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Cascade of uncertainty in CMIP5 climate projections for scenario-led water resource impact assessments in major river basins of Canada

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MOTIVATION

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- **Impacts of climate change on hydrology and water resources an urgent research issue**
  - **Growing focus on risk assessments**
  - **Identification of appropriate adaptation measures**
- **Earth System Models (ESMs)—major source of knowledge for future climate change**
  - **Highly uncertain**
- **The Intergovernmental Panel on Climate Change (IPCC) 2013 report:**
  - **Highlights uncertainty quantification as one of the most pressing research issues in determining how we can adapt to uncertain climate futures**

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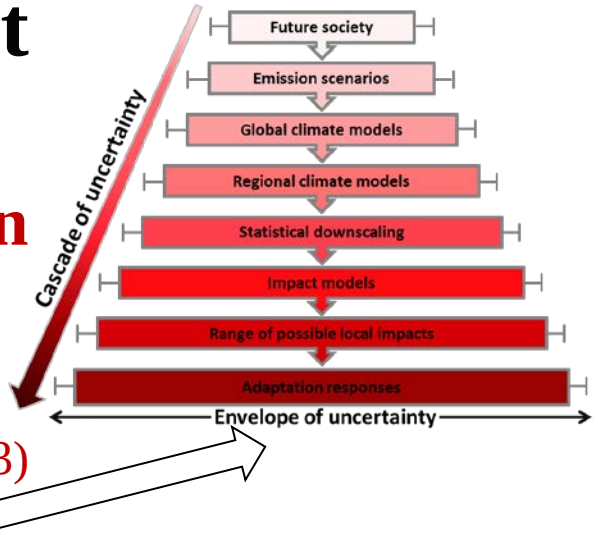
- **Two main perspectives on climate risk assessment for adaptation:**
  - **'Top-down' (also known as 'scenario-led')**
  - **'Bottom-up' methods focus on reducing vulnerability to past and present climate variability**
- **Climate projections have demonstrated the need to adapt to a changing climate:**
  - **but have been less helpful (so far) in guiding how to effectively adapt**
  - **Partly due to the**
    - **'cascade of uncertainty'** (Schneider, 1983) **'uncertainty explosion'** (Henderson-Sellers, 1993)



PROBLEM

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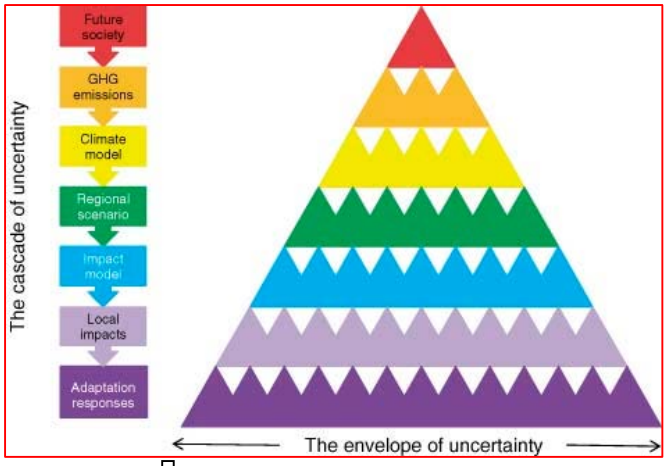
- **Mainly qualitative approaches used in scenario-led frameworks of climate risk assessments**
  - **Envelope of uncertainty may seem overwhelming when trying to adapt to climate change**
  - **Visualize the cascade quantitatively using actual data?**
  - **Crucial because not all layers of the cascade are equally important as qualitative approaches tend to suggest**
- **Relative importance depends:**
  - **Timescale**
  - **Region**
  - **Impact**
  - **Relevant climate variables**
  - **other potential factors…**



Wilby & Dessai (2010): Robust adaptation to climate change, *Weather)*

PROBLEM

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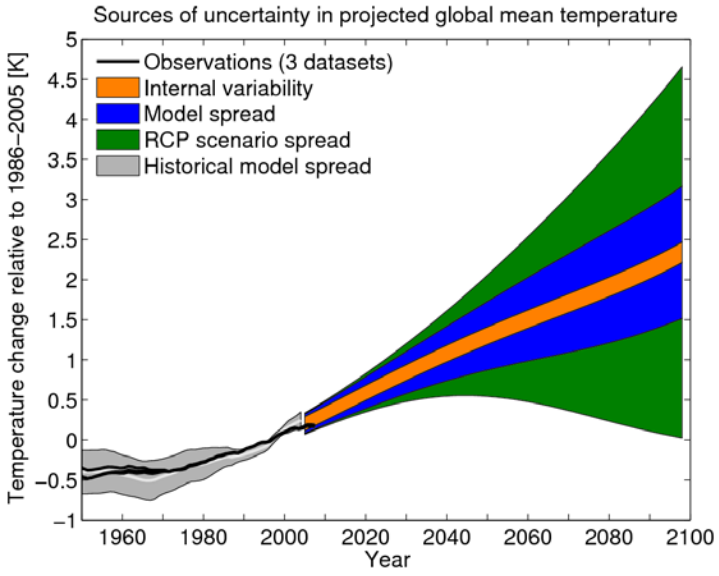
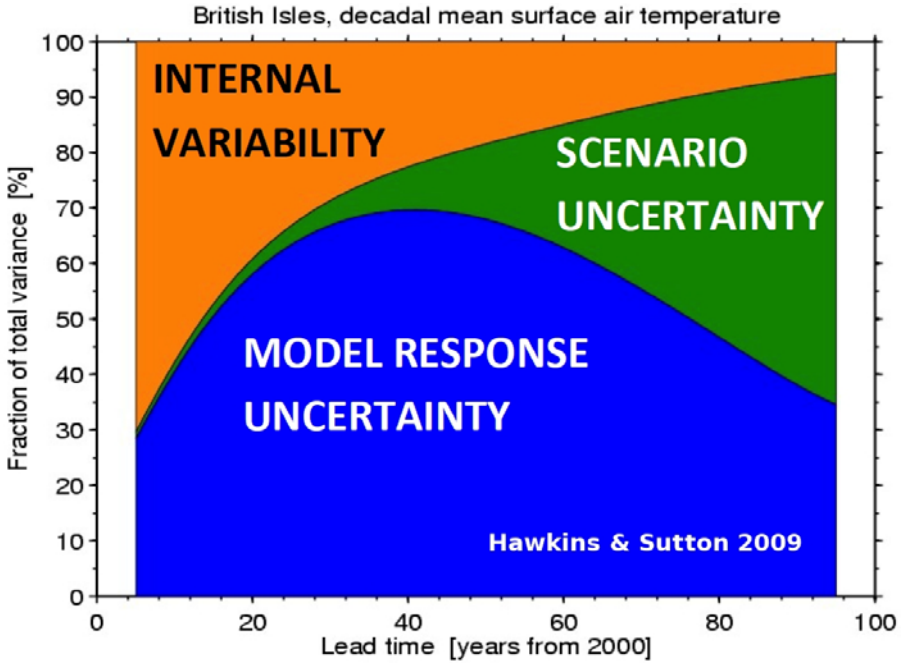
A bigger problem: Climate Uncertainty

- **Which climate model? Which scenario? How many realizations?**





"scenario-led" approach

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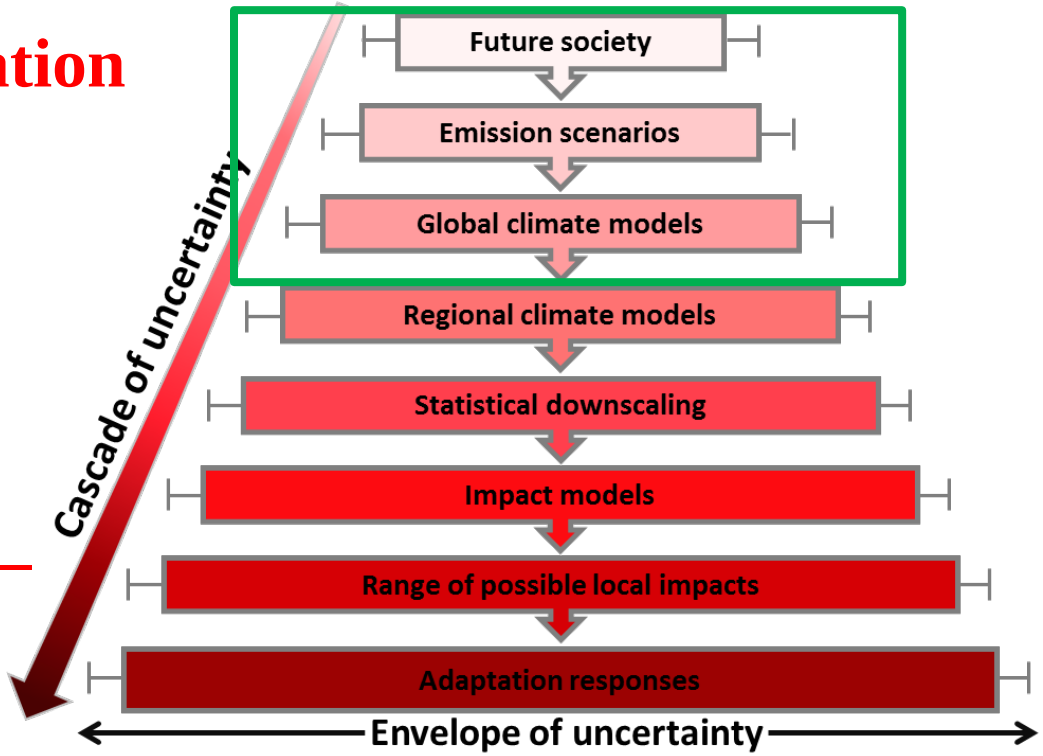
This study focuses on representing the first three layers of the uncertainty cascade using quantitative data

- annual/seasonal precipitation and air temperature
- 32 CMIP5 ESMs
- Four Representative Concentration Pathways— RCPs 2.6, 4.5, 6.0, 8.5)



APPROACH

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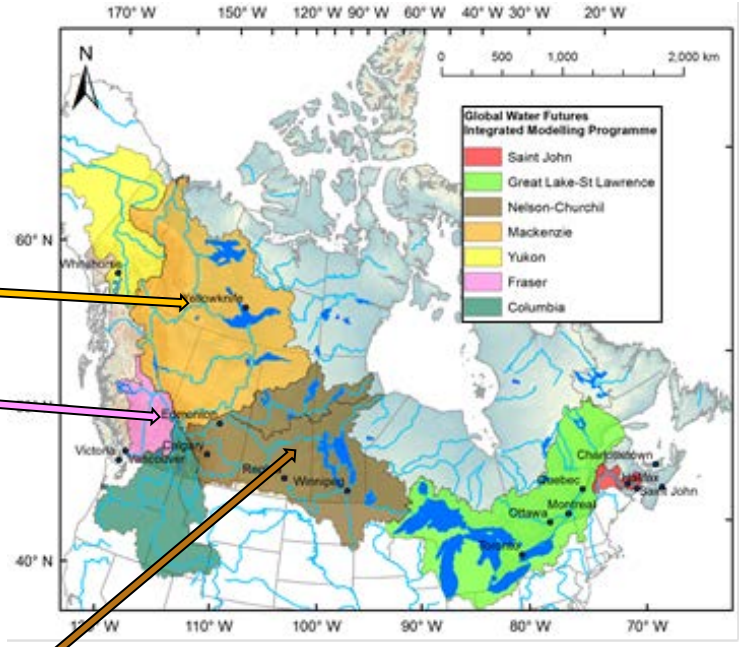
Cascade of uncertainty in CMIP5 projected change in precipitation and surface air temperature over 3 major river basins

McKenzie

Fraser

Nelson-Churchill



Time scales

Annual, DJF, JJA

Time windows

2016 – 2035,
2046 – 2055,
2080 – 2099

Relative to

1986 – 2005

Mackenzie River Basin

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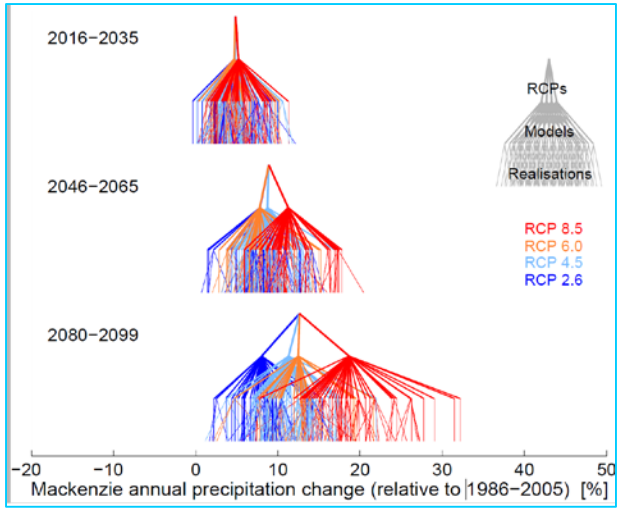
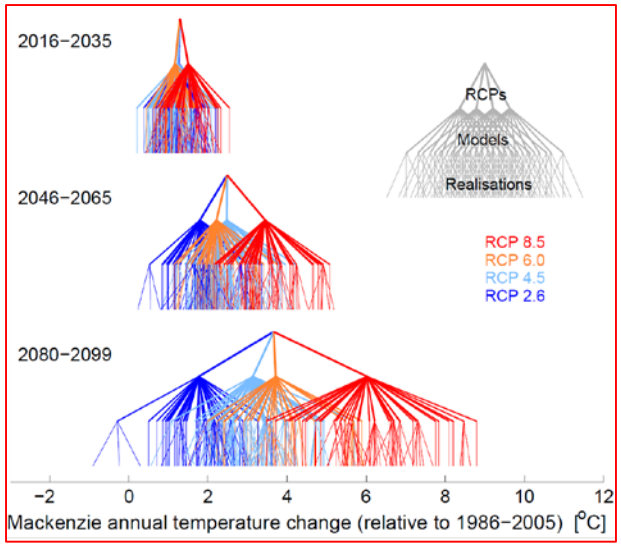
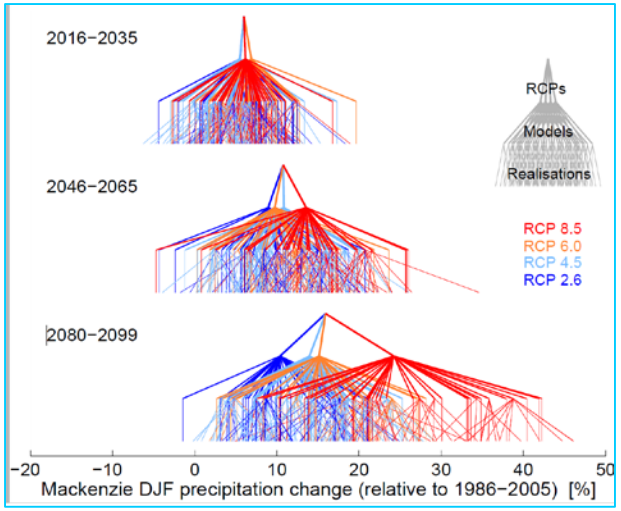
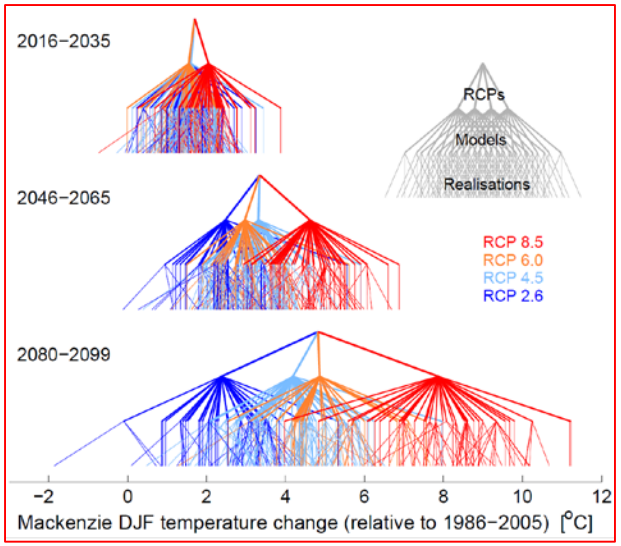


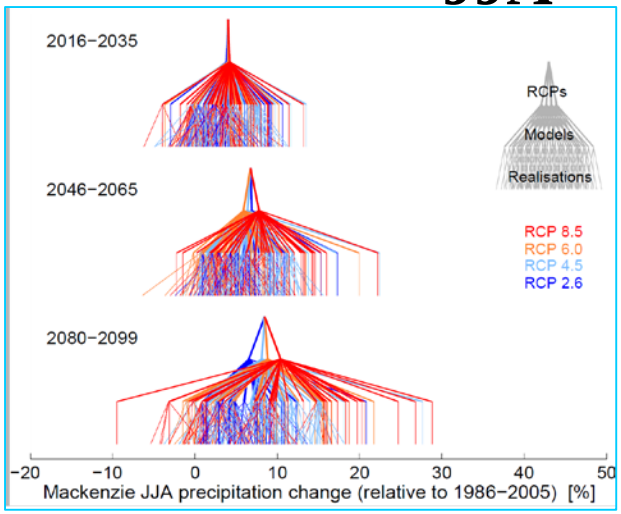


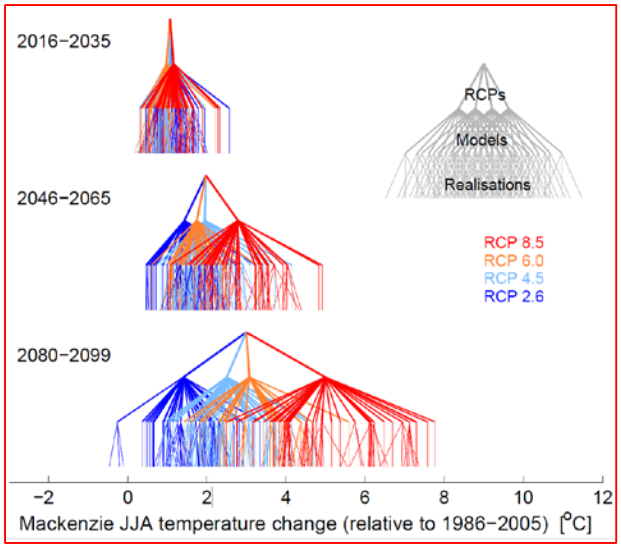
DJF





JJA





The three levels of the pyramid highlight the uncertainty due to the choice of RCP, ESMs and realization of climate variability. The intersection on the top row for each time period is the multi-scenario, multi-model, multi-realization mean

Fraser River Basin

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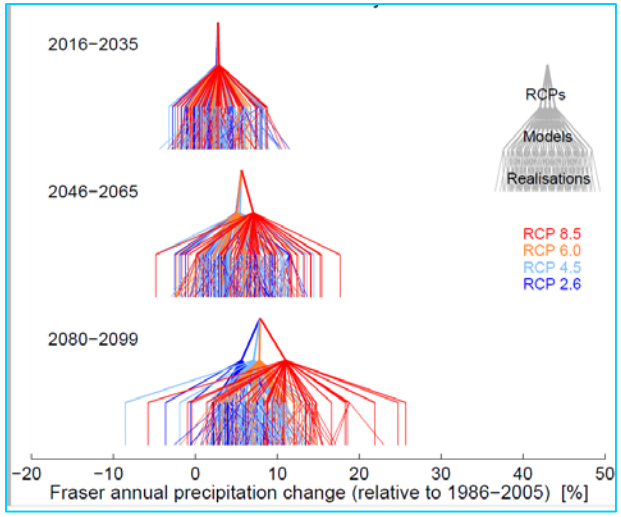

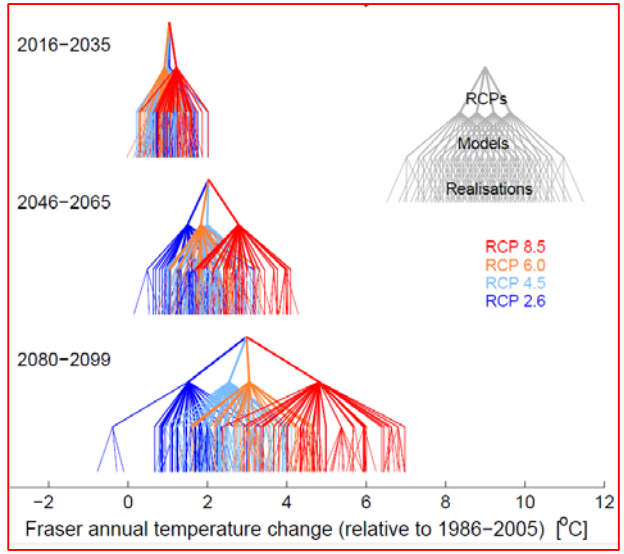

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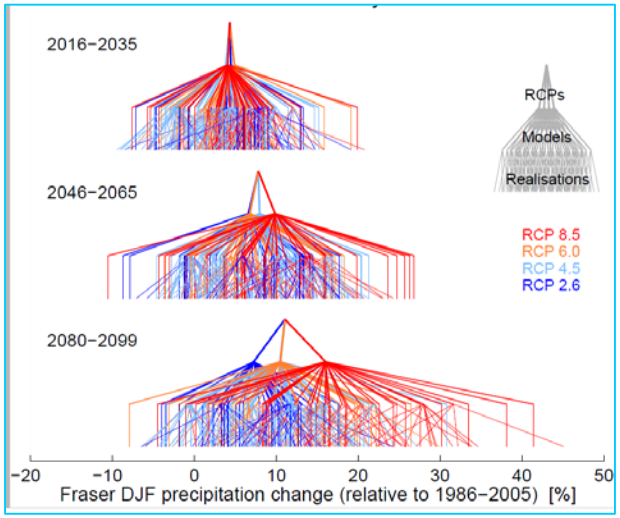

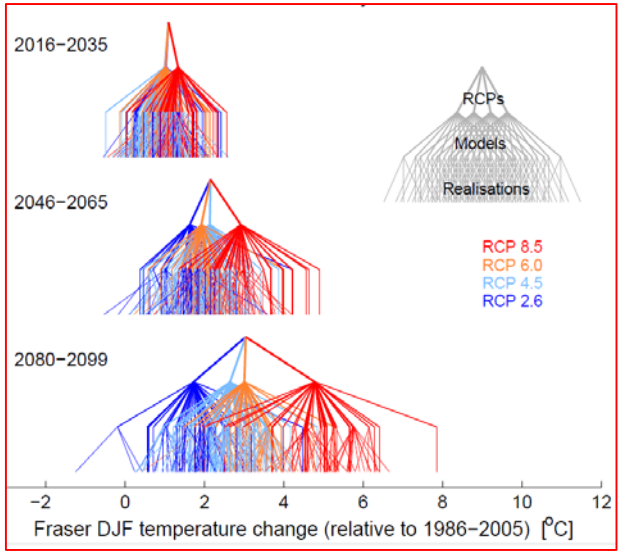

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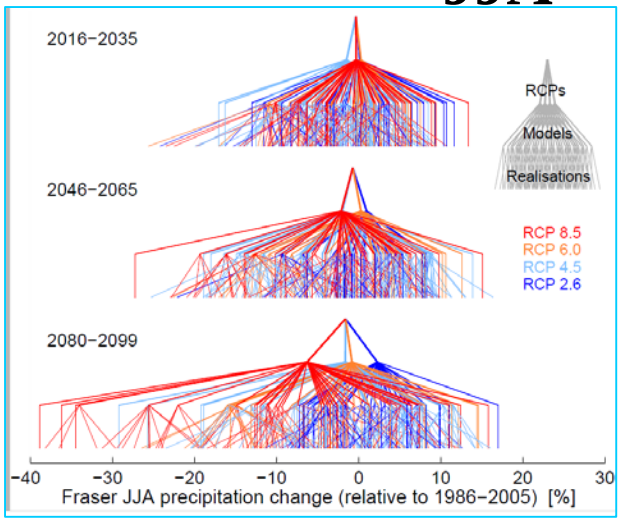

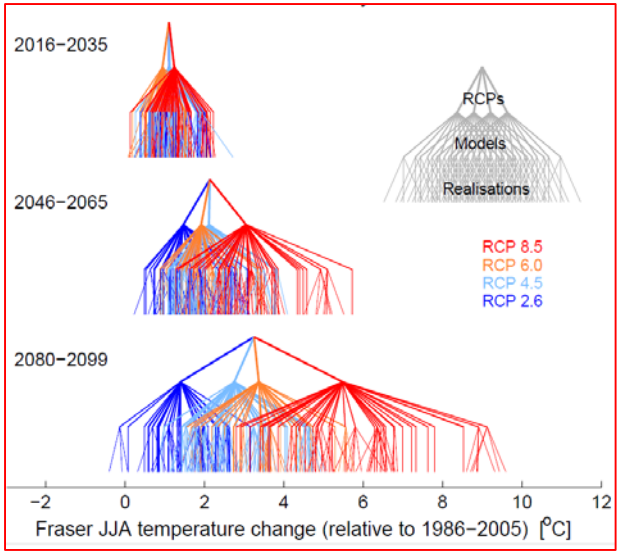

For the near-term (2016-2035), the relative importance of the RCPs is far smaller than the uncertainty in the model response. However, at the end of the century, the RCP uncertainty tends to dominate more

Nelson-Churchill River Basin

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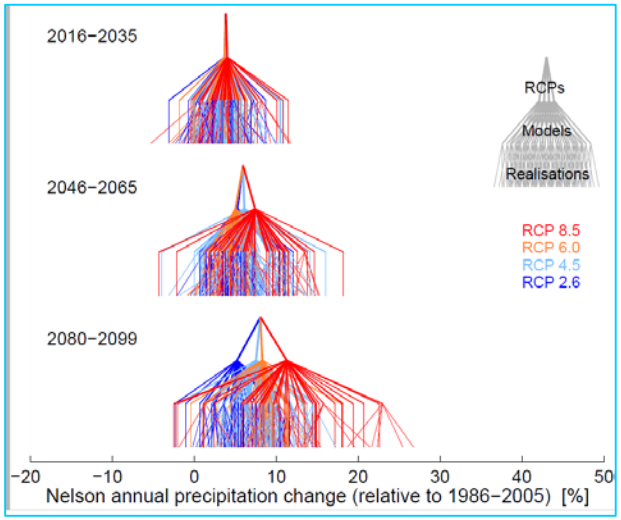

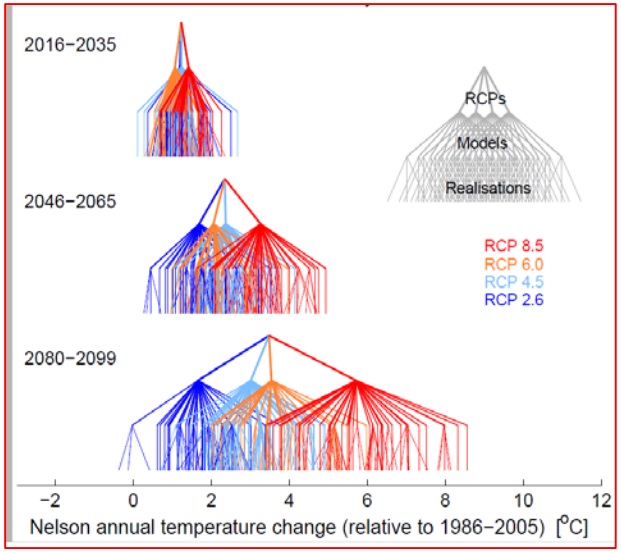

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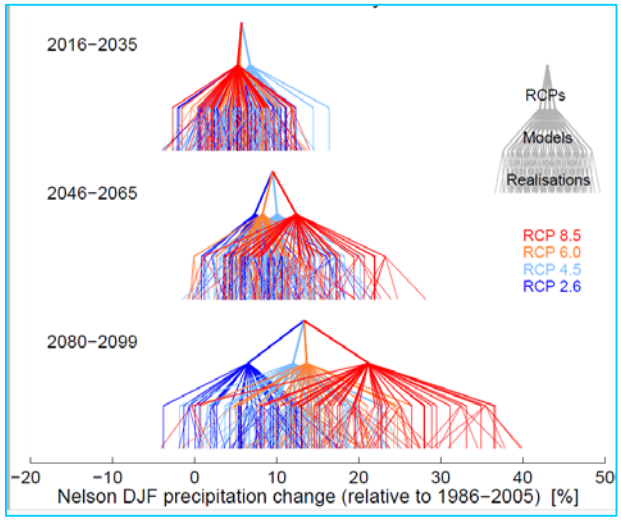

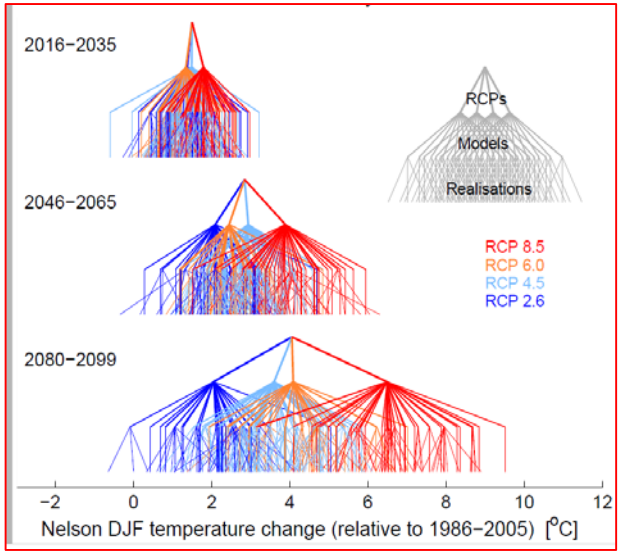

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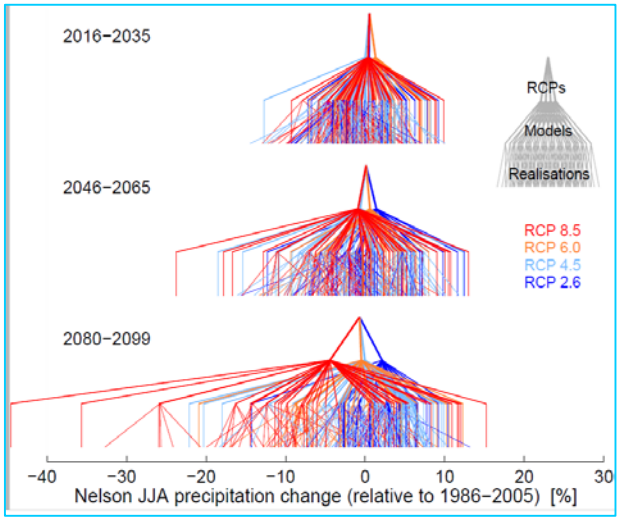

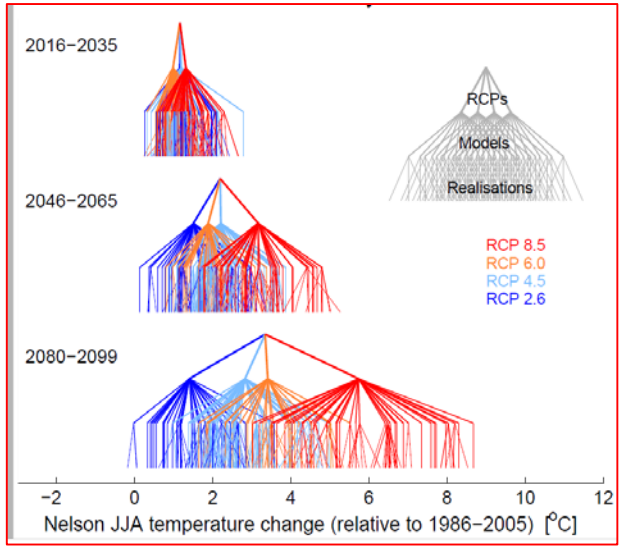

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CORDEX-NA CanESM2

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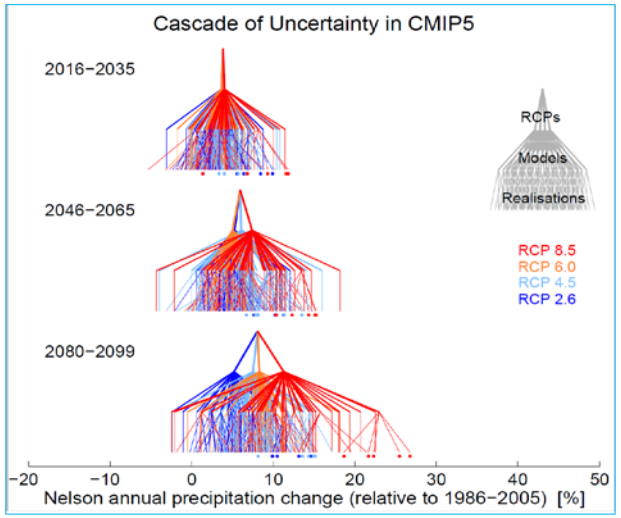

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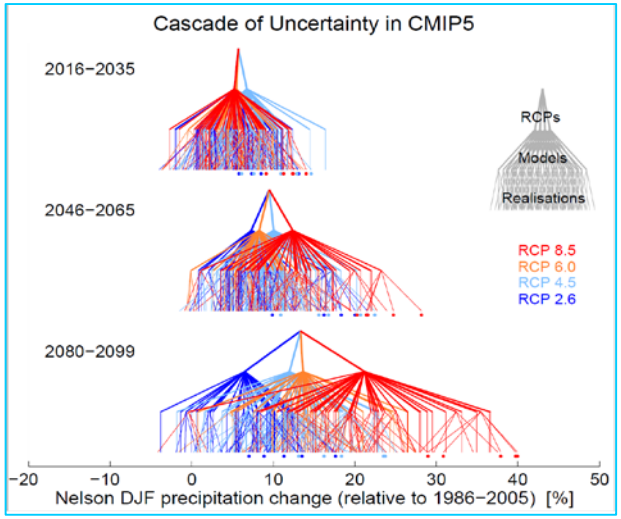

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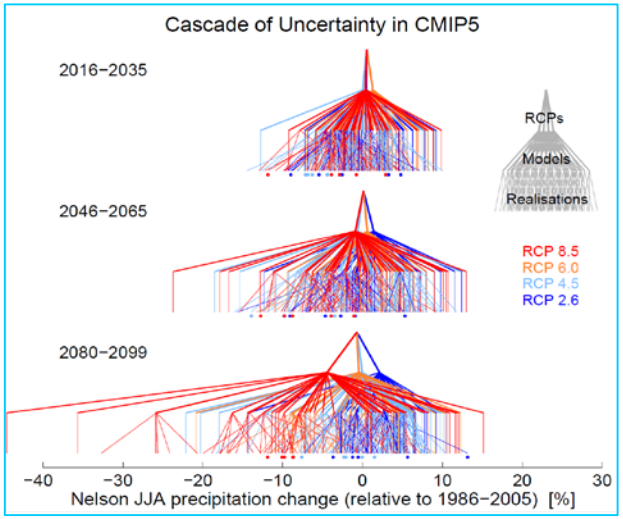

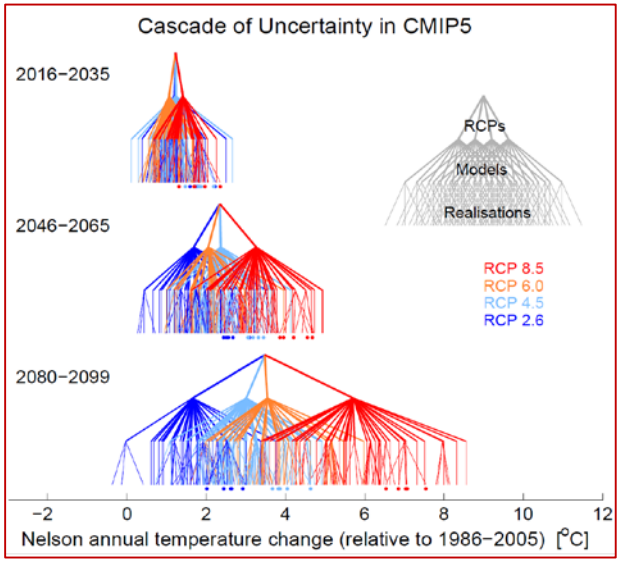

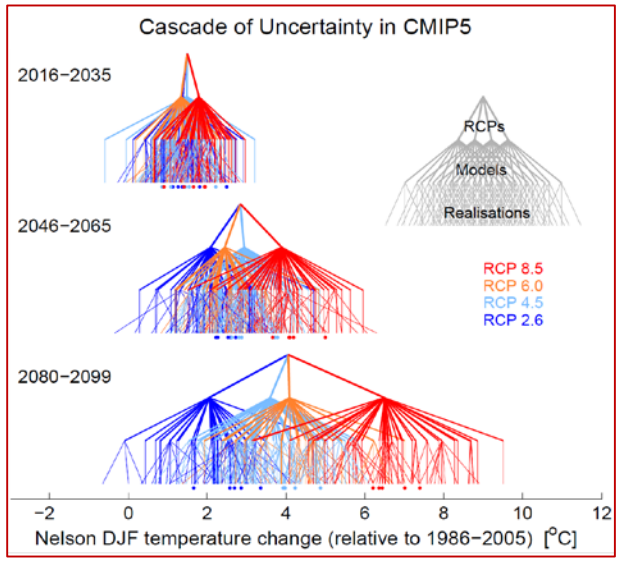

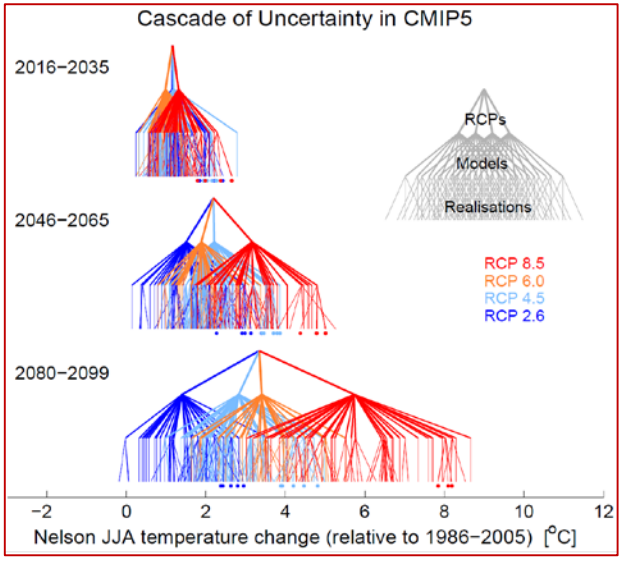

Dots represent the relative position of various ensemble members from the Canadian Earth System Model, CanESM2

Some recommendations for GWF scenarios of change

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- Time windows to consider in a multi-scenario context?
  - RCP scenarios diverge only after 2050

- Don't rely on a single climate model
- Don't rely on a single ensemble member

- Cascade doesn't address the issues of bias. What if the ESMs have too much or too little rain in their present-day climate simulations? Is it reasonable to just use the changes in future? Or the raw model output?

- Not all visualized 3 layers of the cascade are equally important. Depends:
  - Timescale/Future time window
  - Region

THANK YOU

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SOLUTIONS TO WATER THREATS IN AN ERA OF GLOBAL CHANGE

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