tourism, etc.
- Holding a series of technical meetings with stakeholders/users to co-generate scenarios, co-define the problems to address, and co-design robust solutions
  - Dates/frequency?
- Problems To Address [TO BE POPULATED BY THE HELP OF STAKEHOLDRS]:
  - the long-term viability of the Master Agreement of Water Apportionment on the Saskatchewan River
  - the potential for more oil and gas production on the Mackenzie, and
  - the viability of fish and other wildlife species in the Cumberland Delta.
  - Irrigation expansion in Saskatchewan
  - Building new reservoirs
  - ?