Risk, resilience and sustainability of infrastructure under multihazards

CHALLENGES IN USING CLIMATE CHANGE INFORMATION

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OUTLINE

- Climate impact drivers: concept and AR6 assessment
- Information relevant to impacts
- Changes in extreme precipitation
- Changes in peak stream flow
- Take home messages

CHAPTER OUTLINE OF THE WORKING GROUP I CONTRIBUTION TO THE IPCC SIXTH ASSESSMENT REPORT (AR6)

As Adopted by the Panel at the 46th Session of the IPCC

Chapter 12:
Climate change information for regional impact and for risk assessment

Executive Summary

- Framing: physical climate system and hazards
- Region-specific integration of information, including confidence
- Information (quantitative and qualitative) on changing hazards: present day, near term and long term
- Region-specific methodologies
- Relationship between changing hazards, global mean temperature change, scenarios and emissions

Frequently Asked Questions

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CLIMATE IMPACT DRIVERS

- Physical climate system conditions (e.g., means, events, extremes) that affect an element of society or ecosystems and are thus a priority for climate information provision
- Allows for assessment of changing climate conditions that are relevant for regional impacts and risk assessment

AR6 ASSESSMENT ABOUT CIDS

- The current climate in most regions is already different from the climate of the early or mid-20th century with respect to several CIDs.
- Climate change has already altered CID profiles and resulted in shifts in the magnitude, frequency, duration, seasonality and spatial extent of associated indices (high confidence).
- Several impact-relevant changes have not yet emerged from the natural variability but will emerge sooner or later in this century depending on the emissions scenario (high confidence).

AR6 ASSESSMENT ABOUT CIDS

- Every region of the world will experience concurrent changes in multiple CIDs by mid-century (high confidence), challenging the resilience and adaptation capacity of the region.
- Worldwide changes in heat, cold, snow and ice, coastal, oceanic and CO2-related CIDs will continue over the 21st century, albeit with regionally varying rates of change, regardless of the climate scenario (high confidence).
- Many global- and regional-scale CIDs have a direct relation to global warming levels (GWLs)

Table TS.5 (continued)

	Climatic Impact-driver																													
	Heat and Cold				Wet and Dry								Wind				Snow and Ice						Coastal and Oceanic					Other		
	Mean air temperature	Extreme heat	Cold spell	Frost	Mean precipitation	River flood	Heavy precipitation and pluvial flood	Landslide	Aridity	Hydrological drought	Agricultural and ecological drought	Fire weather	Mean wind speed	Severe wind storm	Tropical cyclone	Sand and dust storm	Snow, glacier and ice sheet	Permafrost	Lake, river and sea ice	Heavy snowfall and ice storm	Hail	Snow avalanche	Relative sea level	Coastal flood	Coastal erosion	Marine heatwave	Ocean and lake acidity	Air pollution weather	Atmospheric CO_2 at surface	Radiation at surface
Europe																														
Mediterranean	↗	↗ ***	↘ ***			↘	5			↗ **	↗ **		↘ 6	7			↘						↗		2	↗	↗		↗	
Western and Central Europe	↗	↗ ***	↘ ***		↗	↗	↗	4			↗		↘				↘	↘					↗		2	↗	↗		↗	
Eastern Europe	↗	↗ ***	↘ ***		↗		↗						↘				↘												↗	
Northern Europe	↗	↗ ***	↘ ***		↗	↘ 1	↗ ***			↘			↘				↘	↘					↗	8	2,3	↗	↗		↗	
North America																														
North Central America	↗	↗ **	↘ **						↗			↗											↗	↗	2	↗	↗		↗	
Western North America	↗	↗ **	↘ **		3		5	5	4,7		↗ 6,7 **	↗ 6.7	↘	8		↗ 6	↘ 1		↘	1		1	↗	↗ 5	2	↗	↗		↗	
Central North America	↗				↗		↗ **		7		7	7	↘	8		4	↘		↘				↗	↗	2	↗	↗		↗	
Eastern North America	↗				↗ 5		↗					7	↘	8			↘ 1		↘	1		1	↗	↗	2	↗	↗		↗	
North-Eastern North America	↗	↗ ***	↘ ***	↘	5				5		6,7	6,7		8			↘ 1,6	↘	↘			1	4	↗ 4,6	2,6	↗	↗		↗	
North-Western North America	↗	↗ ***	↘ ***	↘	5			6	5		6,7	↗ 6,7		8			↘ 1	↘	↘			1,6	↗ 9	↗	2	↗	↗		↗	

Note: There are several region-specific qualifiers/exceptions attached to some of the directions of change/confidence levels indicated above. {12.4}

Key for observational trend evidence ↗ Past upward trend (*medium* or *higher confidence*) ↘ Past downward trend (*medium or higher confidence*)

Key for attribution evidence *** *High confidence* (or more) ** *Medium confidence*

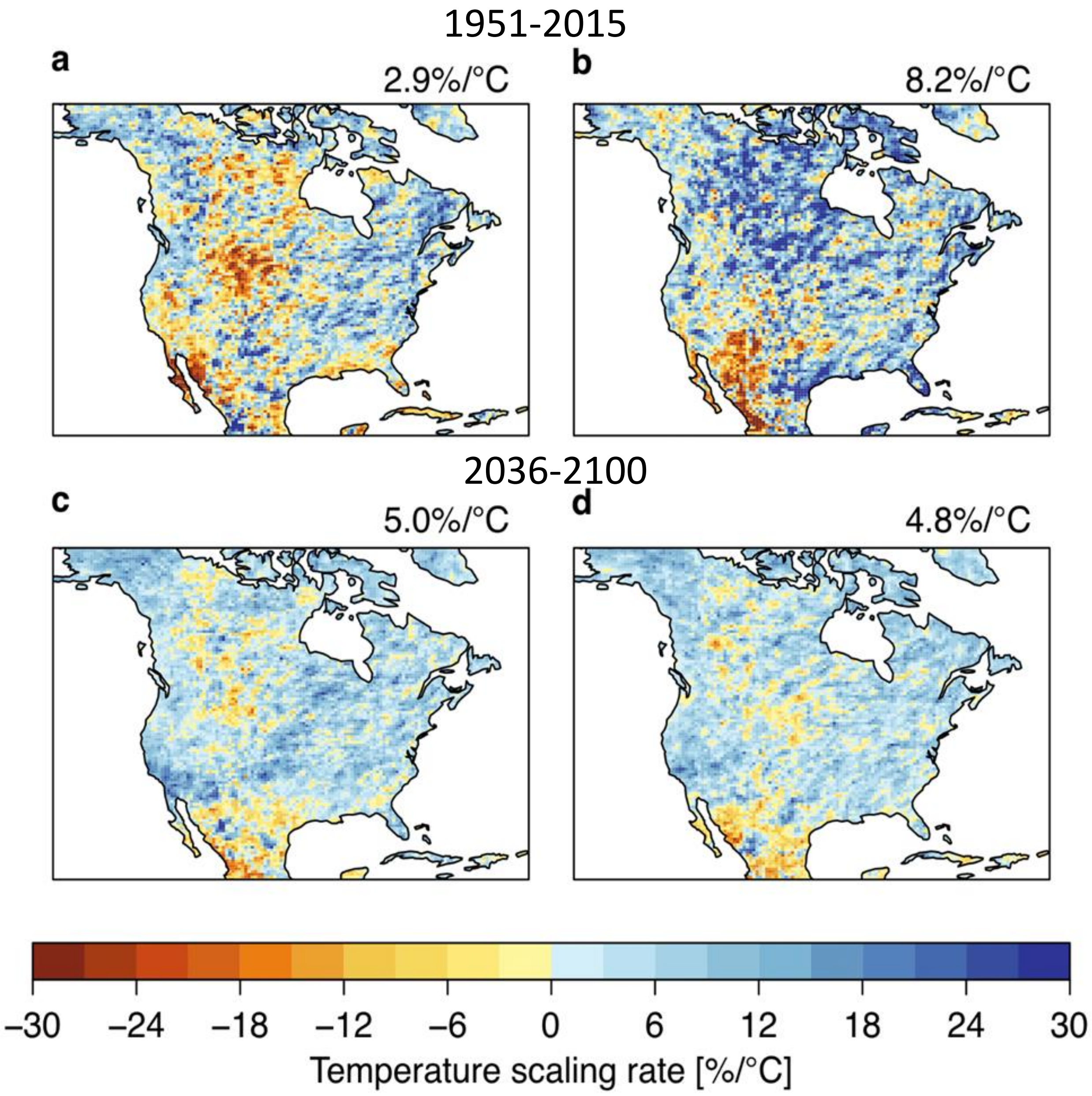
Key for level of confidence in future changes *High confidence* of increase (or more) | *Medium confidence* of increase (or more) | *Low confidence* in direction of change | *Medium confidence* of decrease | *High confidence* of decrease | Not broadly relevant

CHARACTERISTICS OF INFORMATION RELEVANT TO IMPACTS

- Impacts are most often of local and regional nature
- Information about past and future changes are more uncertain at these scales
- Confidence about changes varies among variables, space and time scales
  - Highest confidence in changes in temperature
  - Some confidence in changes in precipitation
  - Little confidence in changes in wind
  - Generally higher confidence in changes over larger regions and more remote future

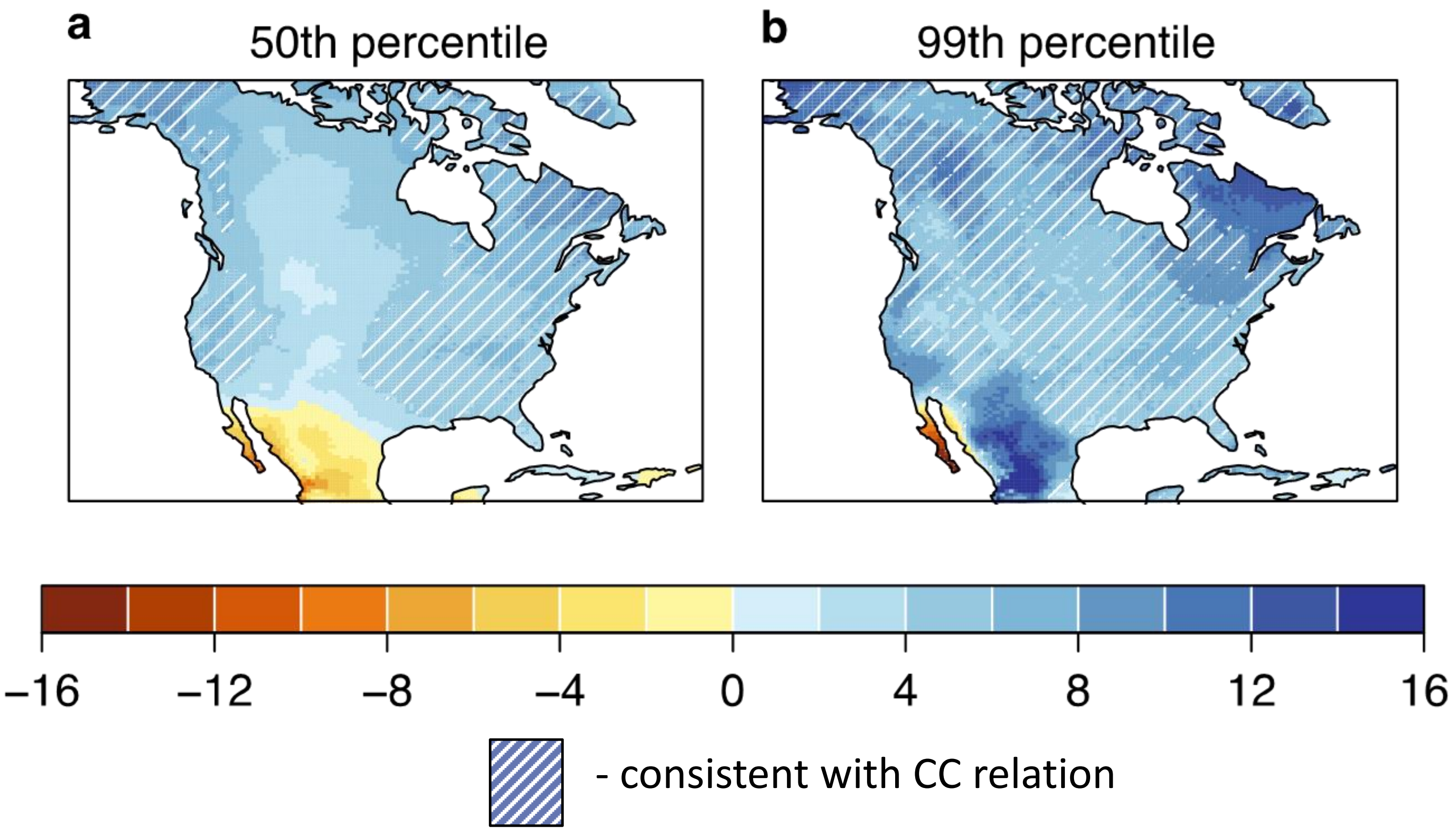
Extreme precipitation generally scales with the level of global warming, but

- Estimates of local scale changes based on available observation are highly uncertainty.
- At site analysis of single 65-year records is insufficient to identify temperature scaling relationships.
- Locally estimated scaling is based on a 65-year period and a single CanRCM4 run.



Li et al. 2018, J. Climate

And there may be regional difference in scaling



Li et al. 2018, J. Climate

A practitioner's guide

"It would be prudent for those undertaking adaptation planning and requiring engineering design values for long-lived infrastructure to be guided by the CC relationship in most mid-latitude locations, consistent with results for extreme daily precipitation from observations and models, bearing in mind that the levels of uncertainty in future projection is high and may remain so for some time." – *Zhang et al. 2017, Nature GeoScience*

CSA GROUP™

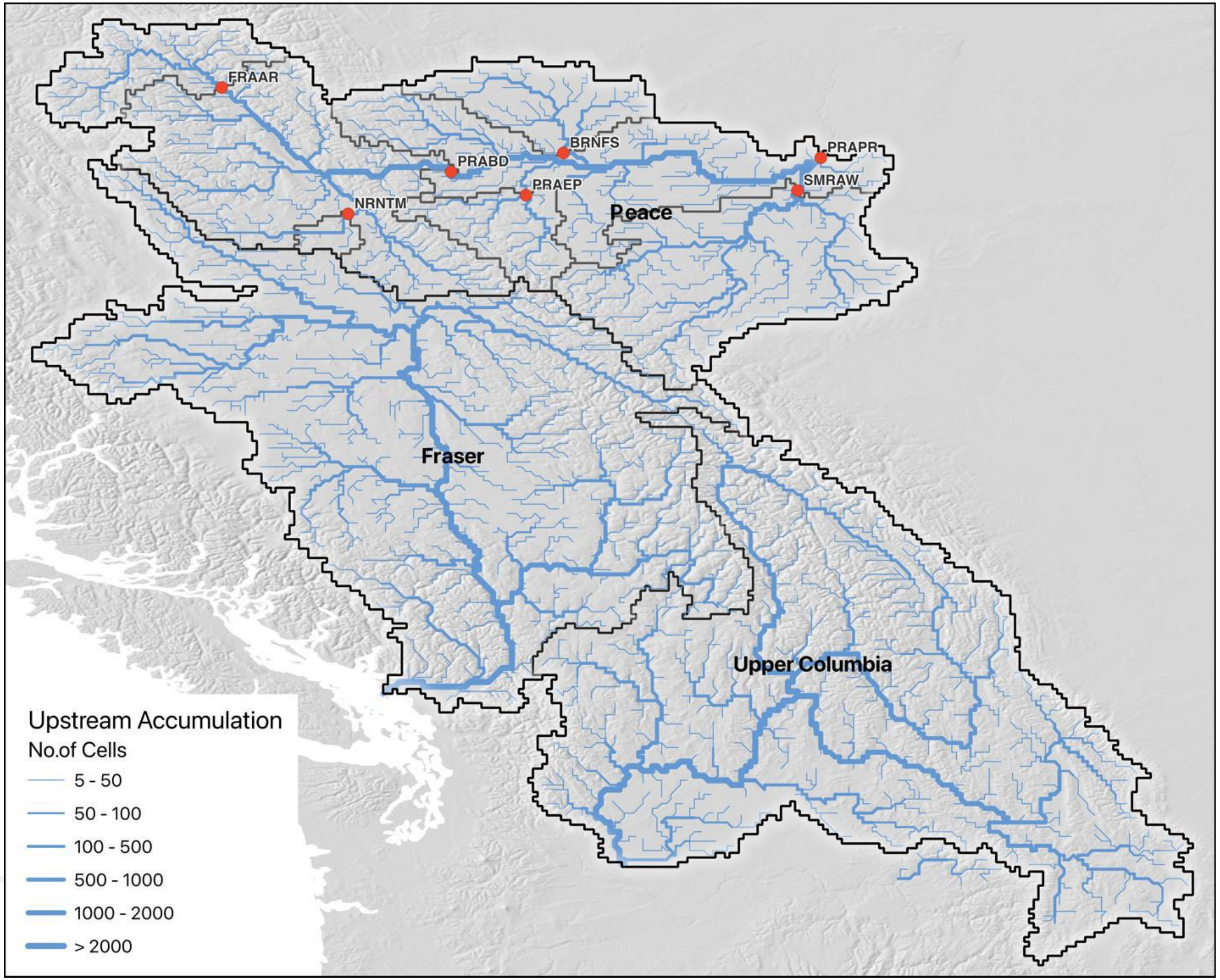
CSA PLUS 4013:19

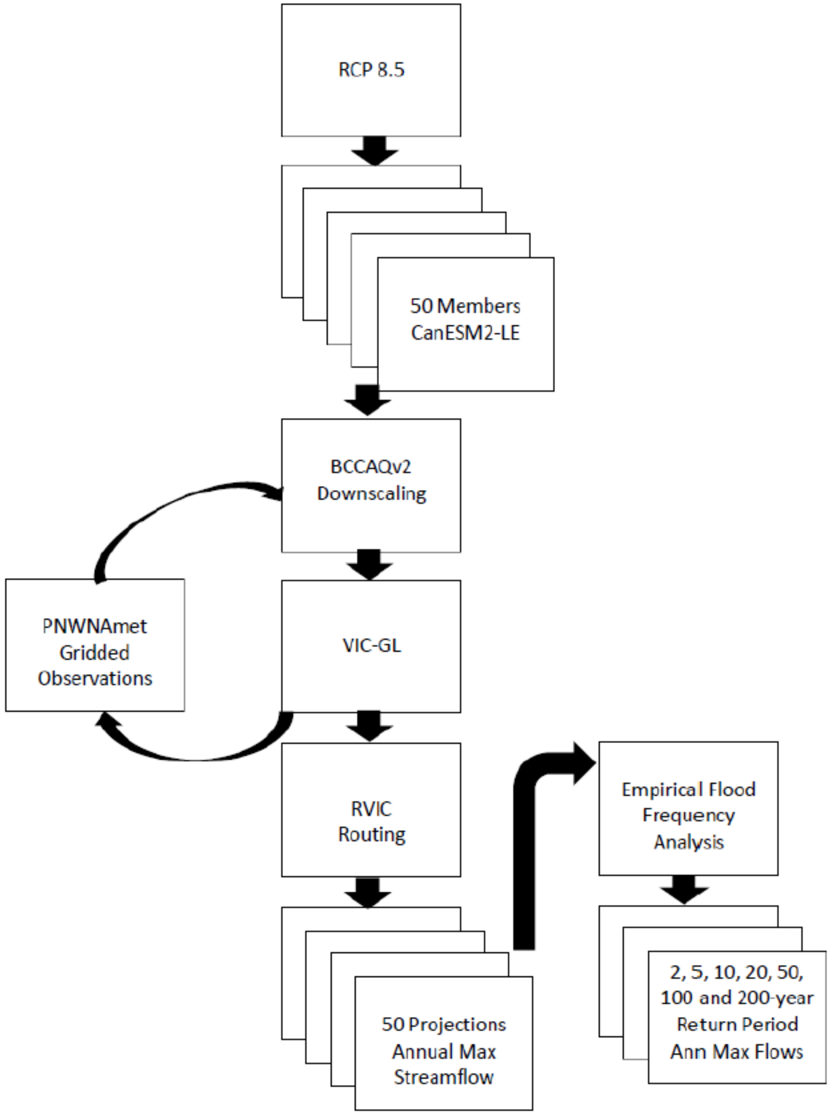
TECHNICAL GUIDE
Development, interpretation, and use of rainfall intensity-duration-frequency (IDF) information: Guideline for Canadian water resources practitioners

But even if we have confidence in changes in some variables, changes in downstream of those variables can be very complicated

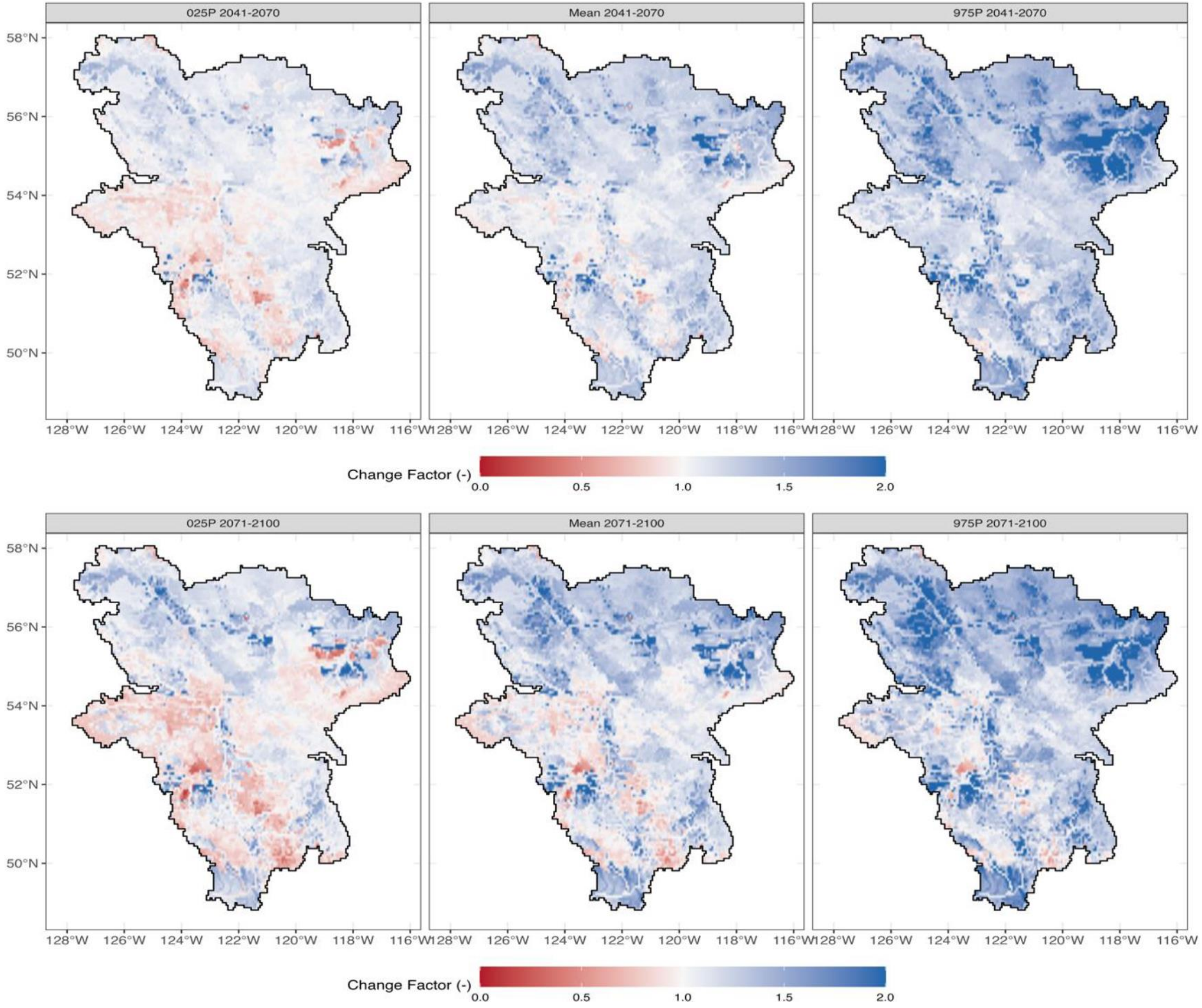
Example: Peak stream flow is affected by many factors, in addition to extreme precipitation

Changes in peak flow in the upper Columbia, Fraser, and Peace rivers:





Change factor relative to 1951-2000 value



Schnorbus and Ben Alaya 2023

Take home message

- In the context of climate change, what is traditionally not considered as hazard (such as changes in mean state) can be very relevant to resilience and sustainability of infrastructure.
- Climate change has already altered CID profiles and resulted in shifts in the magnitude, frequency, duration, seasonality and spatial extent of associated indices (high confidence).
- Generally lower confidence at impact relevant scale is a significant challenge for proper interpretation of future projection.
- Changes in one climate variable and in its downstream variable may not be linear and can be region/location and time scale dependent.

https://www.pacificclimate.org/