WSML Watershed Science & Modelling Laboratory

Water footprint analysis of barley production in Alberta: implications for water use and yields to 2064

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Motivation

- Alberta is globally recognized for its large oil and agricultural exports including beef and live cattle.
- Beef production highly depends on feed crops, where barley is the principal feed.
- Global beef production is expected to increase 74% by 2050 (FAO, 2017).
- To sustain Alberta beef exports, there will be an increased need to produce barley.

- Therefore, an assessment of barley production in light of the uncertainties in water availability arising from climate change is needed.
- Here, Water Footprint (WF) is used as an usable metric for the current and future crop water use.

Research objectives

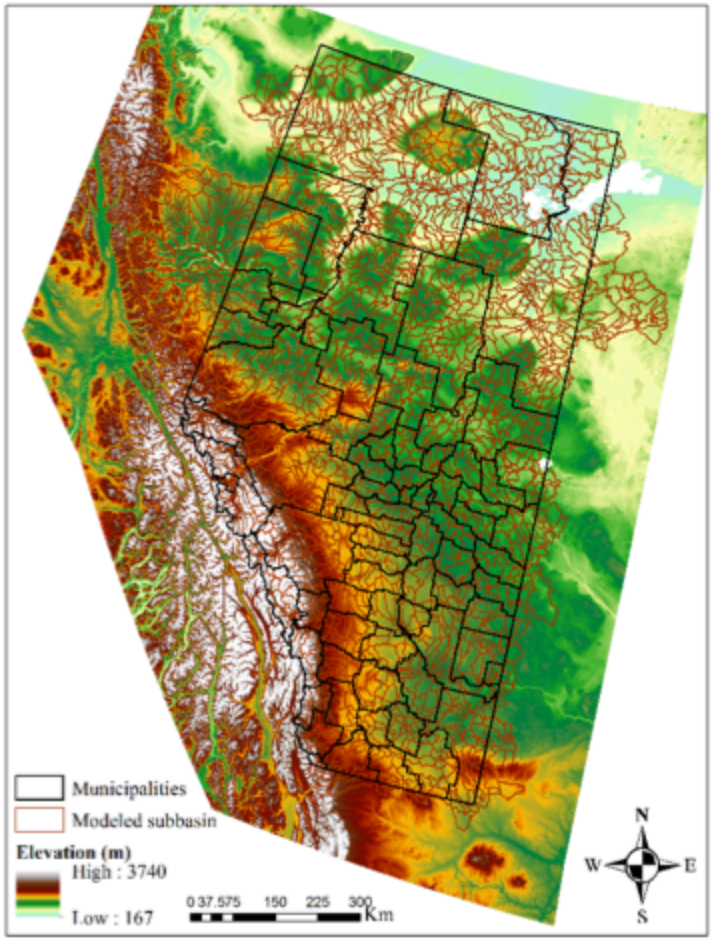
(i) to investigate quantitatively the potential effect of prospective climate change scenarios on crop production and

(ii) to quantify the effects of the projected changes in climate on the WF

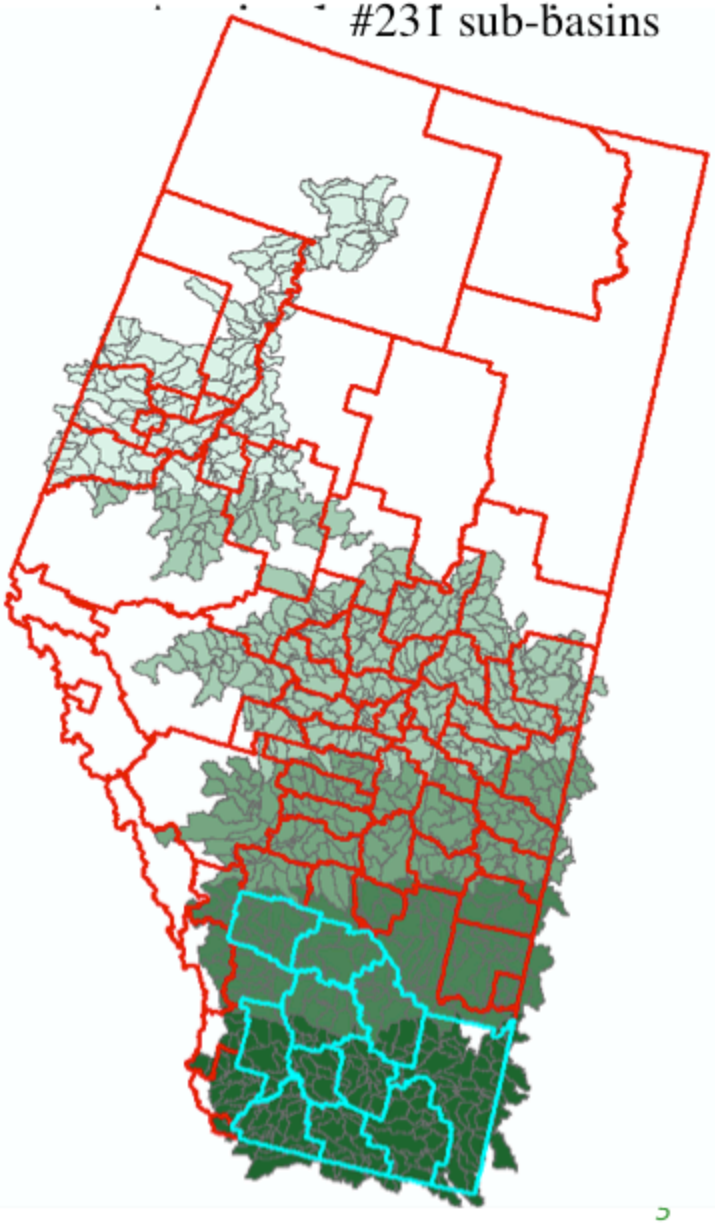
Model Setup

- Used SWAT hydrological model [Faramarzi et al., 2015]
  - DEM
  - Land use
  - Soil
  - Climate
  - Pothole
  - Dam, reservoir and lake
  - Glacier
- 2255 sub-basins were delineated.
- Yearly barley yield data were collected from Alberta Financial Services Corporation (AFSC)
- Agricultural management operations:
  1. Tillage
  2. Planting
  3. Fertilizer application
  4. Irrigation application
  5. Harvesting

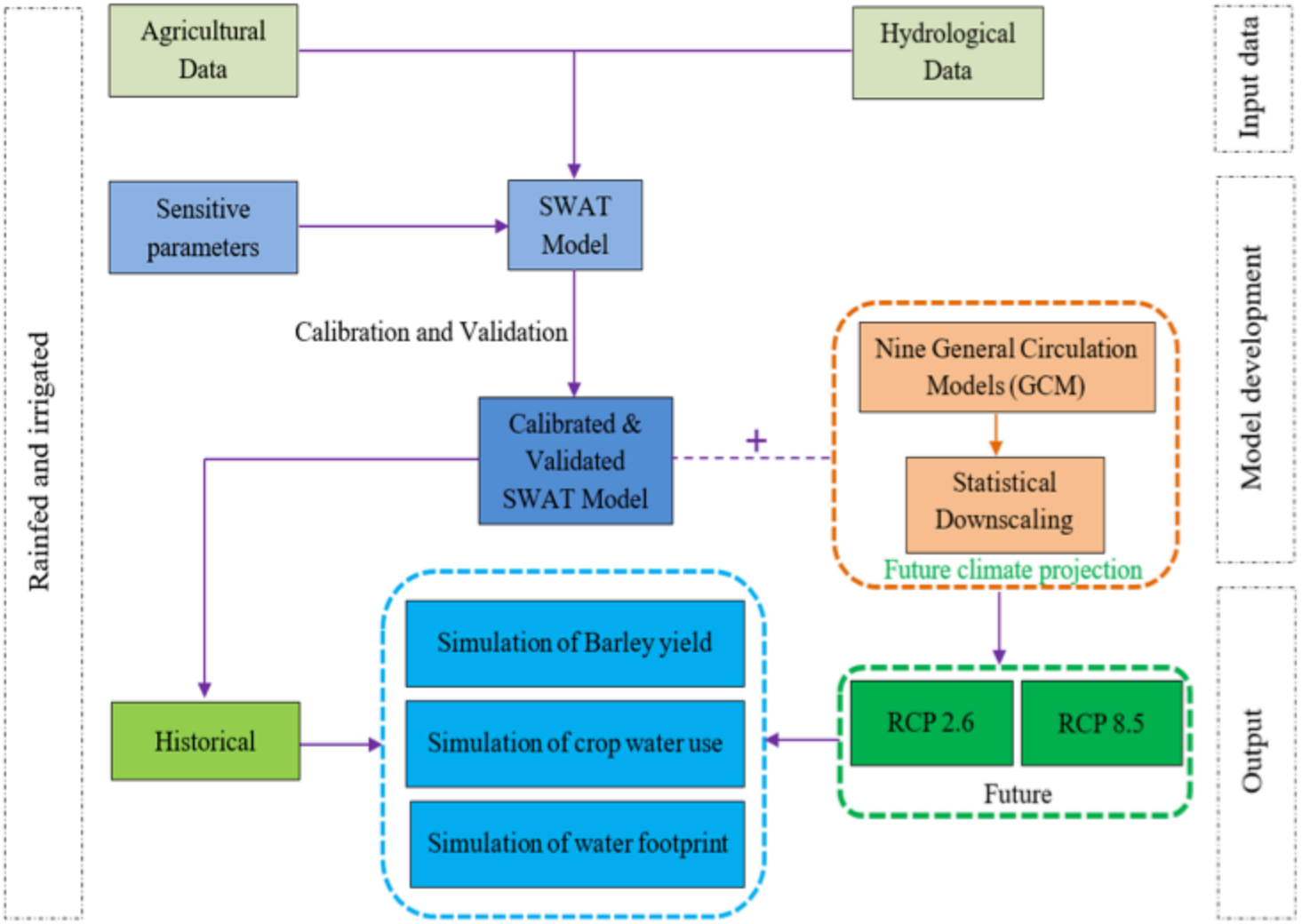
Study domain
2255 sub-basins



#11 counties
#231 sub-basins



Adopted research framework



√ Nine GCMs from PCIC √ 90 SWAT projects √ Windows based high computing machines
√ Used over 500 processors √ Parallel processing system

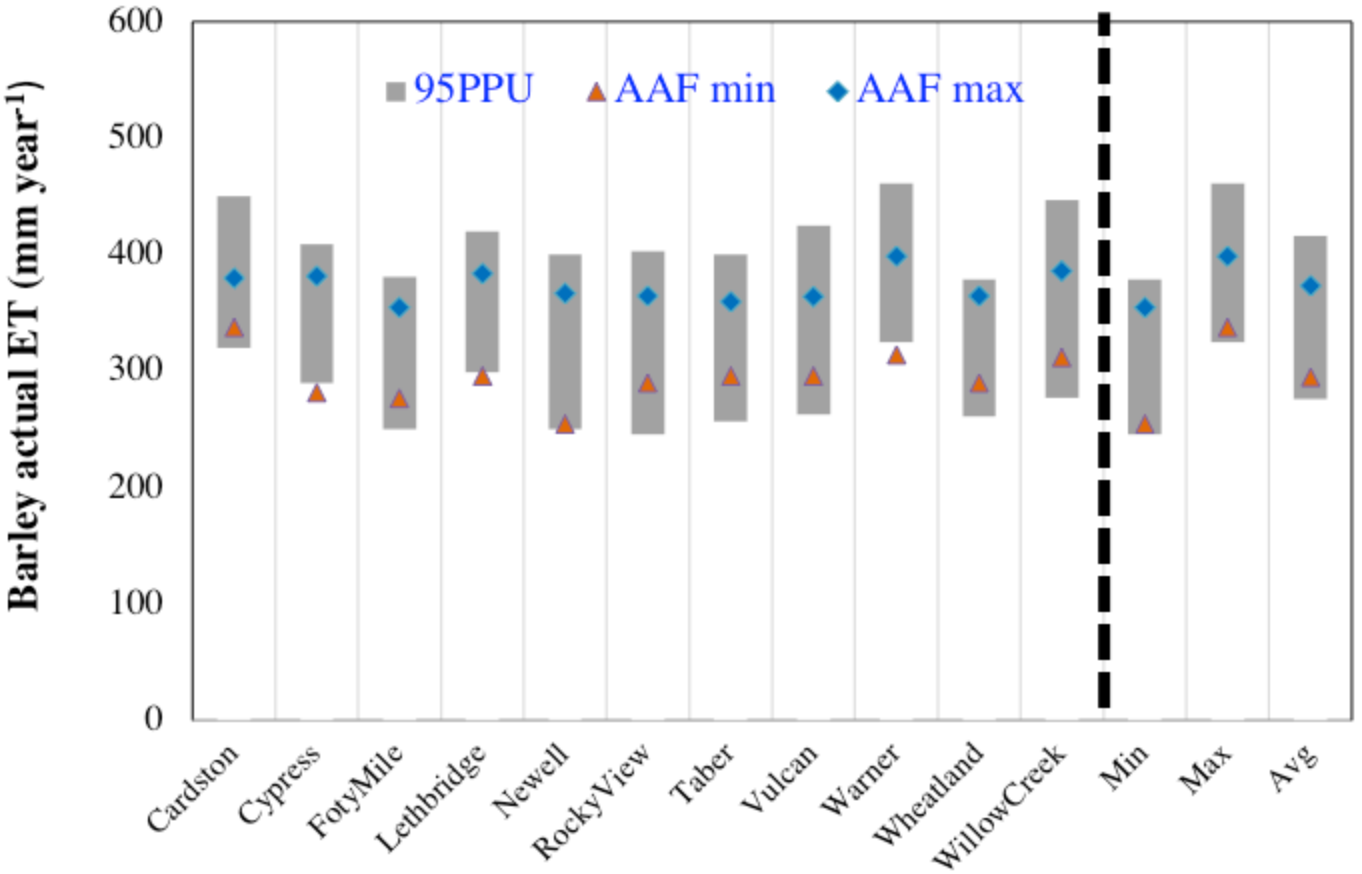
Model performance

Model calibration: 1995 – 2009 (15 years)
Model validation: 1983 – 1994 (12 years)

- Calibration and validation were performed for each county.
- Total number of parameters were 805 and 134 for rainfed and irrigated barley, respectively after sensitivity analysis.

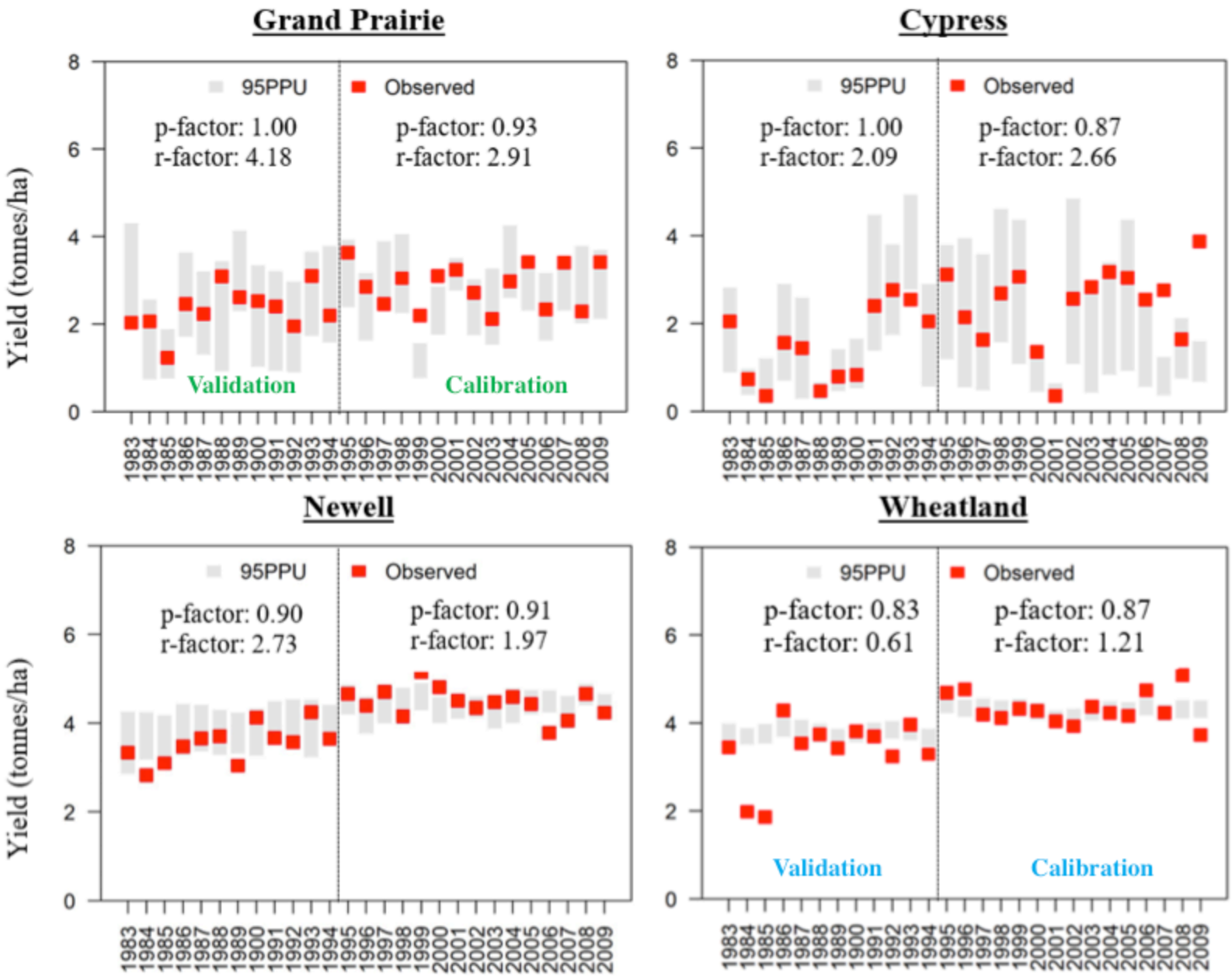
	Calibration				Validation			
	# counties	p-Factor	r-Factor	MSE	# counties	p-Factor	r-Factor	MSE
Rainfed	66	0.88	4.48	0.62	66	0.85	5.35	0.59
Irrigated	11	0.92	2.11	0.25	11	0.82	2.34	0.68

Verification of crop ET in irrigated counties

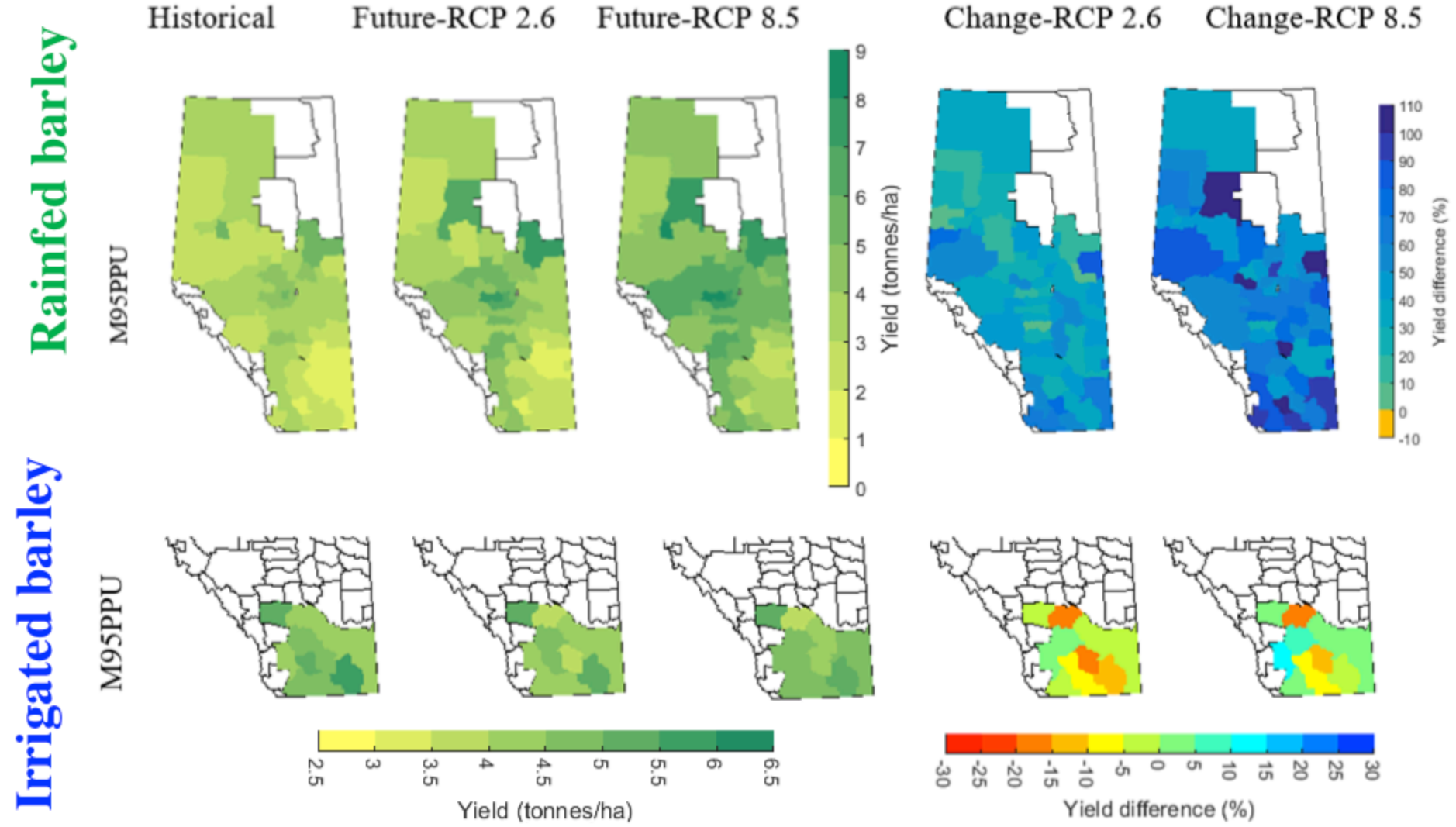


Rainfed barley

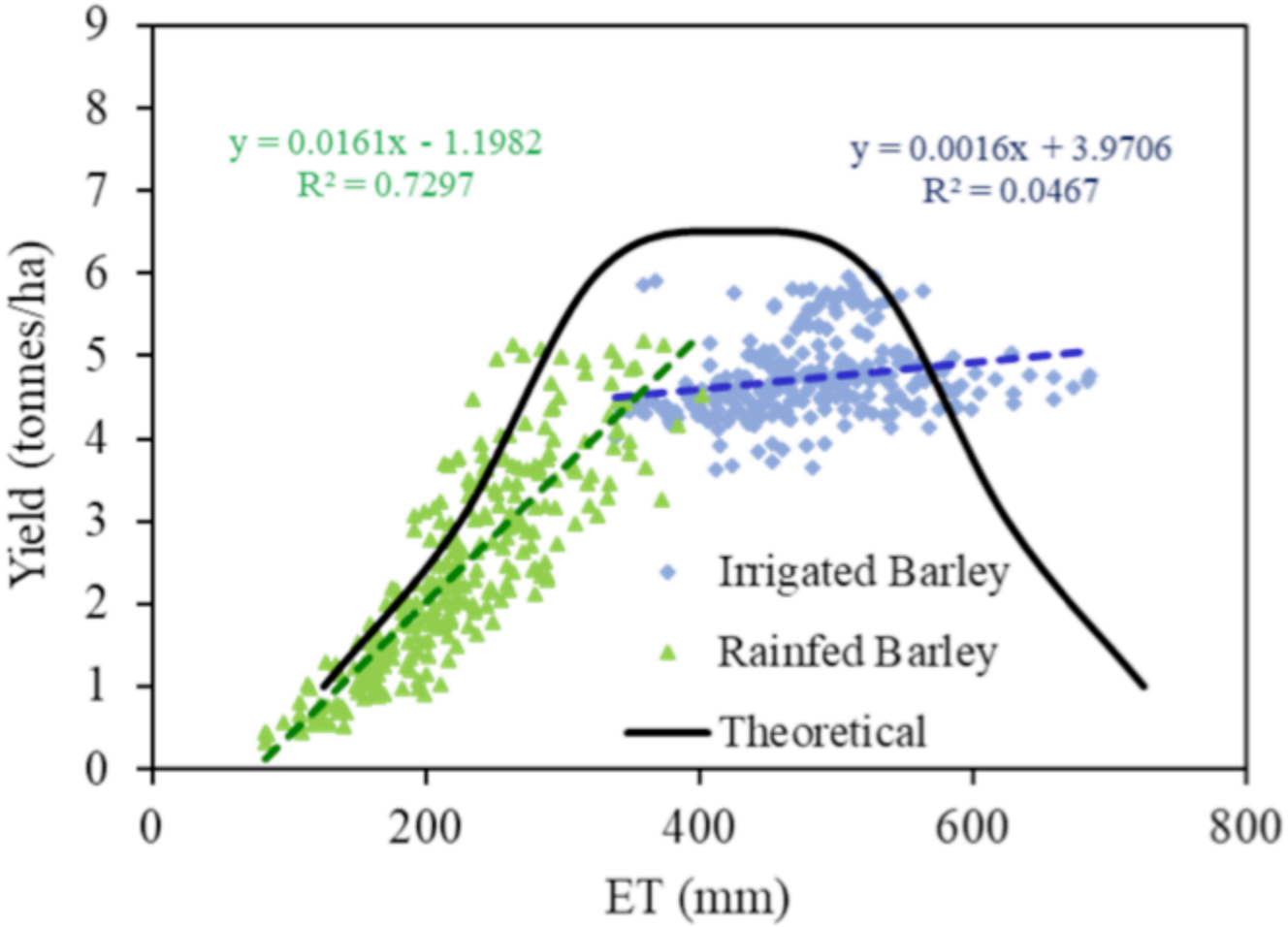
Irrigated barley



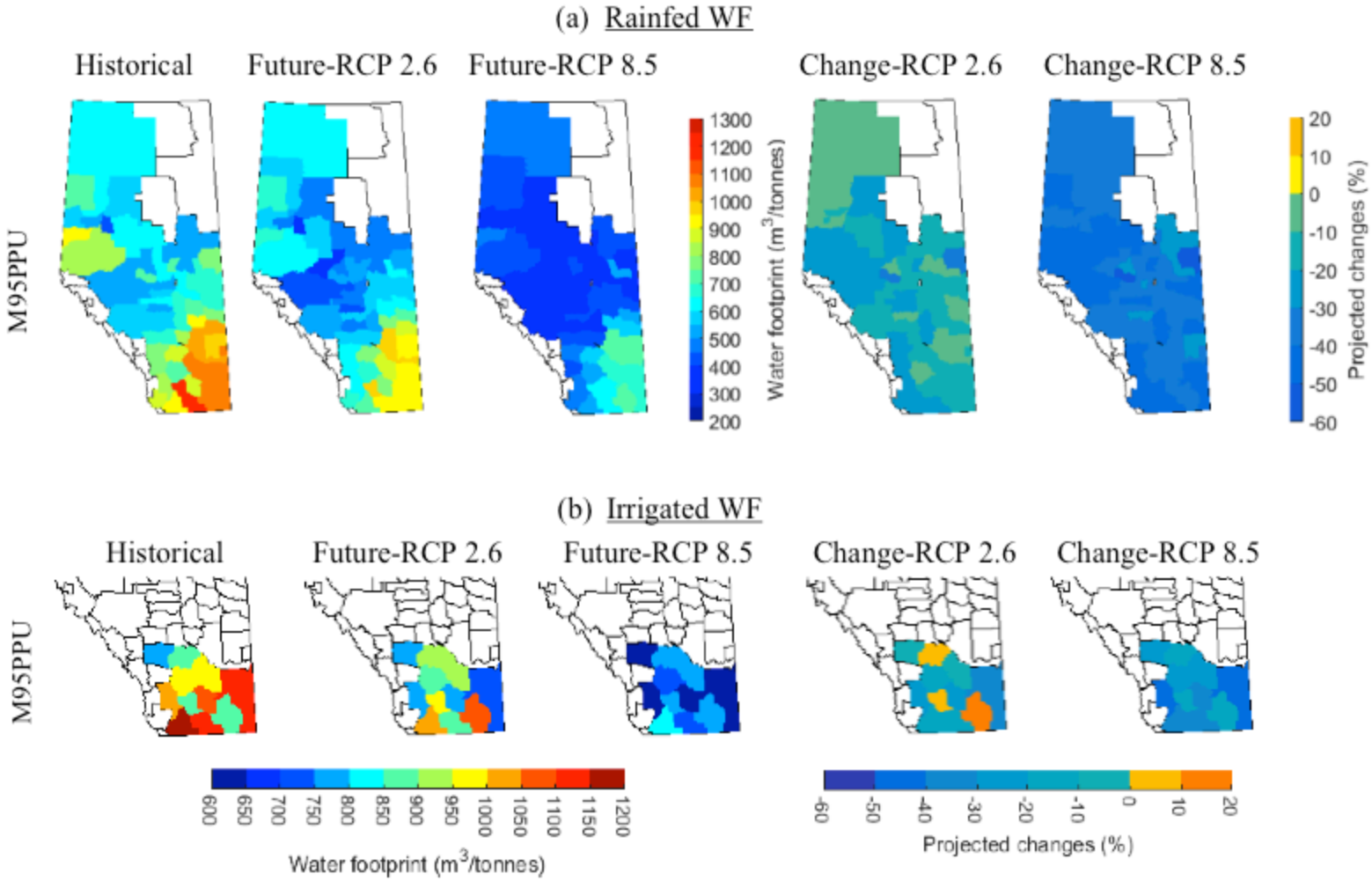
Projected changes in rainfed barley yield Y (2040-2064)



Y and ET relationship for 1986-2009



Spatial pattern of WF (2040-2064)



Adjusted WF of irrigated barley

	M95PPU	
County	WF	WF_{adj}
Cardston	1269	1661
Cypress	1130	542
Forty Mile	892	727
Lethbridge	897	1174
Newell	971	1214
Rocky View	767	959
Taber	1051	1375
Vulcan	993	1270
Warner	1120	1288
Wheatland	882	650
Willow Creek	1038	1359

Take Home Messages

- Developed a model to simulate rainfed and irrigated crops
- Climate change leads to an increase in rainfed barley yield, while irrigated barley is projected to remain unchanged.
- WF will decrease in the future due to higher Y and lower crop water use.
- Higher CO_2 concentration in the future boosts crop yield by:
  - Increasing the rate of photosynthesis, which spurs growth
  - Reducing crop stomatal closure and plant transpiration.

PDF and PhD position on:

Risk assessment, integrated management and adaptation to changing water in Alberta

THANK YOU



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Poster: D-43 (Wed-Thu)