

Mountain snow and hydrological change modelling



INARCH Workshop – 24 October 2015

Do-Hyuk Kang, Xiaogang Shi, Huilin Gao, Siraj ul Islam,
Waqar Younas and Stephen Déry

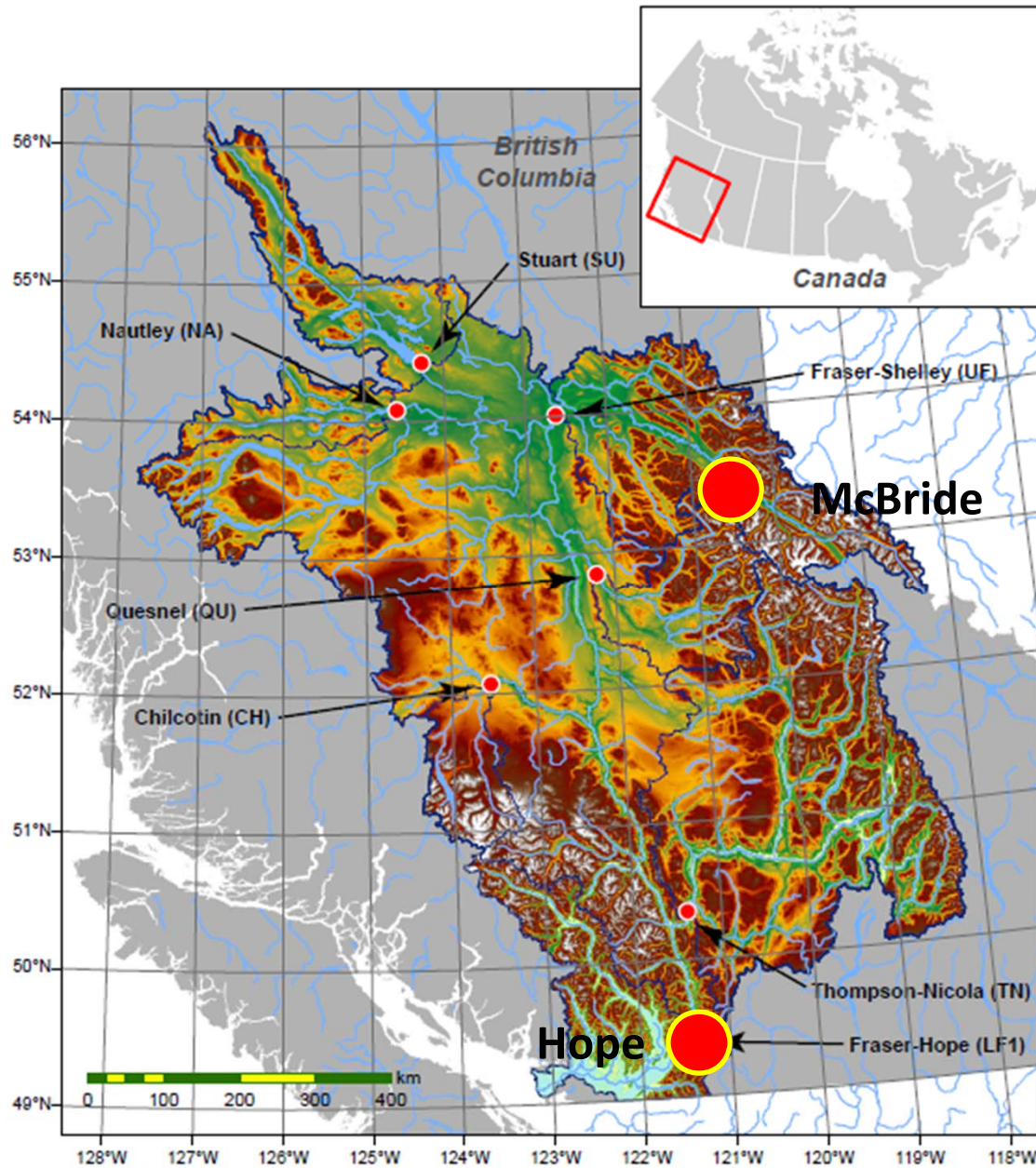


Assessing climate change impacts on the snowpacks and water availability of the Fraser River Basin, British Columbia

Canadian Sea Ice and Snow Evolution (CanSISE) Network

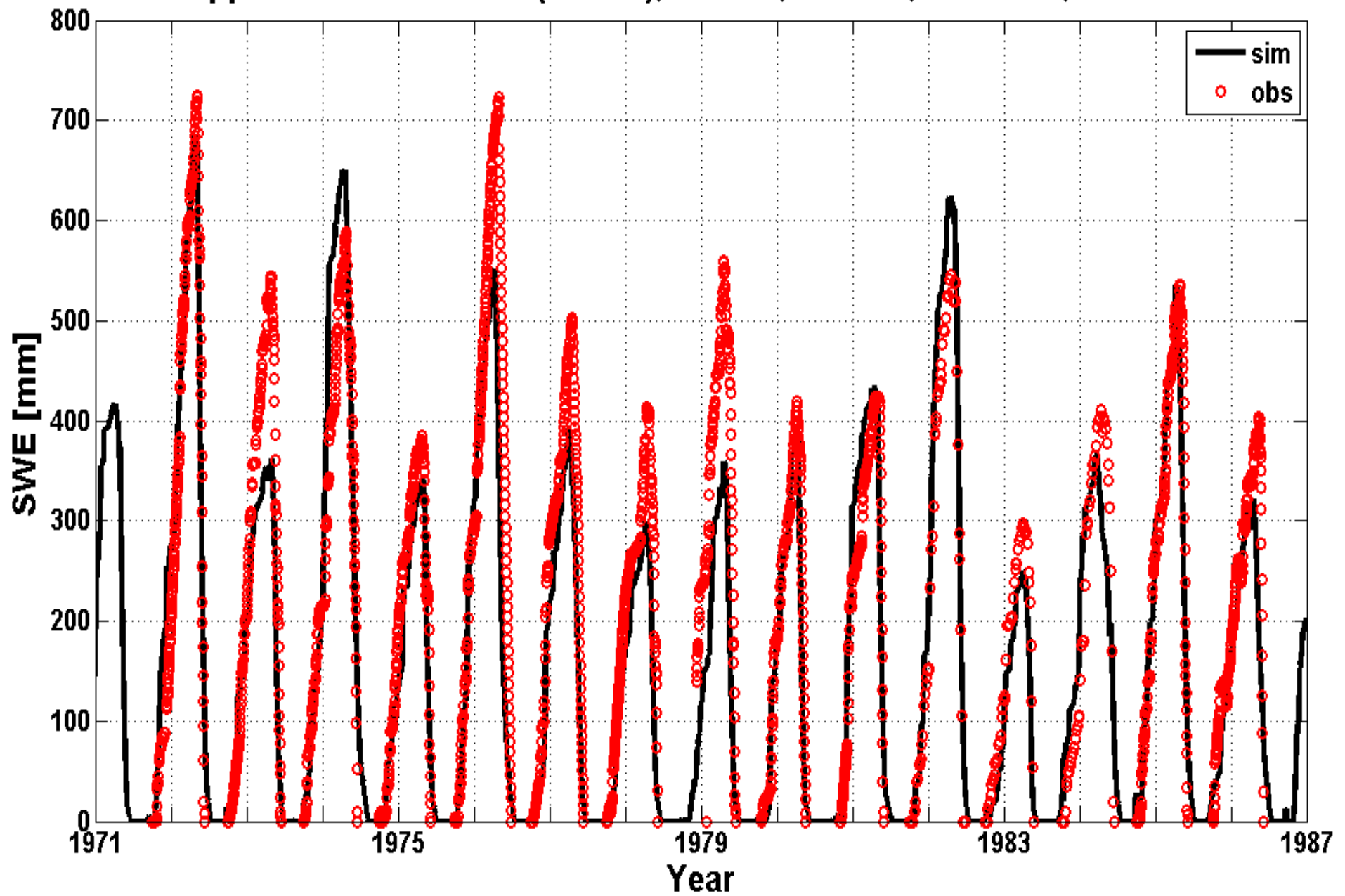


Fraser River Basin (FRB), BC

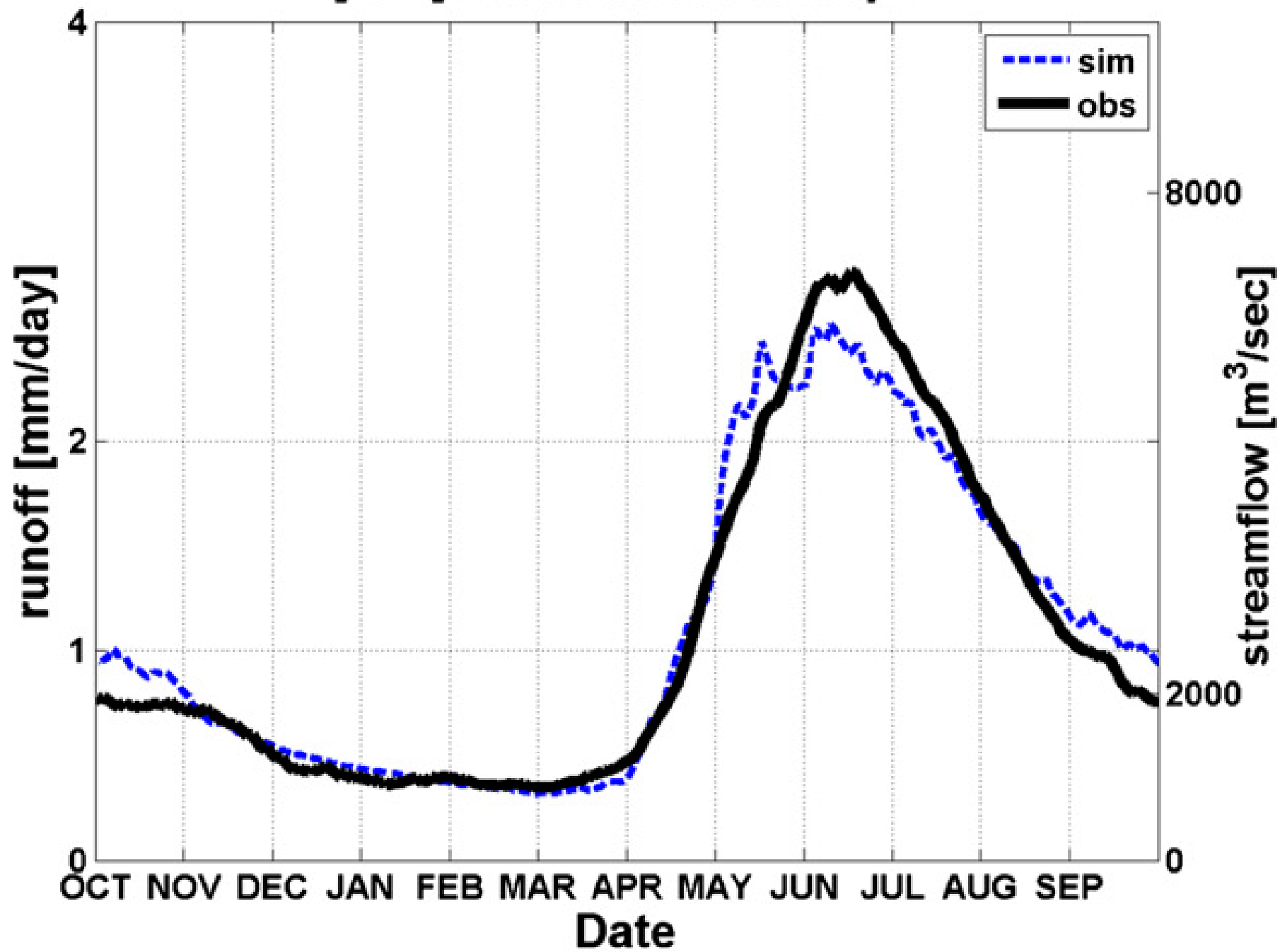


- Area ~ 240,000 km²
- 13 sub-watersheds
- Application of the Variable Infiltration Capacity Model (Liang et al. 1994) to the FRB
- Simulations at 0.25°, daily timescale forced by P, T_{min}, T_{max} and Wind Speed
- Historical period (water years 1949-2006)
- Future projections (2050's relative to 1990's)

Upper Fraser: McBride (1A02P), 1620 m, 53°18 N, 120°20 W, NSE:0.74

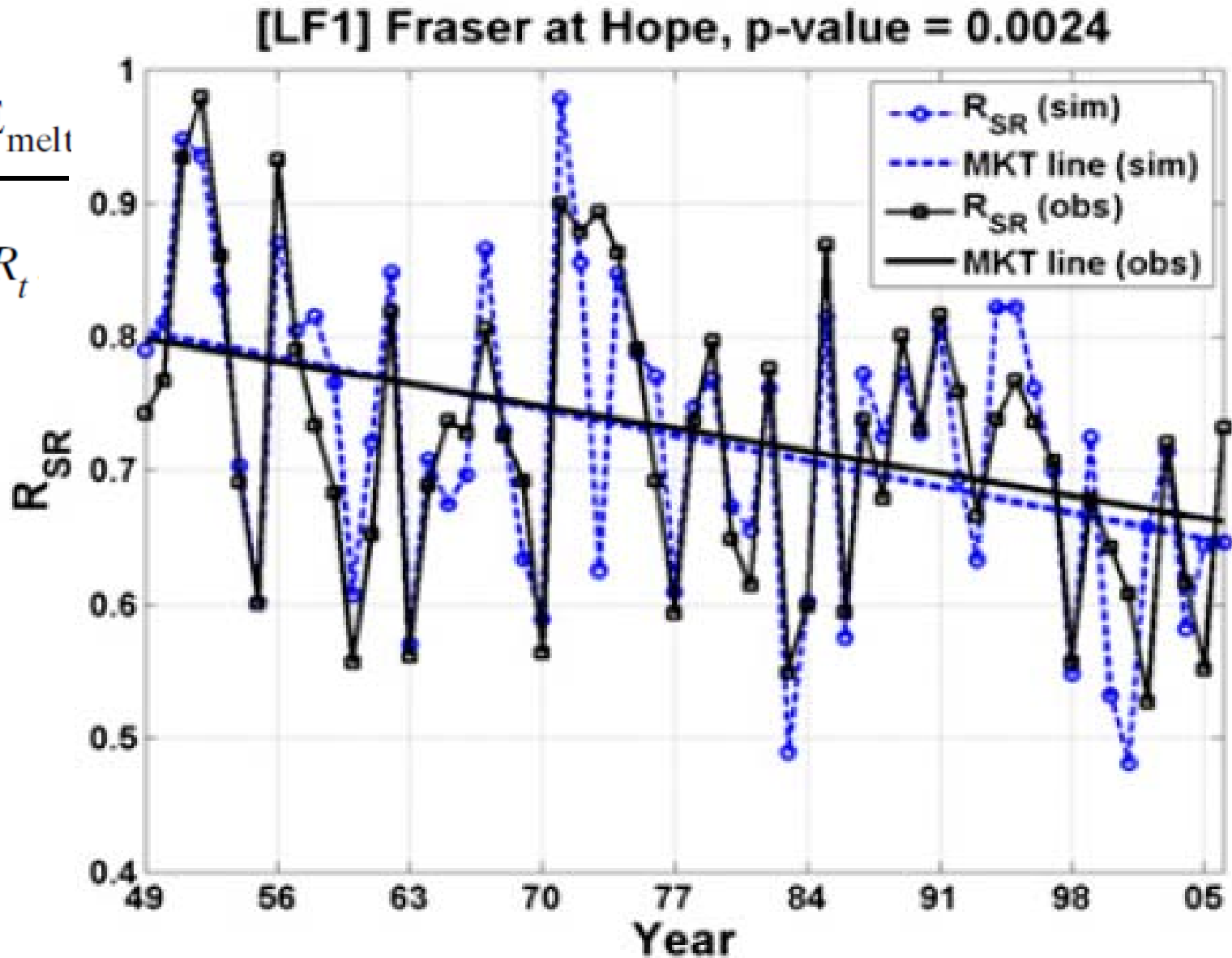


[LF1] Fraser River at Hope



Variable Infiltration Capacity (VIC) Liang et al., 1994

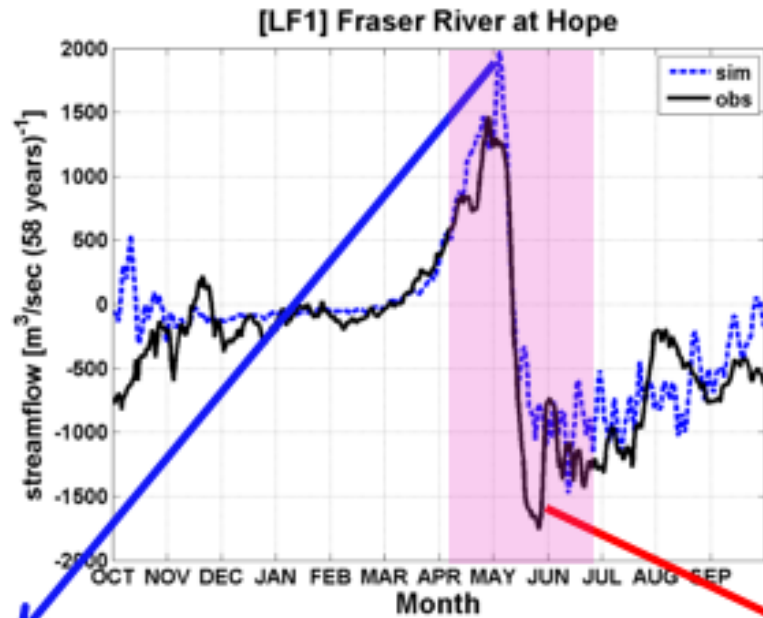
$$R_{SR} = \frac{SWE_{melt}}{\sum_{t=1}^N R_t}$$



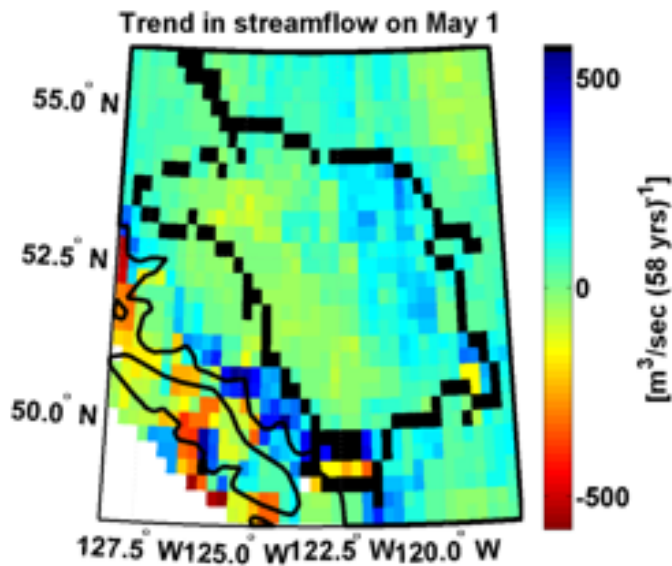
(Kang et al. 2014)

Trend in observed and simulated daily streamflow (1949-2006)

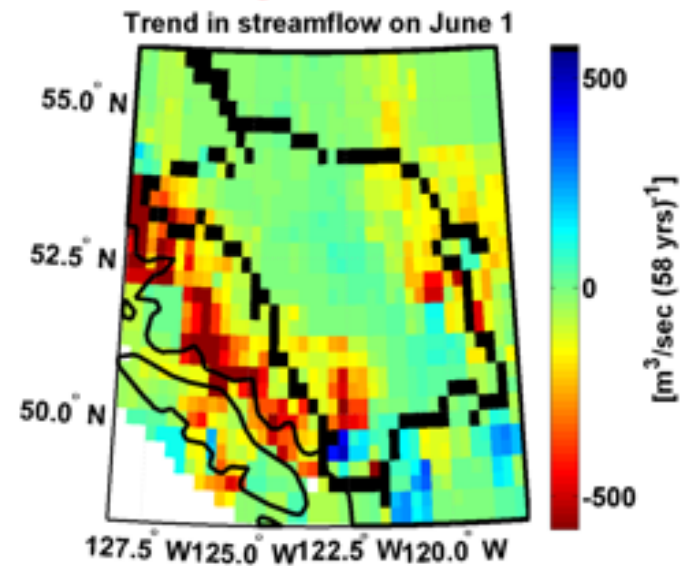
(Kang et al. 2015)
In review



(a)

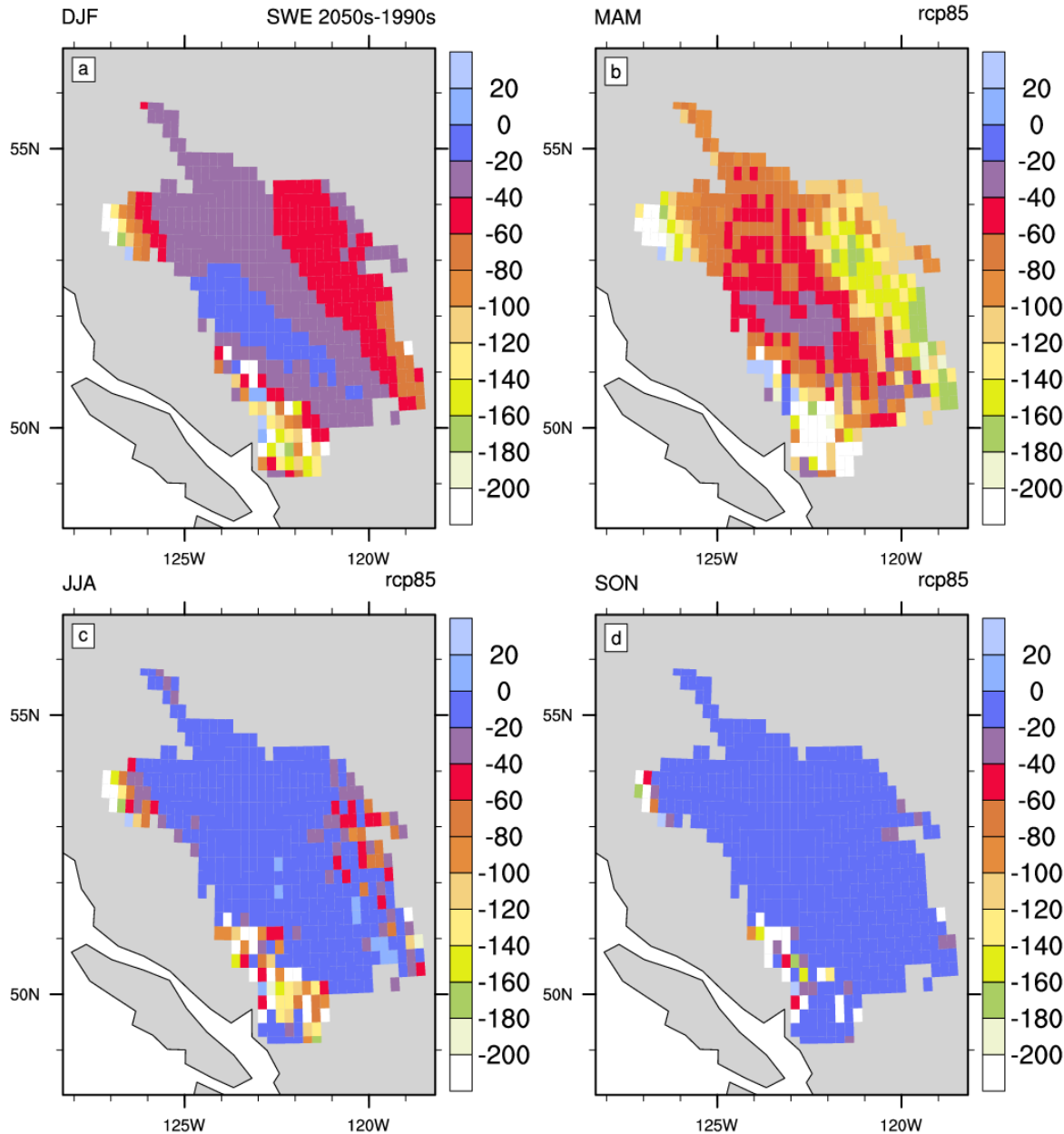


(b)

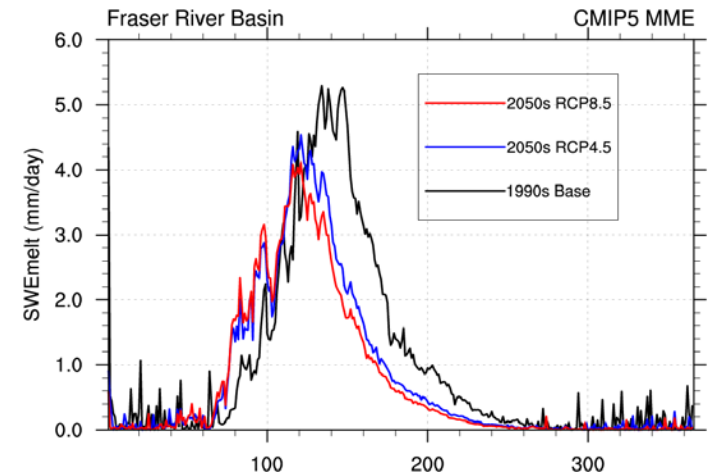


(c)

VIC Simulated SWE and SWE_{melt}



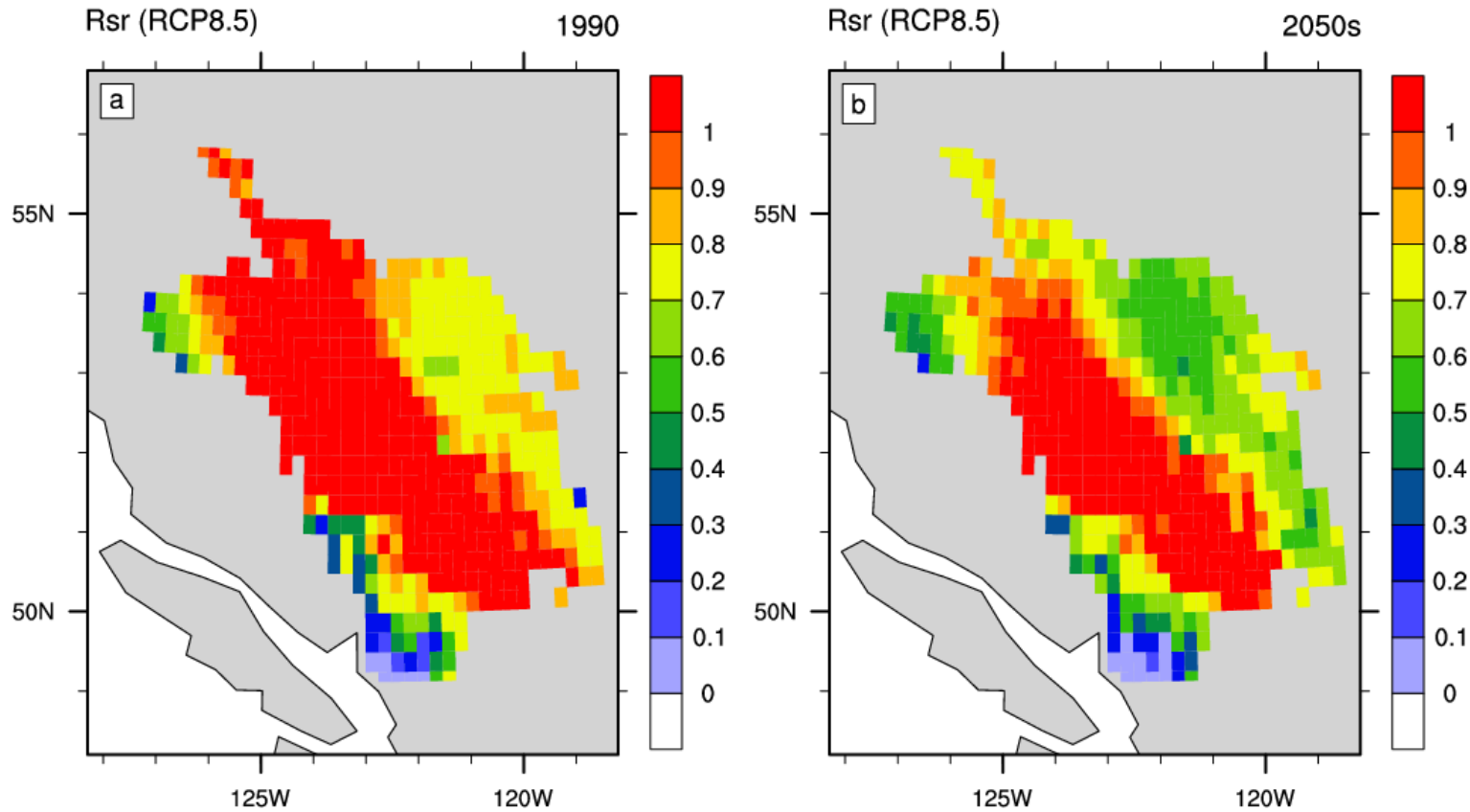
Multi-model Ensemble (MME) future projection results
Statistically-downscaled projection data provided by PCIC



$$SWE_{melt} = SWE_{max} - SWE_{min}$$

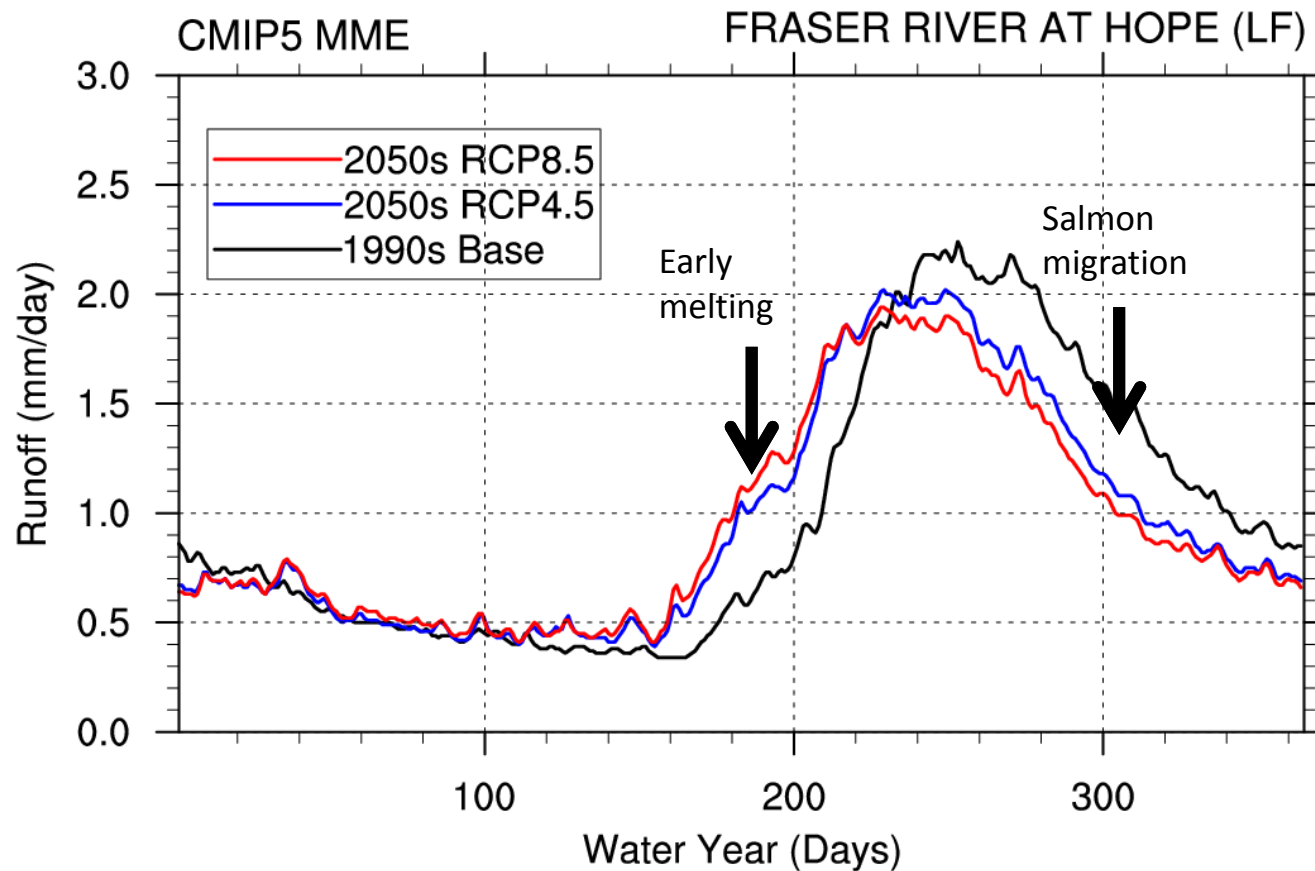
(mm)

Spatial Distribution of Mean R_{SR}



$$R_{SR} = \frac{SWE_{melt}}{\sum_{t=1}^N R_t}$$

Daily runoff at Fraser River at Hope (LF)



Summary and Conclusions

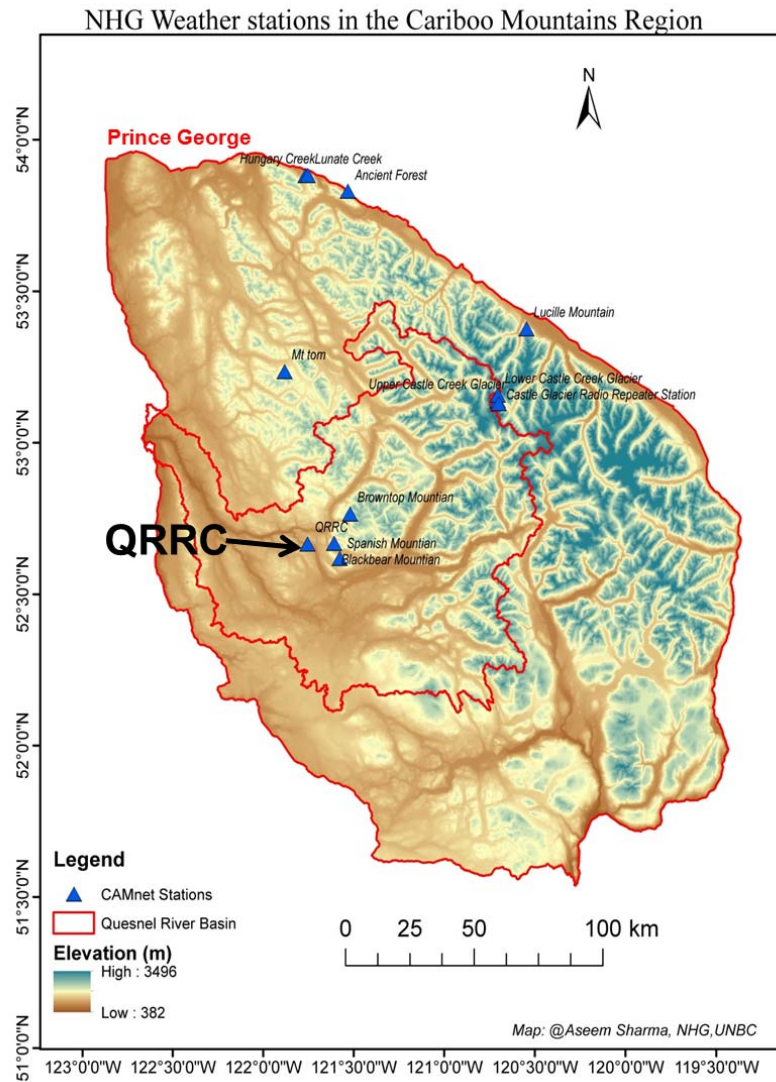
- The MME-based VIC simulations reveal widespread and regionally coherent spatial changes in snowfall, SWE and SC over most of the FRB by the 2050s.
- Significant changes seen over FRB in 2050s are:
 - 20-30% decrease in precipitation falling as snow
 - future onsets of FRB springtime snowmelt around 20-25 days earlier than the current onsets
 - more winter and spring runoff for the Fraser River main stem at Hope, BC
 - decreases in the R_{sr} ratio for all sub-watersheds.
 - decrease in SWE_{melt}
 - substantial decline in the snow accumulation and snow covered areas.
 - Stronger decreasing rates of SWE and SC decrease at high elevations



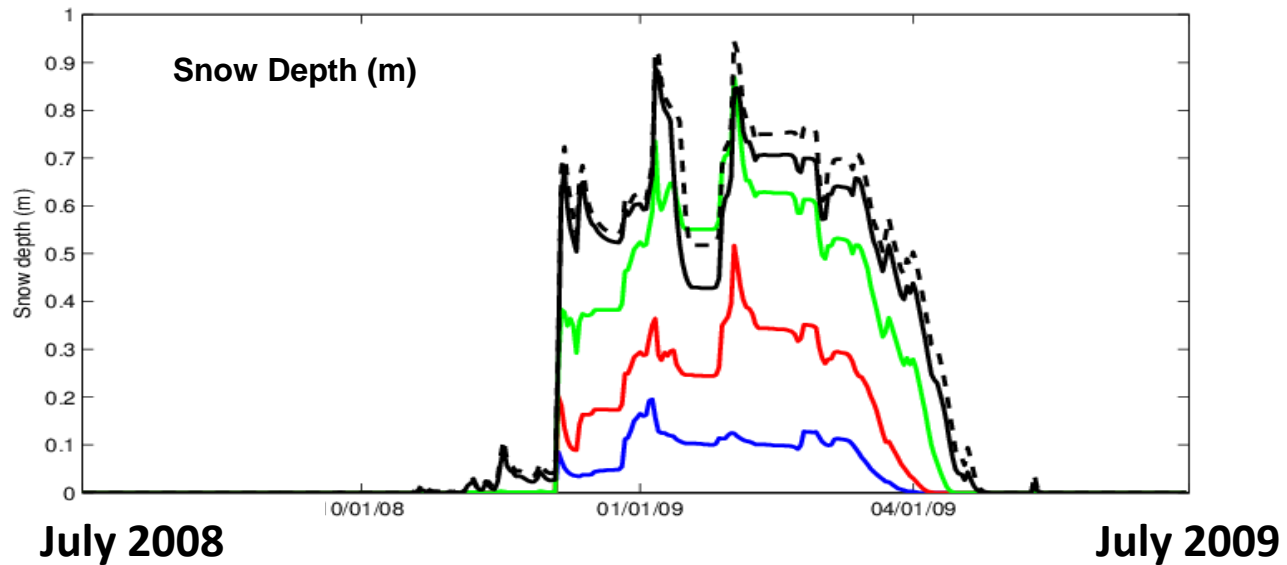
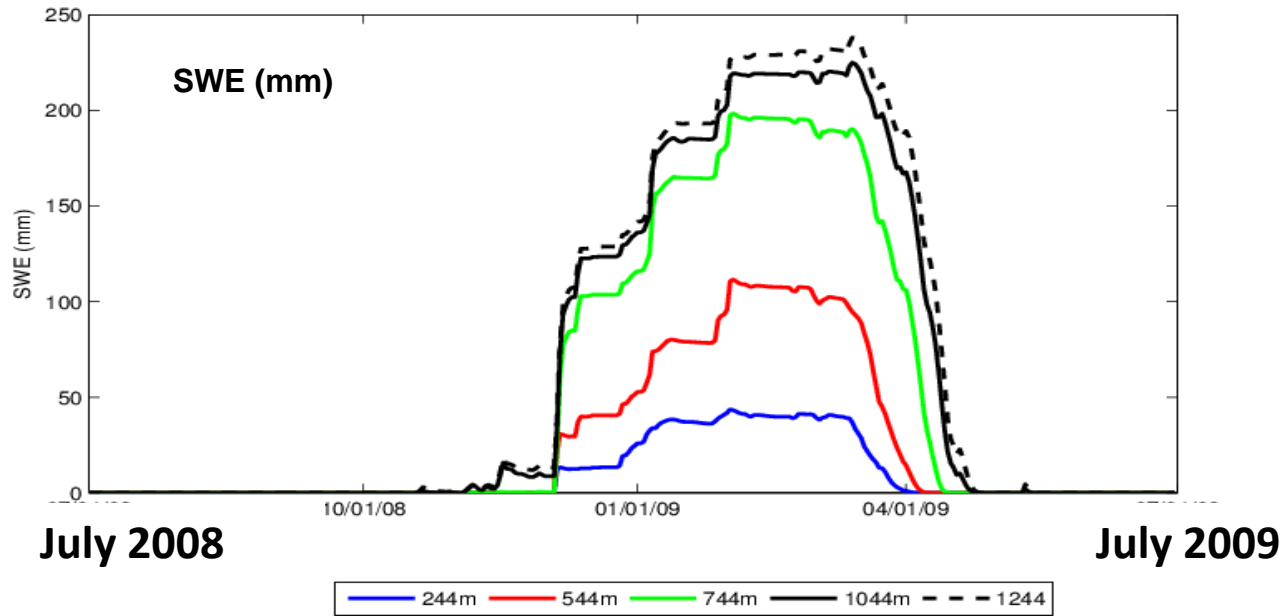
Representing sub-grid scale snow processes
in CLASS for the simulation of the hydrological
cycle in western Canada's watersheds

Canadian Network for Regional Climate and Weather Processes

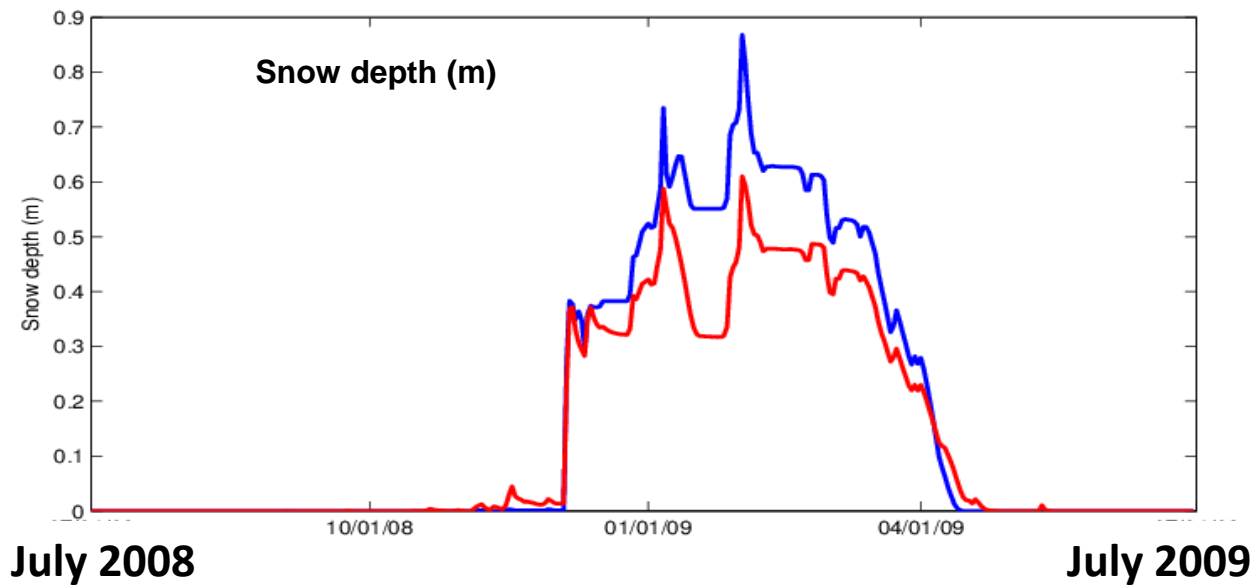
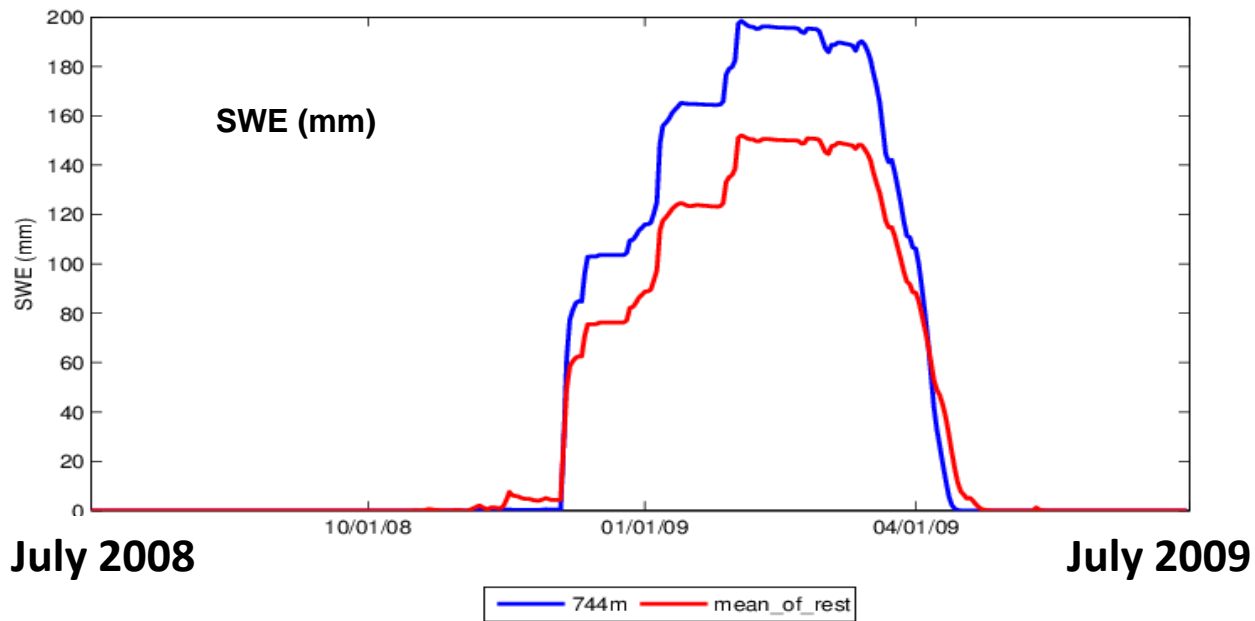
Study Area



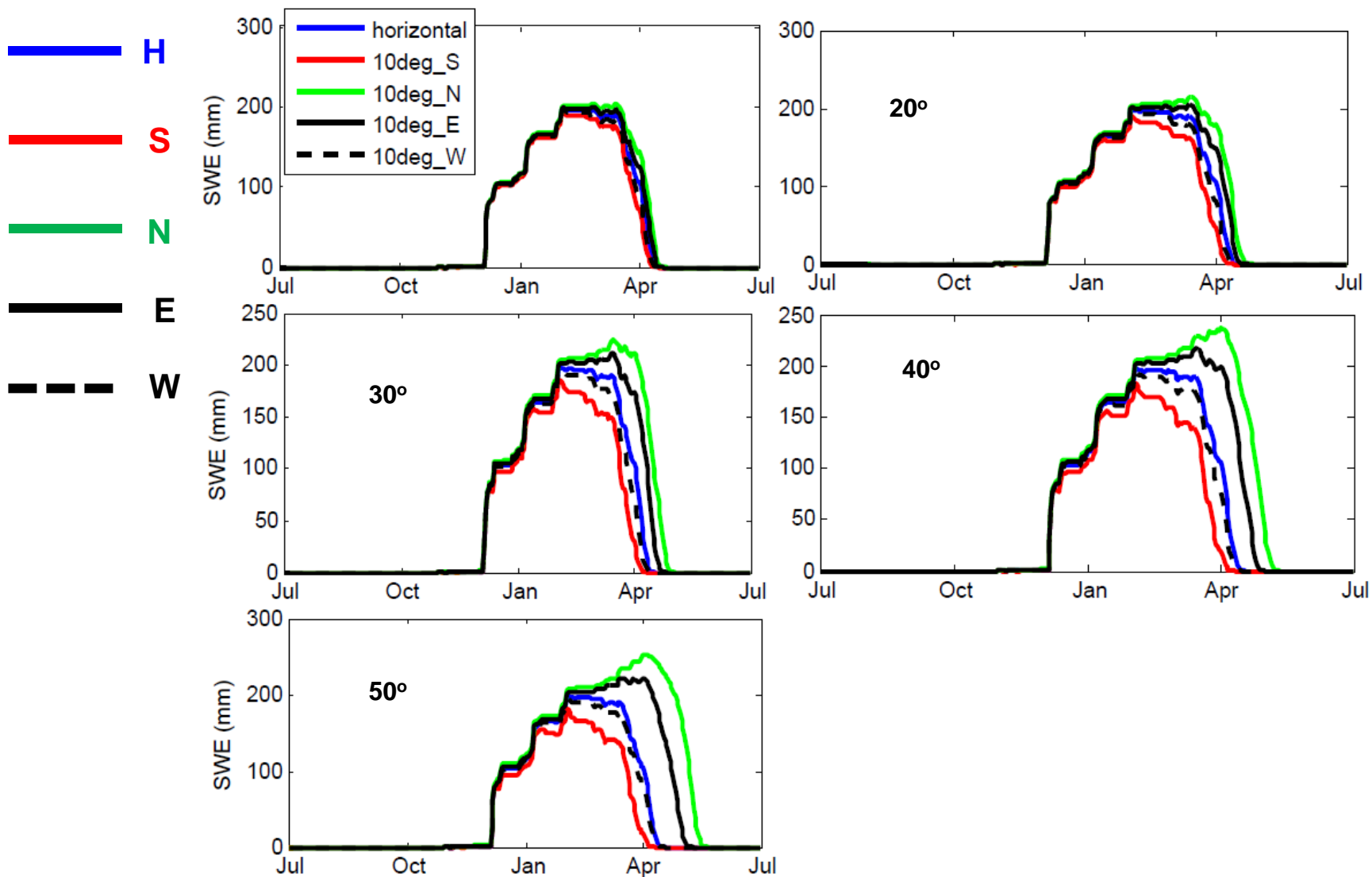
Temperature Lapse Rate Results (6.4 K km^{-1})



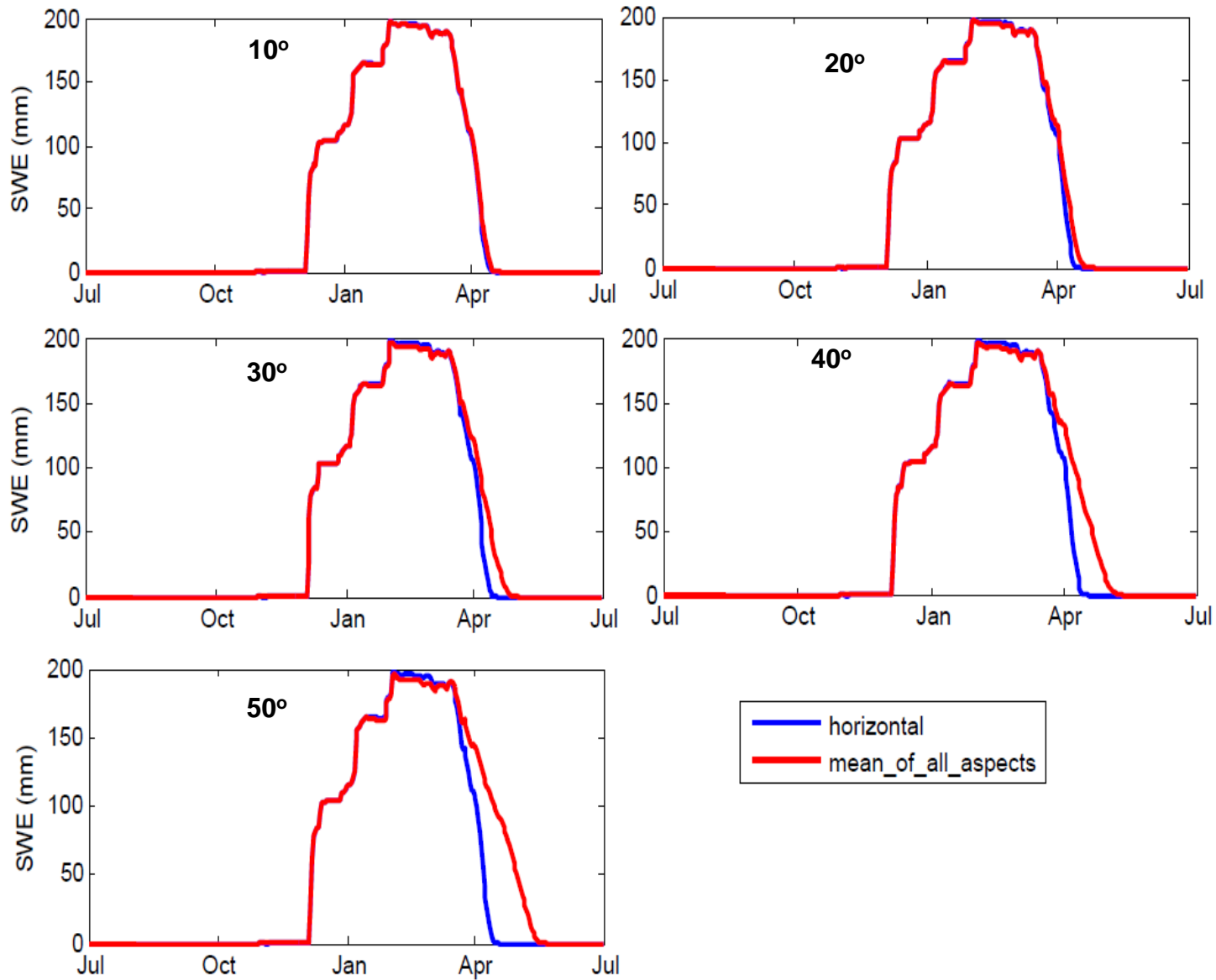
Mean Elevation vs Mean of Elevation Bands



Impacts of slope and aspect



Mean Elevation vs Mean of all aspects



Summary and Conclusions

- Hydrological variables such as snowmelt, SWE, snow depth and accumulated snow show significant variation by only applying a standard temperature lapse rate.
- The results were also different by comparing the mean of all the elevation bands with the results for the mean elevation (744 m), revealing non-linearities in snowpack evolution.
- The variation in solar radiation based on different slopes and aspect also exhibit non-linearities compared to flat surfaces.
- SWE showed significant variation during the melt period but did not show any variation during the fall or winter time.

Acknowledgements

- Thanks to our co-investigators/collaborators: Laxmi Sushama, Shawn Marshall, Diana Verseghy and Claude Duguay
- Thanks to Paul Bartlett (Environment Canada) for providing CLASS 3.6 and extensive email communication.
- Thanks to Francis Zwiers, Arelia Werner, Alex Cannon and Reza Najafi of Pacific Climate Impacts Consortium (PCIC) for scientific support and providing statistically downscaled CMIP5 data
- Funding provided by the Government of Canada's Natural Sciences and Engineering Research Council's Climate Change and Atmospheric Research initiative for a grant awarded to the Canadian Sea Ice and Snow Evolution (CanSISE) Network.



Questions for discussion

- What are the spatial scales of catchments that INARCH is interested in?
- How can remote sensing data contribute to INARCH?