Projecting future extreme streamflow for the Fraser River: a nonstationary extreme value analysis approach

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Rajesh R. Shrestha, Alex J. Cannon, Markus A. Schnorbus, Francis W. Zwiers
(Shrestha et al., 2016, in revision)

Photo: F. Zwiers (Kennedy Lake River)

Outline

- Background
- CMIP5 based projections
- Discussion

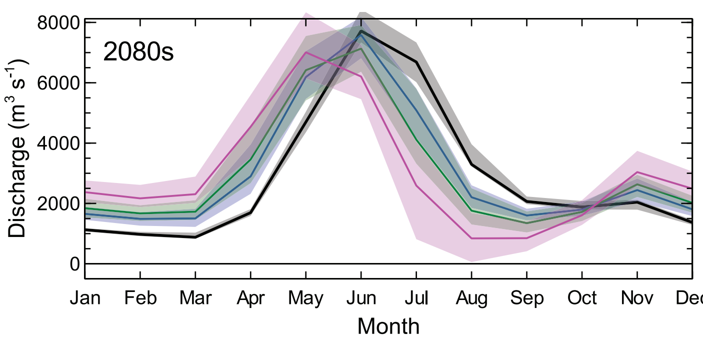
Photo: F. Zwiers (American Dipper)

PACIFIC CLIMATE IMPACTS CONSORTIUM

Fraser River Basin

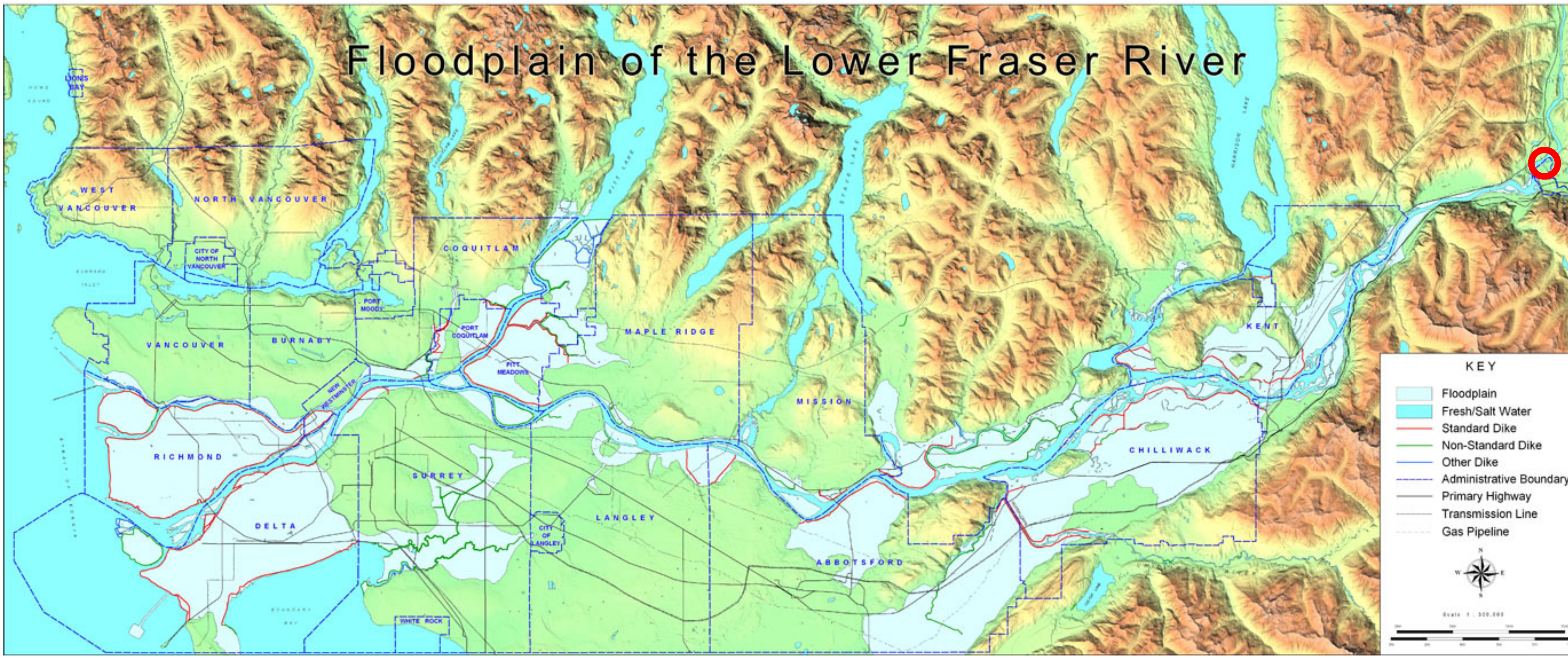
Monthly mean discharge, 1970’s vs 2080’s

rcp8.5, rcp4.5, rcp2.6



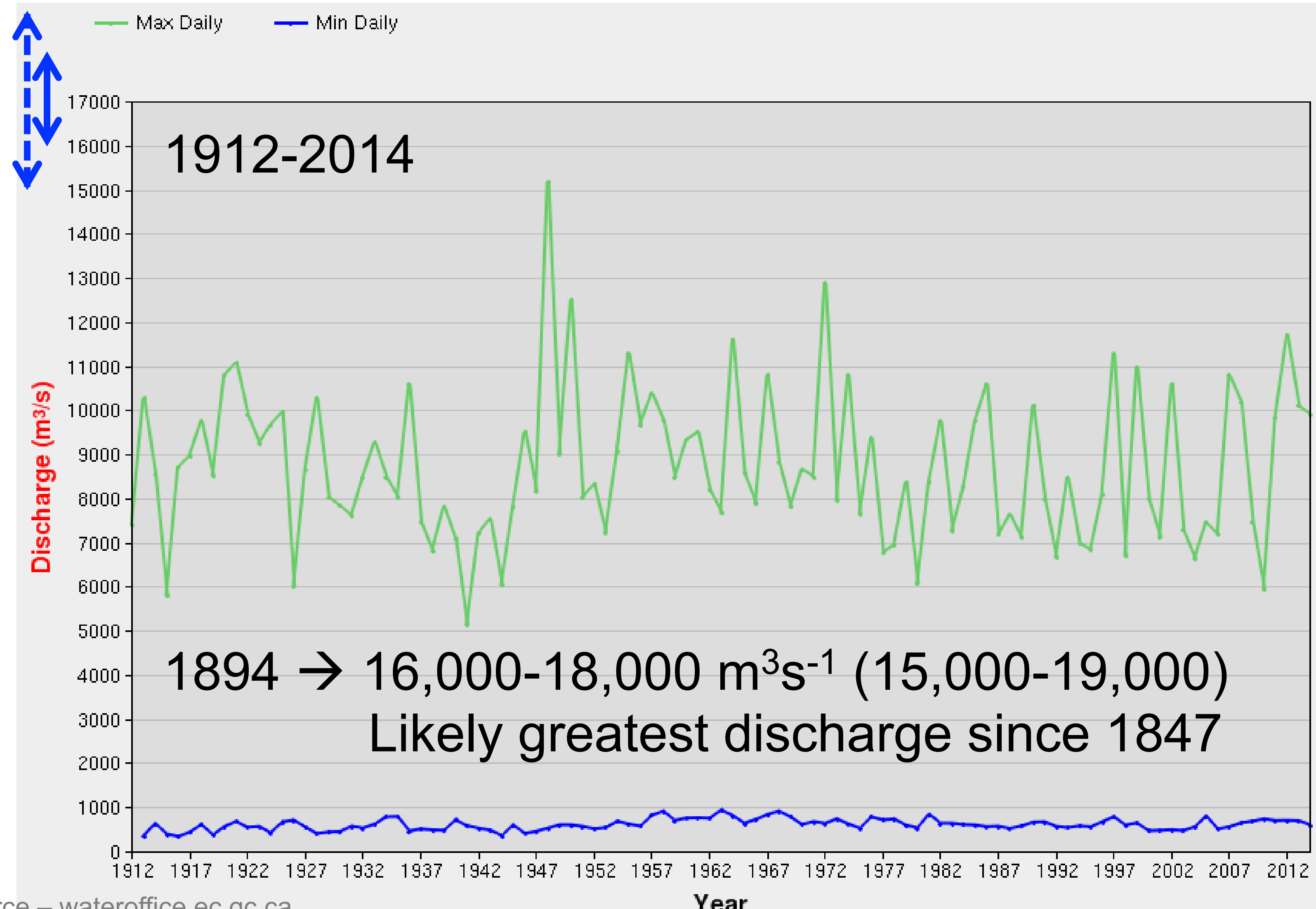
Schnorbus and Cannon, 2014

Lower Fraser River Flood Plain



○ Hope

Annual max discharge, Fraser at Hope



Source – wateroffice.ec.gc.ca

Alexandra Bridge, 44km north of Hope

1863

Figure 2.7: Alexandra Bridge Completed in 1863

Source – Northwest Hydraulic Consultants / BC Ministry of Environment, 2008

Alexandra Bridge, 44km north of Hope

1894

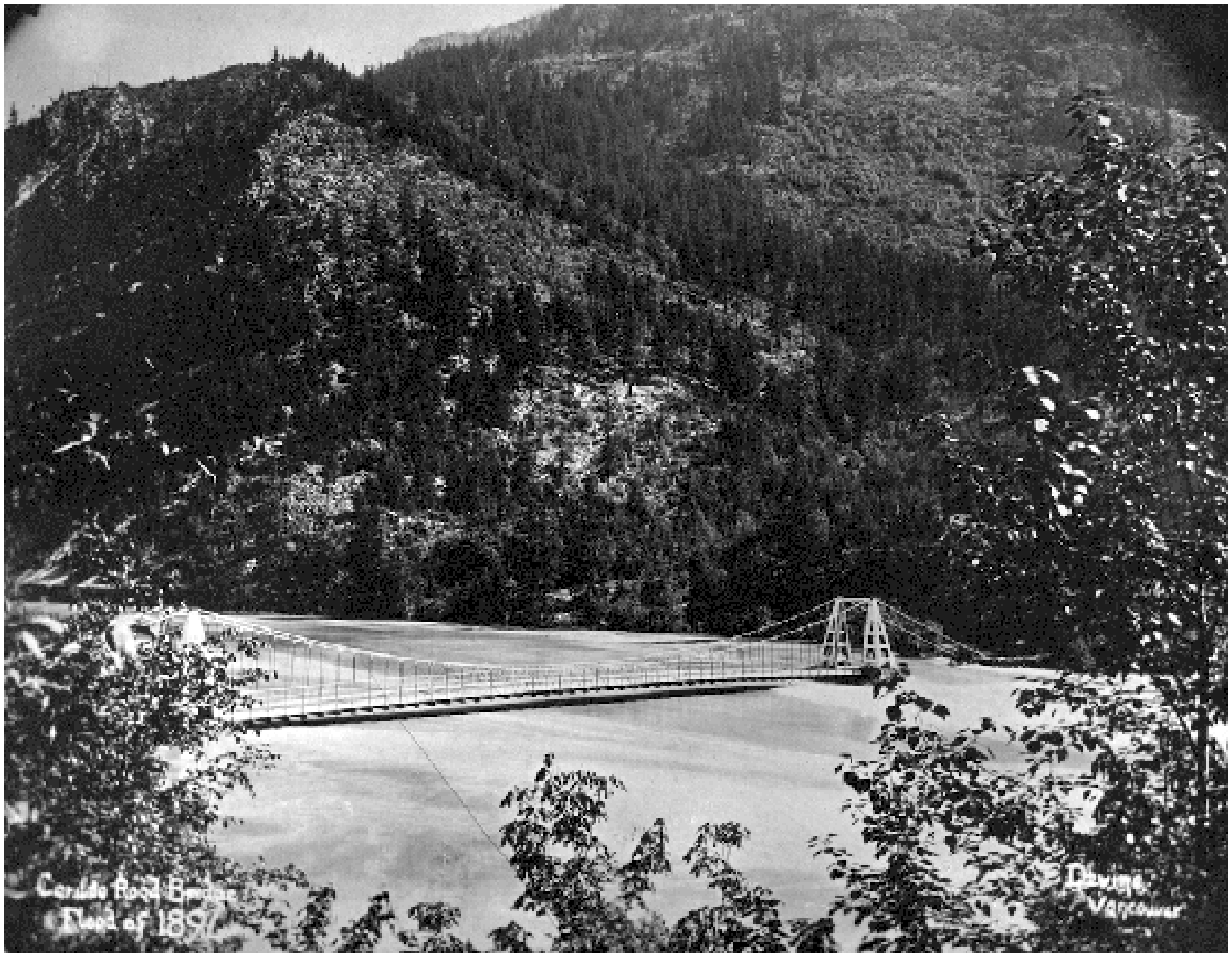
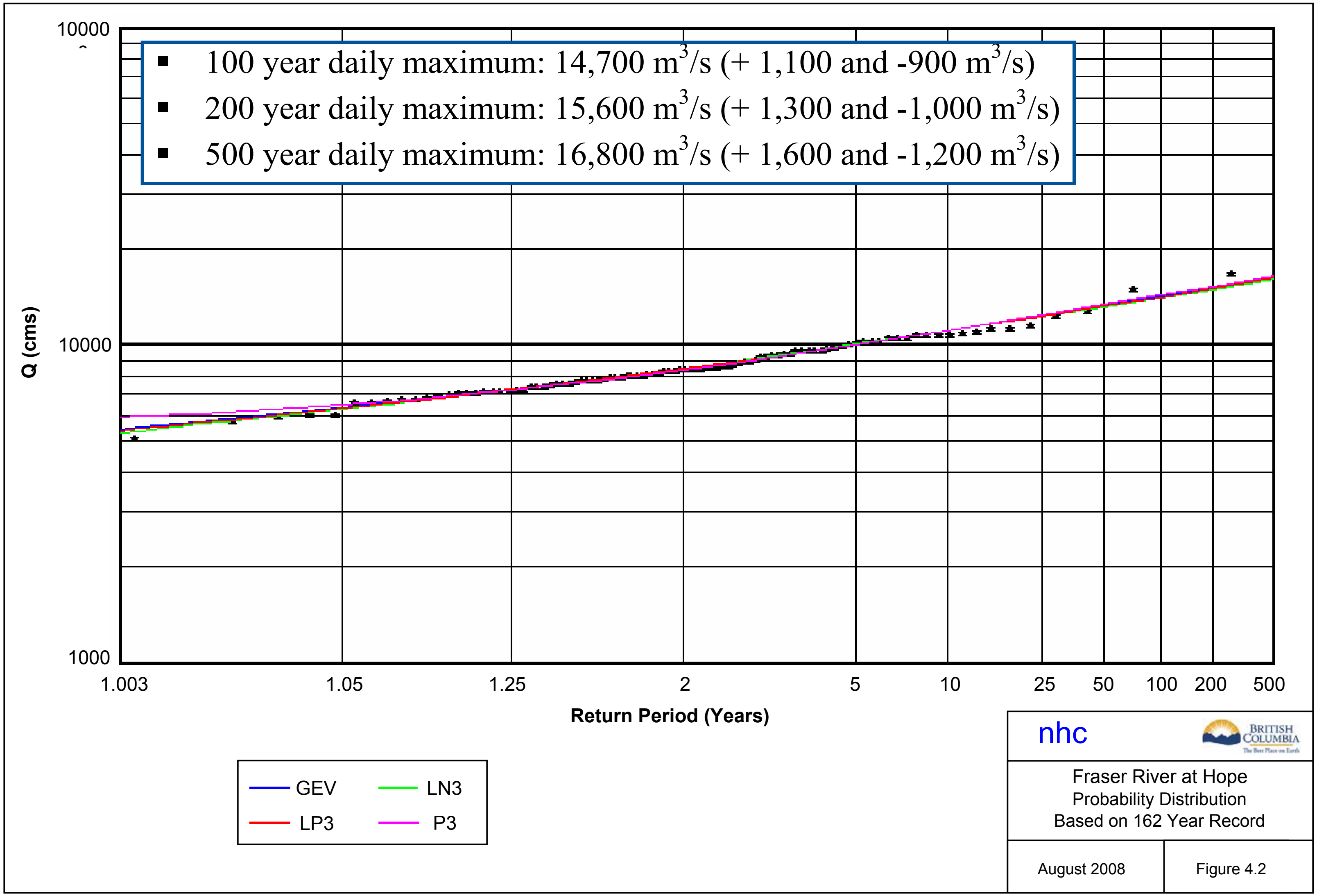


Figure 2.8: Alexandra Bridge during Flood of 1894

Source – Northwest Hydraulic Consultants / BC Ministry of Environment, 2008

Maximum discharge frequency

- 100 year daily maximum: 14,700 m^3/s (+ 1,100 and -900 m^3/s)
- 200 year daily maximum: 15,600 m^3/s (+ 1,300 and -1,000 m^3/s)
- 500 year daily maximum: 16,800 m^3/s (+ 1,600 and -1,200 m^3/s)

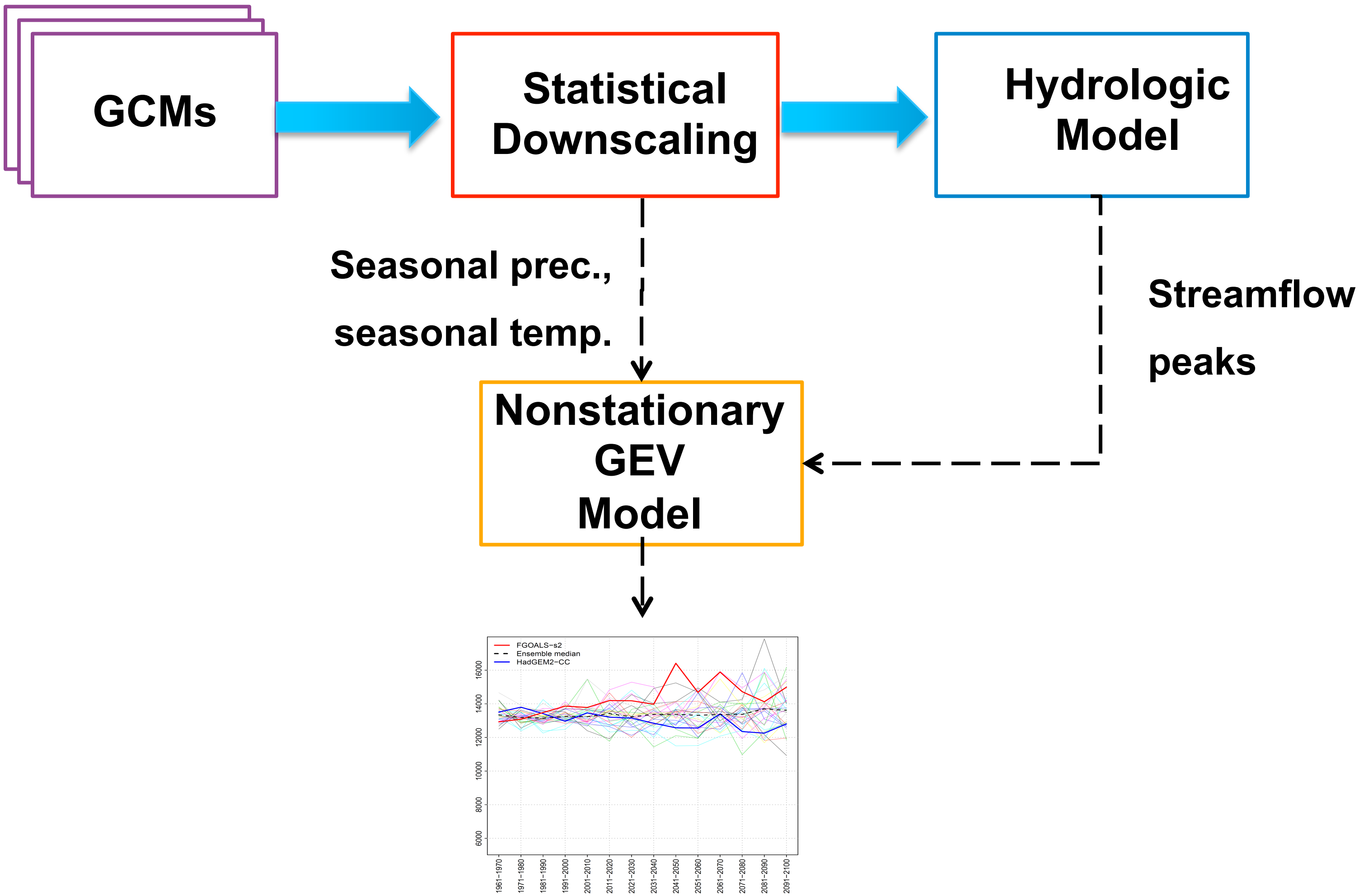


Source – Northwest Hydraulic Consultants / BC Ministry of Environment, 2008

VIC/emulator based projections

Photo: F. Zwiers **(Yukon River)**

Nonstationary Extremes Modelling



Streamflow Quantiles

Consideration of Nonstationarity

Generalized Extreme Value (GEV) distribution

$$f(z,\theta) = \exp\left[-\left\{1+\xi\left(\frac{x-\mu}{\sigma}\right)\right\}^{-1/\xi}\right]$$

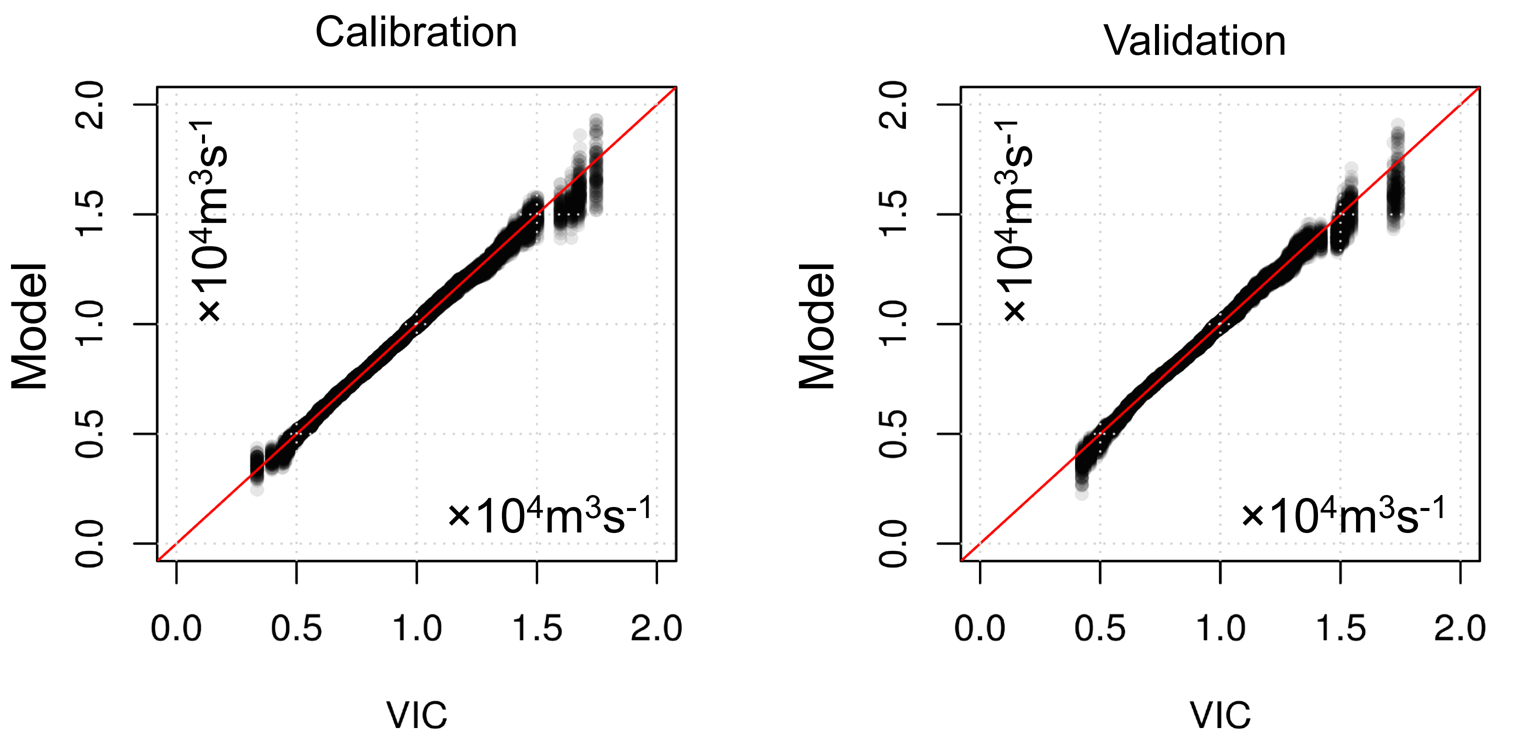
$$\xi \neq 0, \qquad 1+\xi\left(\frac{x-\mu}{\sigma}\right) > 0$$

where,

$\theta=(\mu,\sigma,\xi)$ are the location (μ), scale ($\sigma>0$) and shape (ξ)

Nonstationarity is represented by making GEV parameters dependent upon climate state
➔ Achieved using neural nets (details in Shrestha, et al, 2016, submitted)

Evaluation of nonstationary model skill



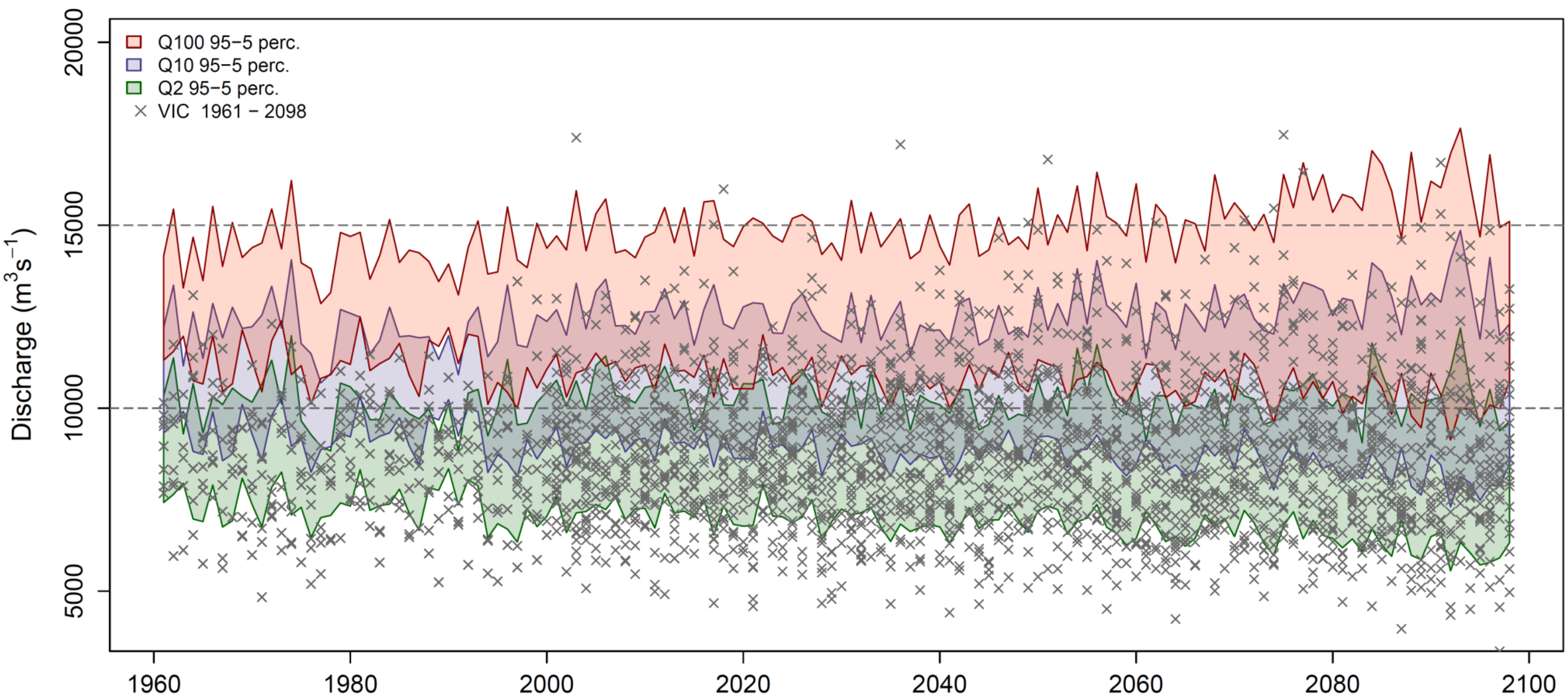
Predictors – DJF and MAM T and P

Training data – CMIP3 predictors, CMIP3 driven VIC, 1961-2098, A1B (8 GCMs) and B1 (7 GCMs)

Evaluation data – as above, except A2 (8 GCMs)

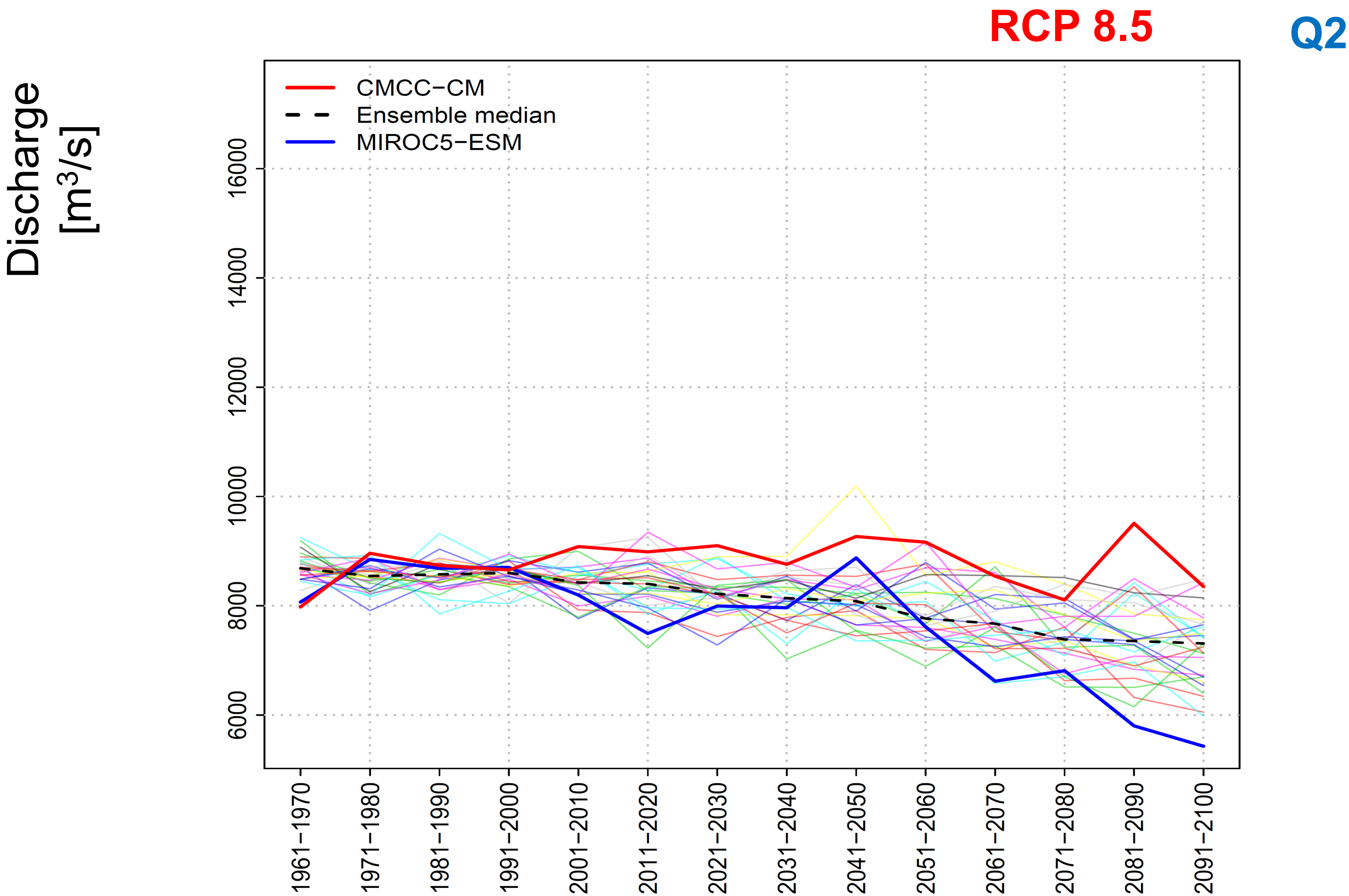
Location and scale parameters set to be predictor dependent

Changes in Q2, Q10, Q100



Selected model retrained with all CMIP3
Applied to CMIP3, and subsequently to CMIP5

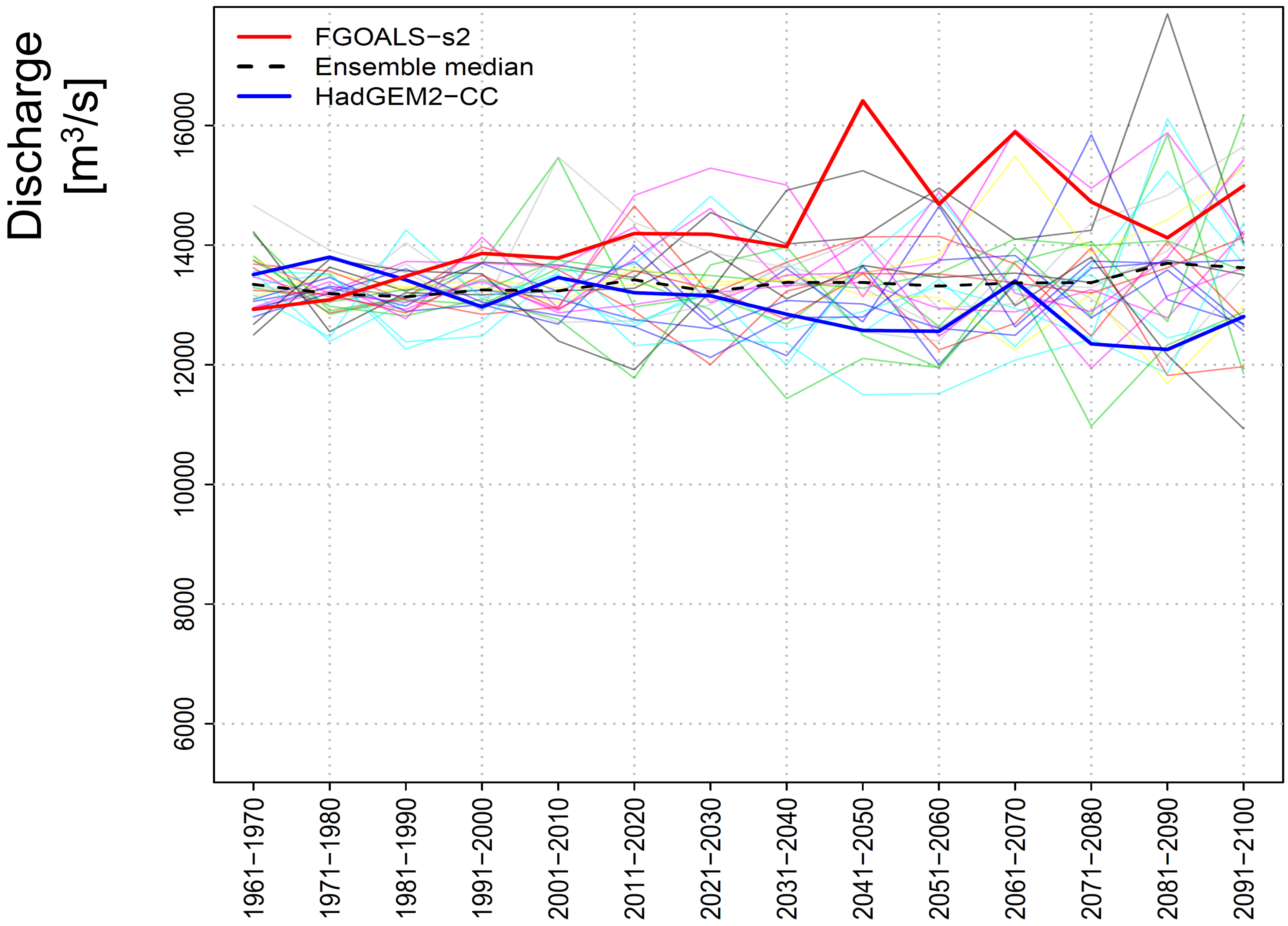
Projected Change in Flow Quantiles (CMIP5)



Projected Change in Flow Quantiles (CMIP5)

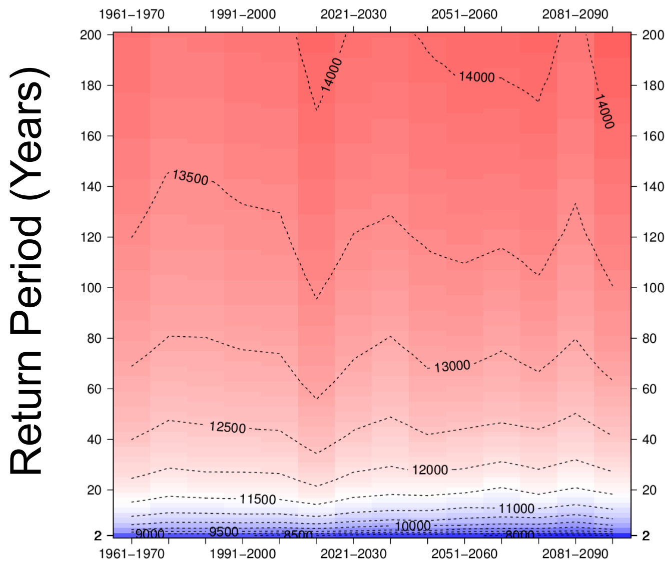
RCP 8.5

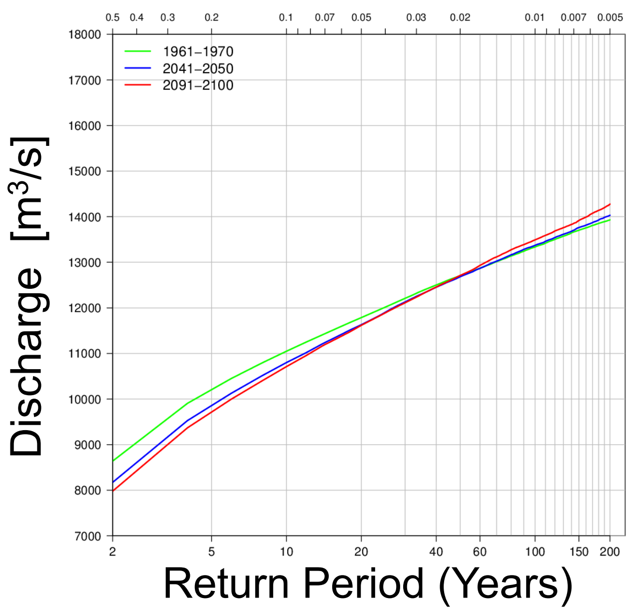
Q100



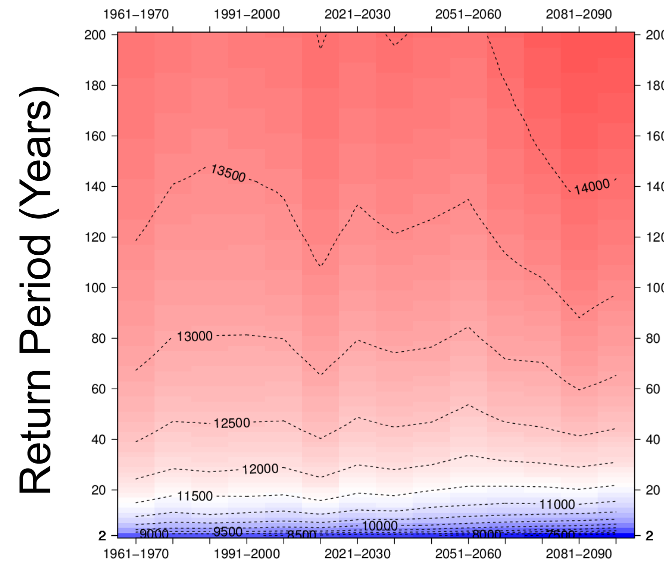
Projected Change in Return Values (CMIP5)

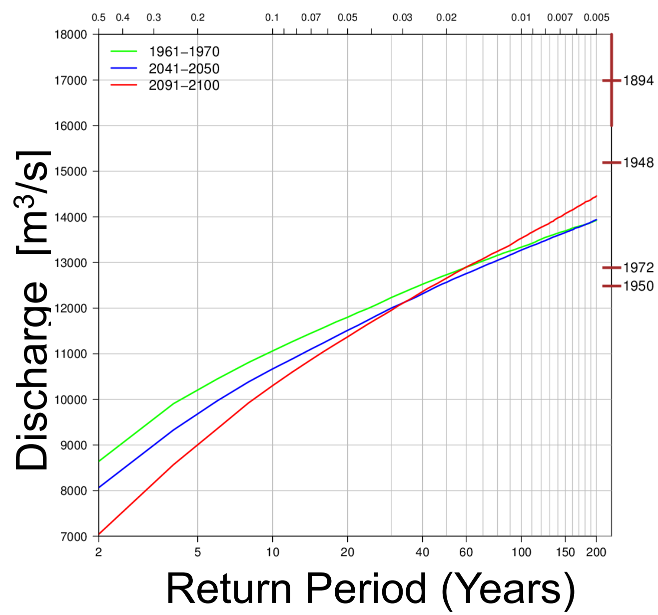
RCP 4.5



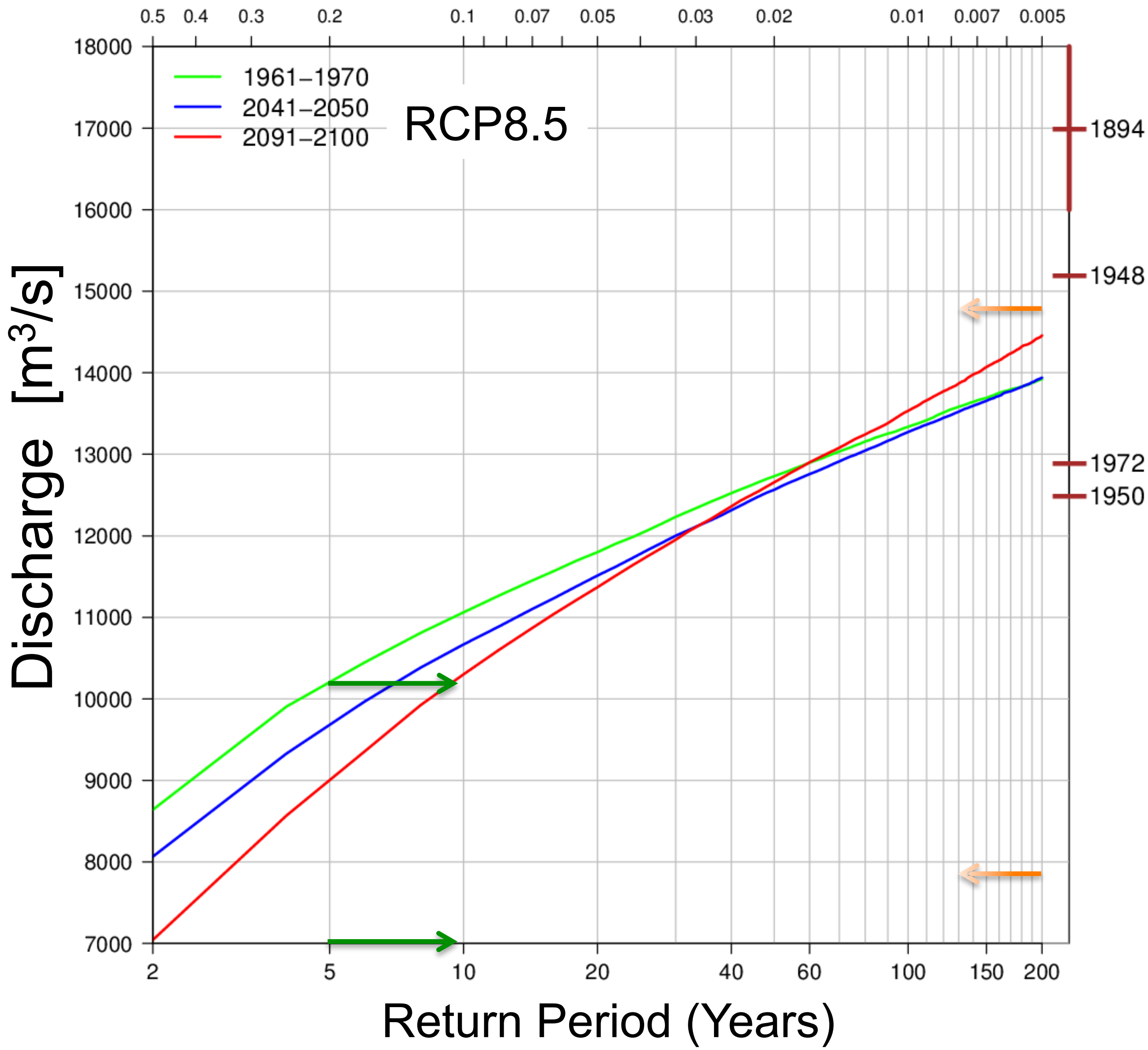


RCP 8.5





Assessing Fraser River flood risk



Discussion

***Photo: F. Zwiers* (Yukon River)**

Discussion

- Is 1894 more or less likely today than historically?
- Design criteria flood protection in the Lower Fraser still largely based in 1894 (although recently updated in 2014)
- Any increase in magnitude/frequency would be compounded with sea-level rise
- What physical process would allow magnitude to increase at very low frequencies?
- This seems a critical “event attribution”/risk assessment problem given the population and infrastructure at risk

Questions?

Photo: F. Zwiers