Reducing the Uncertainty in Groundwater Availability and its Sensitivity to Land-use and Climate Variability

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*Groundwater Recharge in the Prairies

Water Innovation Program Forum
May 22-23, 2019

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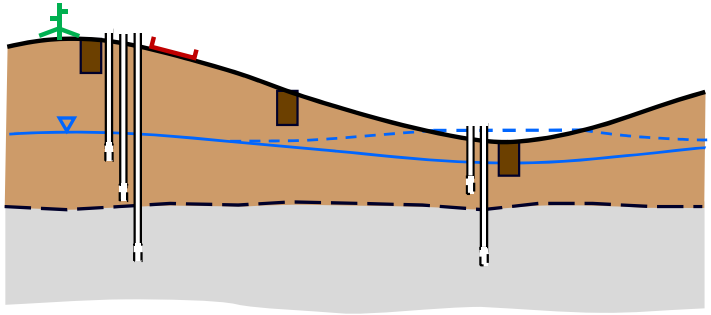
Amir Niazi, Alanna Felske, Freda LeBlanc, Brandon Hill, Eric Mott, Alana Muenchrath, Paul Fontaine, Kristyn Juergensen, and more…

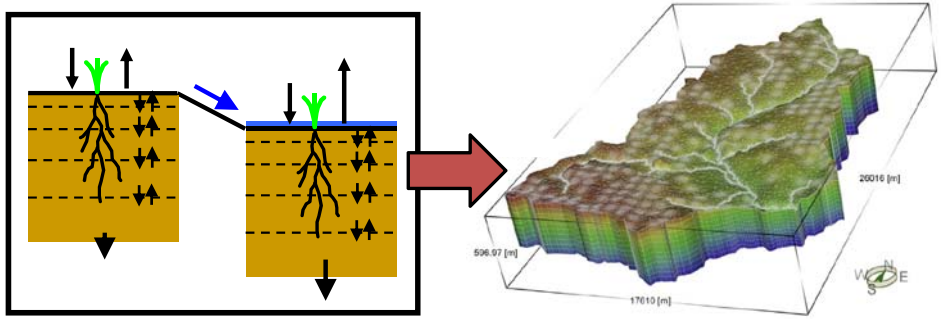
- **Improve GW recharge estimates** to provide scientific foundation for **sustainable GW management**

1. GW recharge processes

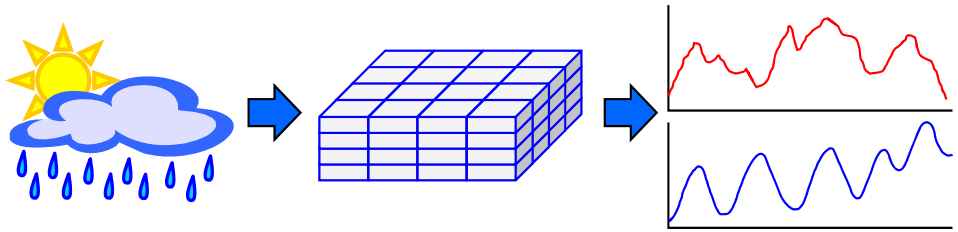


2. Land use effects

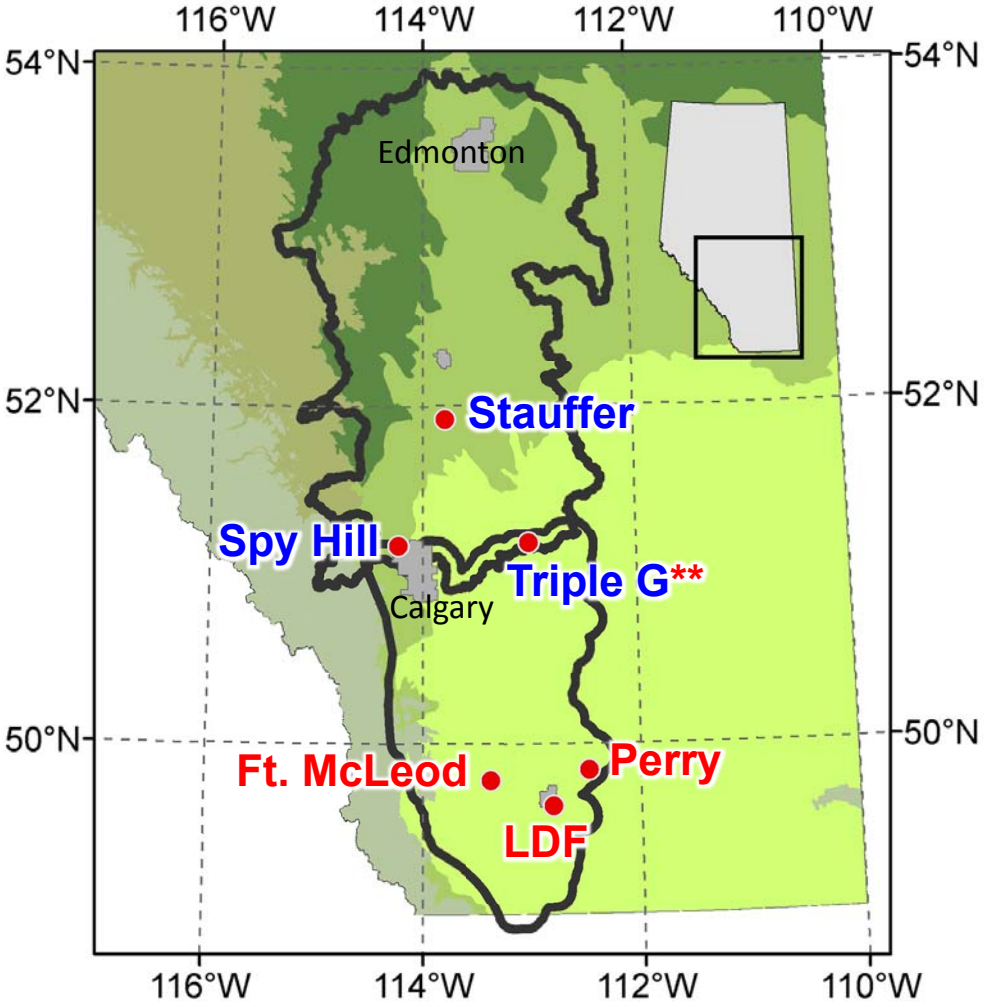
3. Model development, integration and upscaling



4. Climate change impacts



Study Sites



Natural region

- Rocky Mountain
- Foothills
- Boreal
- Parkland
- Grassland

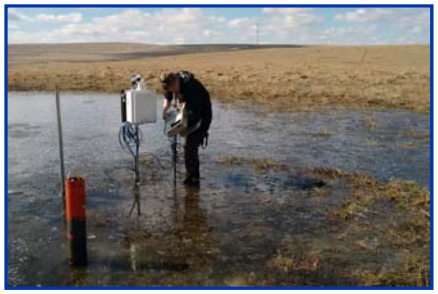
2 existing sites

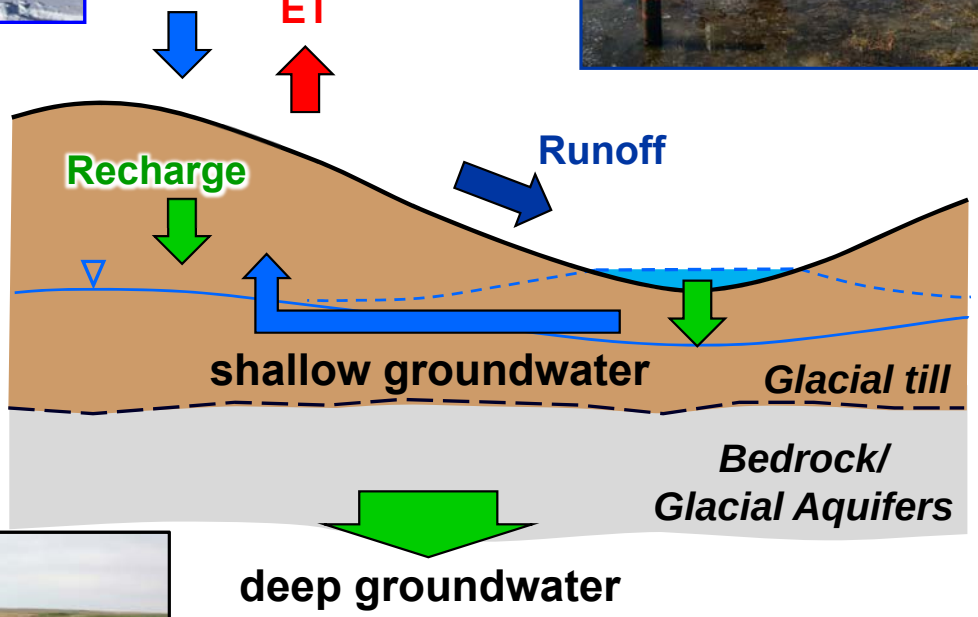
1 expanded site**

3 new sites

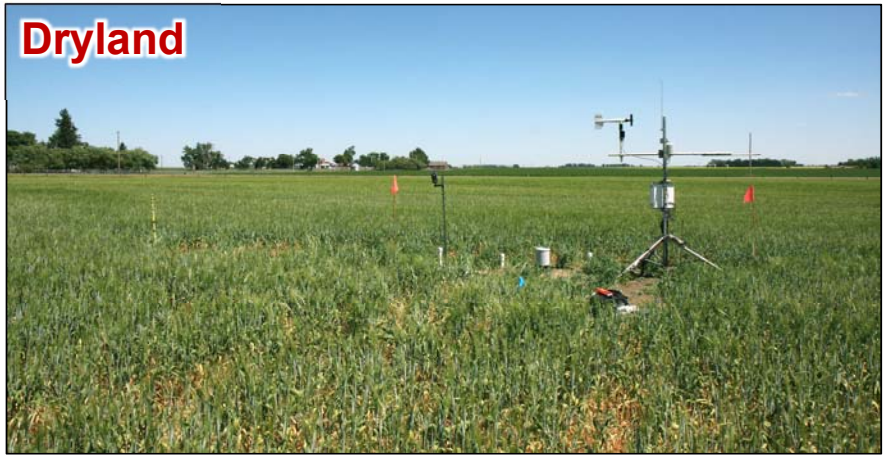
Recharge Processes

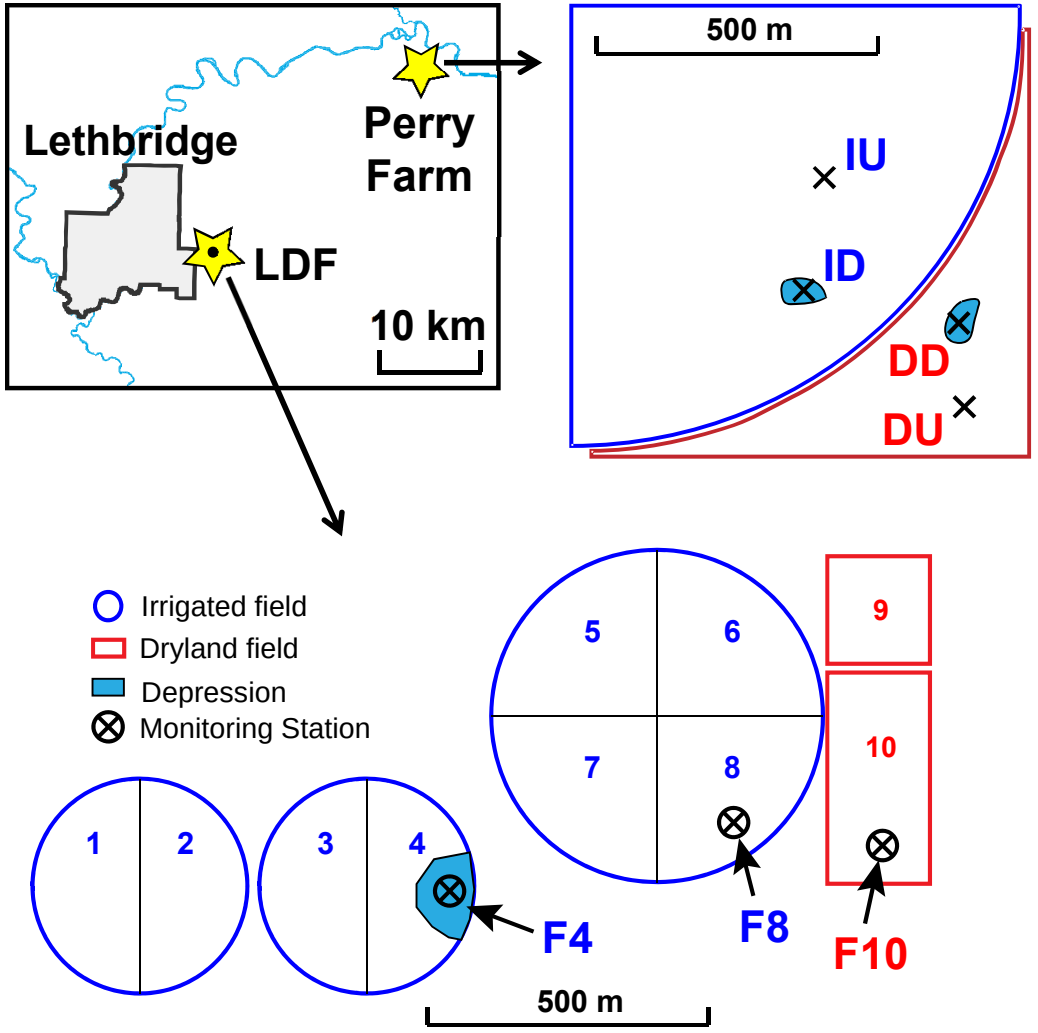
- Detailed field studies
- Multiple lines of evidence
- **Recharge estimation**
  - Water balance
  - Tracer profiles
  - Chloride mass balance
  - GW levels
  - Modeling
    - local and regional-scale



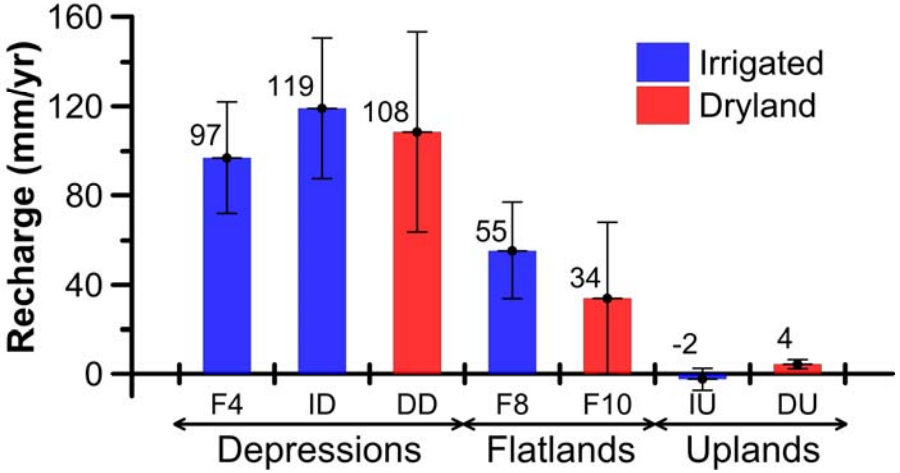


Irrigation Influence

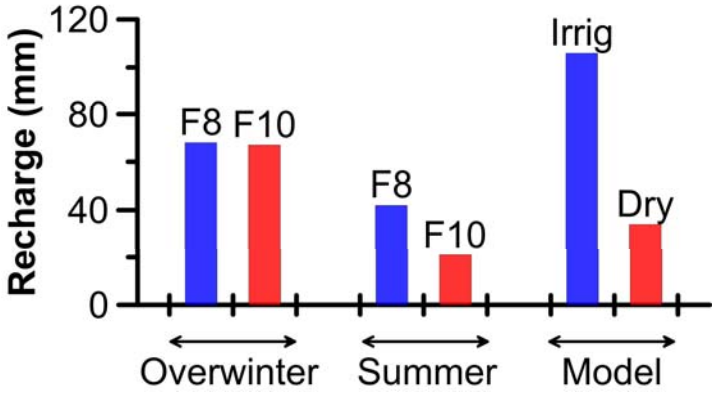




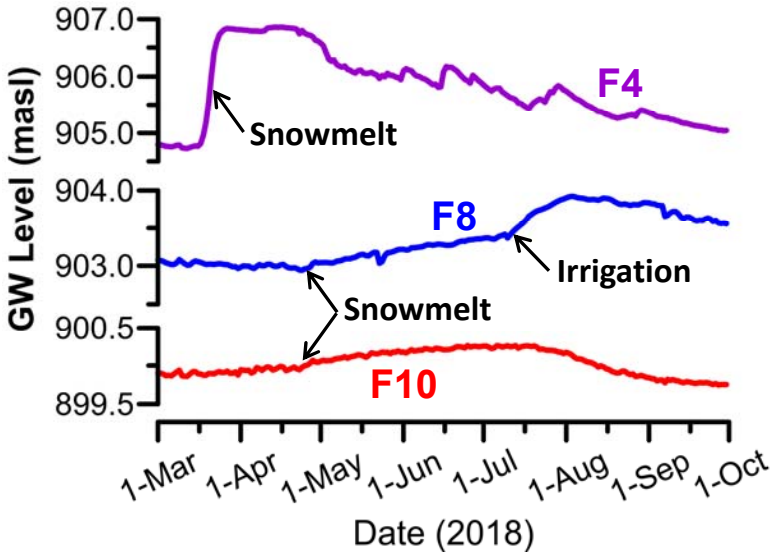
1. Chloride Mass Balance (CMB)

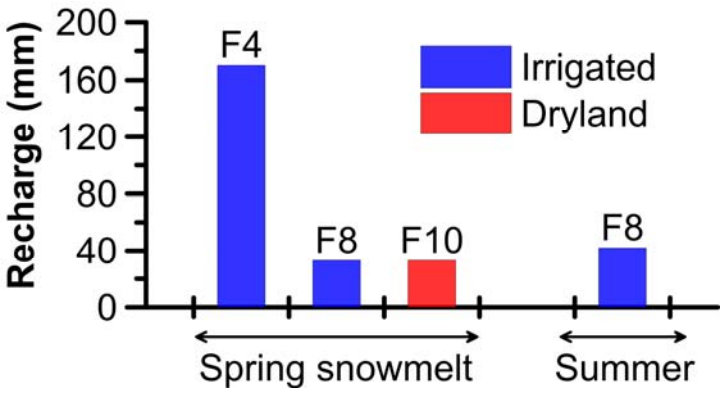


2. Water Budget



3. Water Table Fluctuation (WTF)

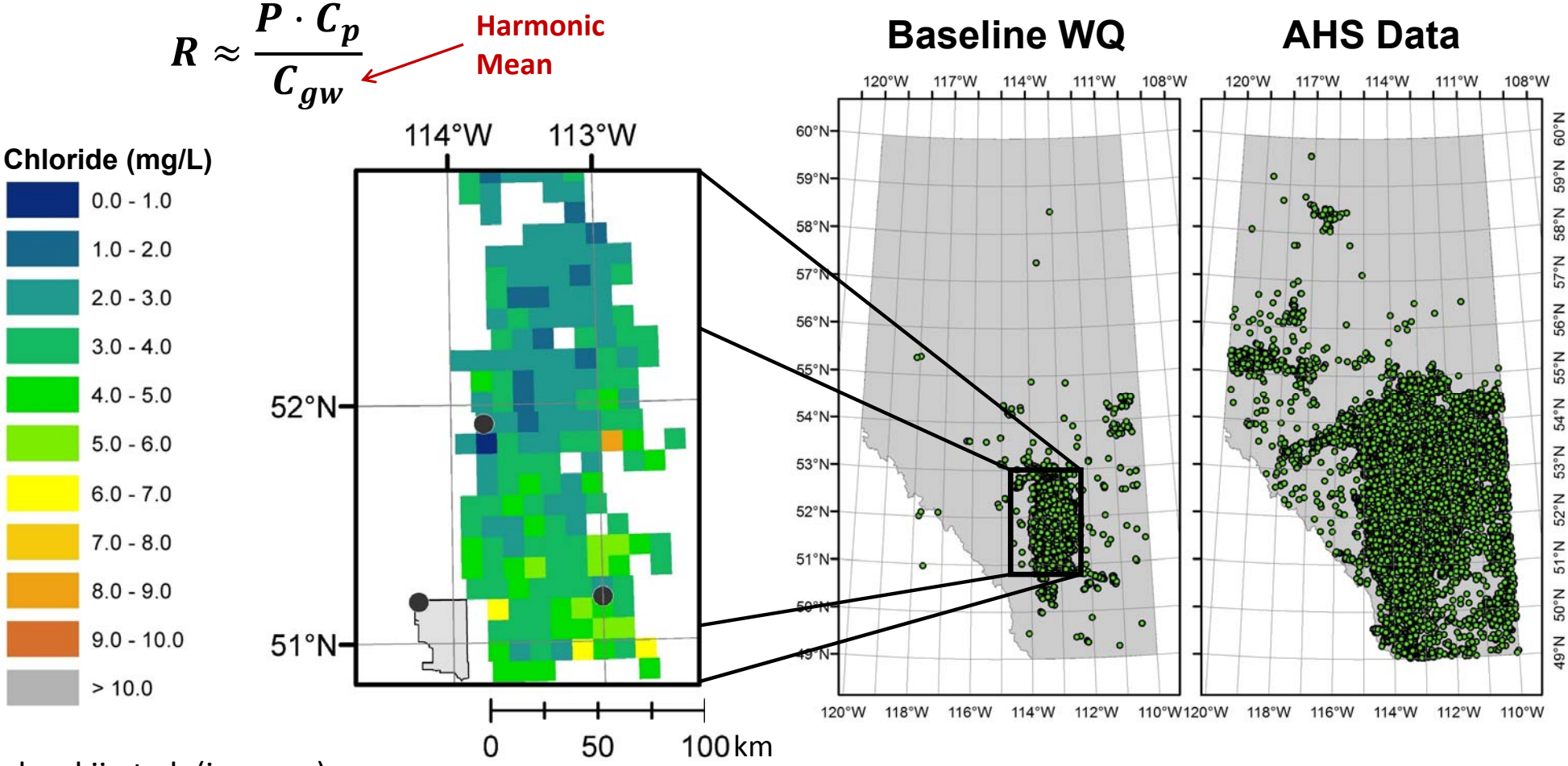




Upscaling CMB Estimates - New Possibilities

$$R \approx \frac{P \cdot C_p}{C_{gw}}$$

Harmonic Mean



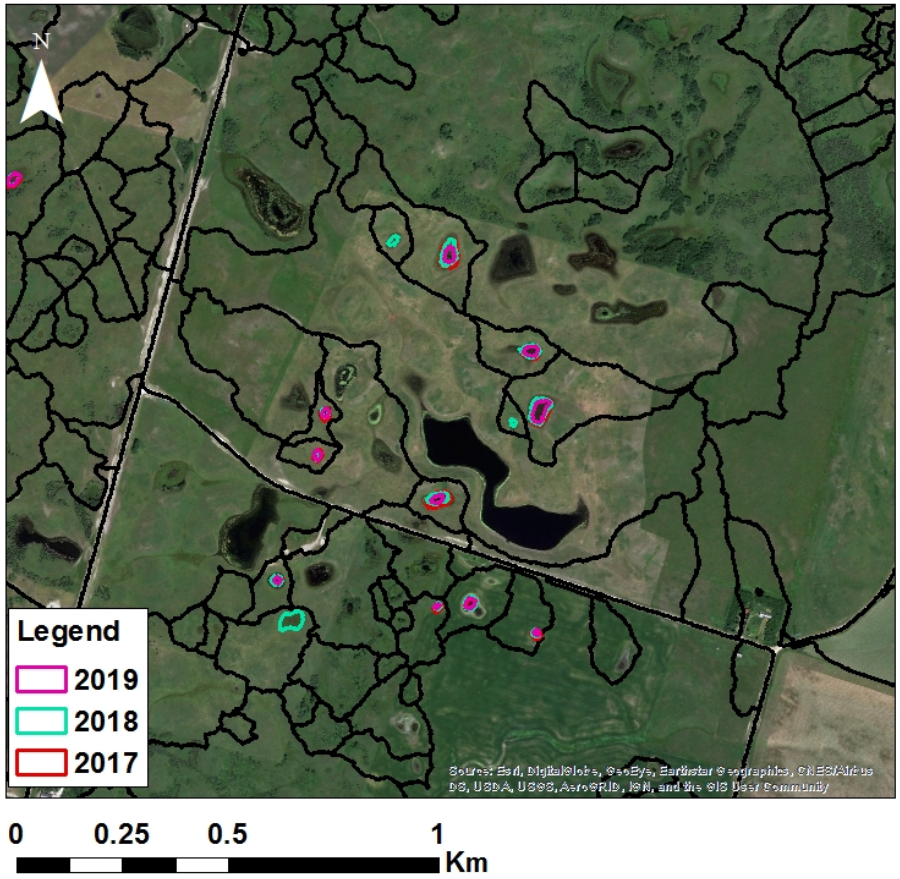
Pavlovskii et al. (in press)

Land Cover Effects - Snowmelt Runoff & Remote Sensing

- **Runoff** is key process for DFR

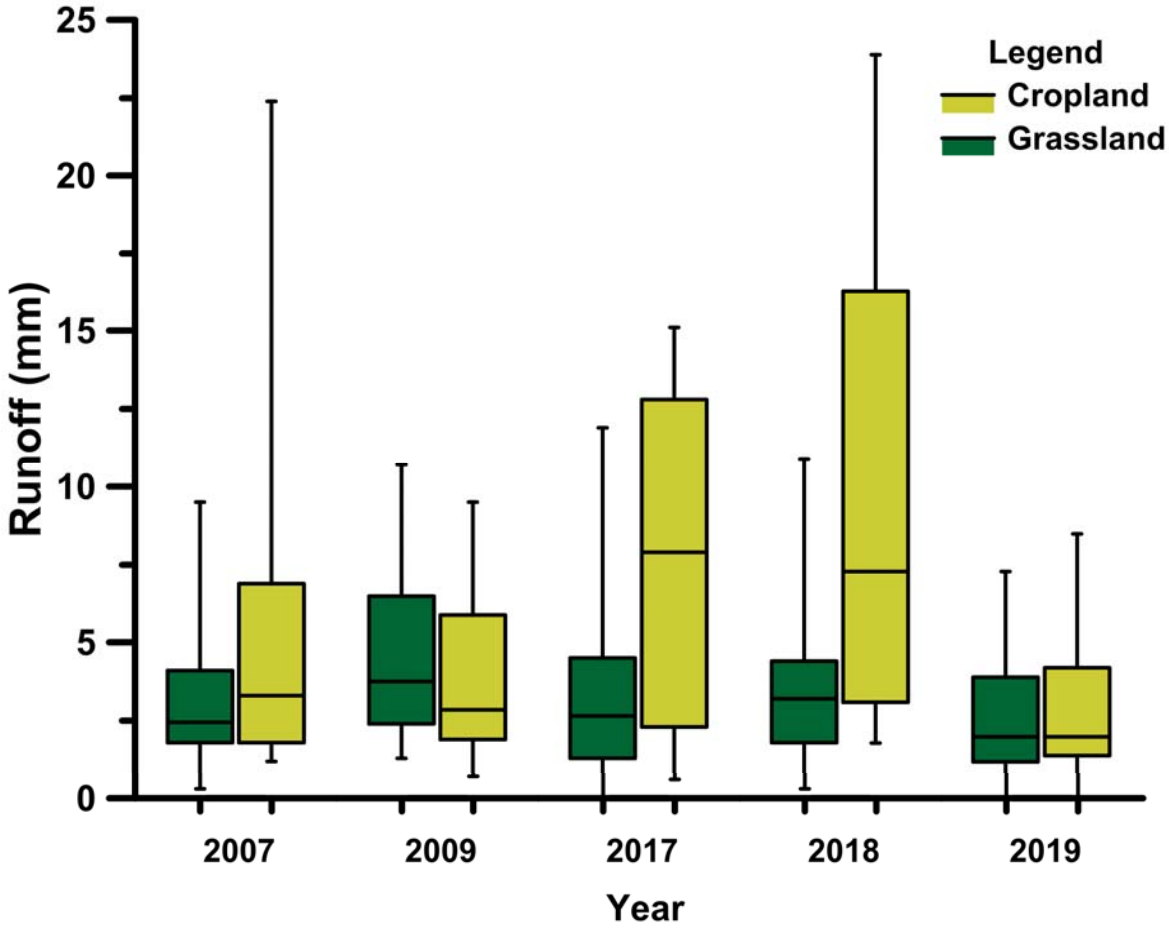
Site	SWE (mm)	Runoff (mm)	Runoff Ratio
Grass	91	0	0
Alfalfa	84	19	0.22
Barley	137	34	0.25

- IR remote sensing imagery
- **Proof of concept** testing at select sites
  - 17 grassland
  - 13 cropland

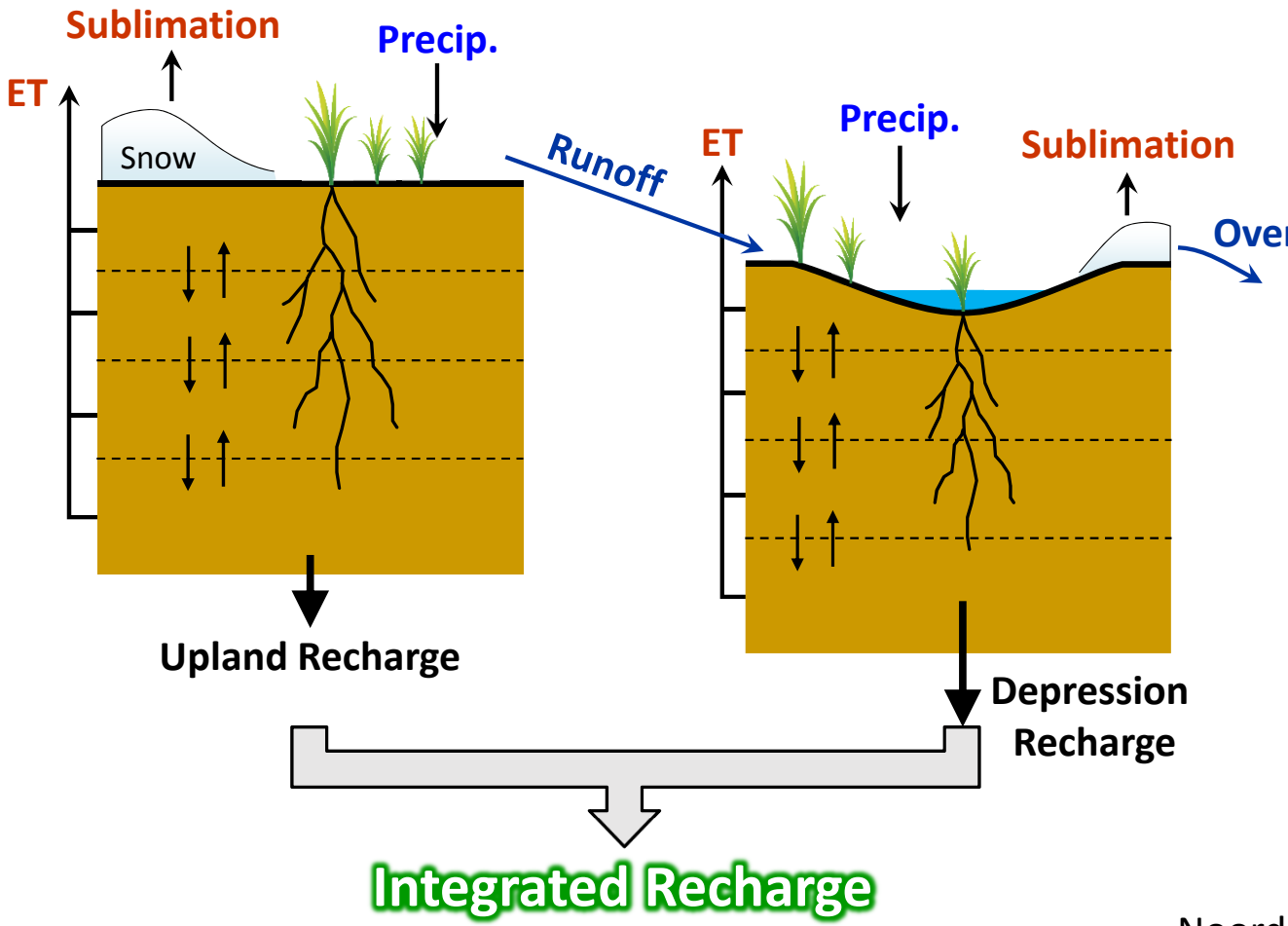


Crop vs Grassland Runoff

- Compares well to measured values in monitored fields
- Croplands have:
  - more runoff
  - more variability
- No correlation between runoff and:
  - pre-melt snowpack
  - total winter precip.
  - number of midwinter melt events



Versatile Soil Moisture Budget (VSMB) Model

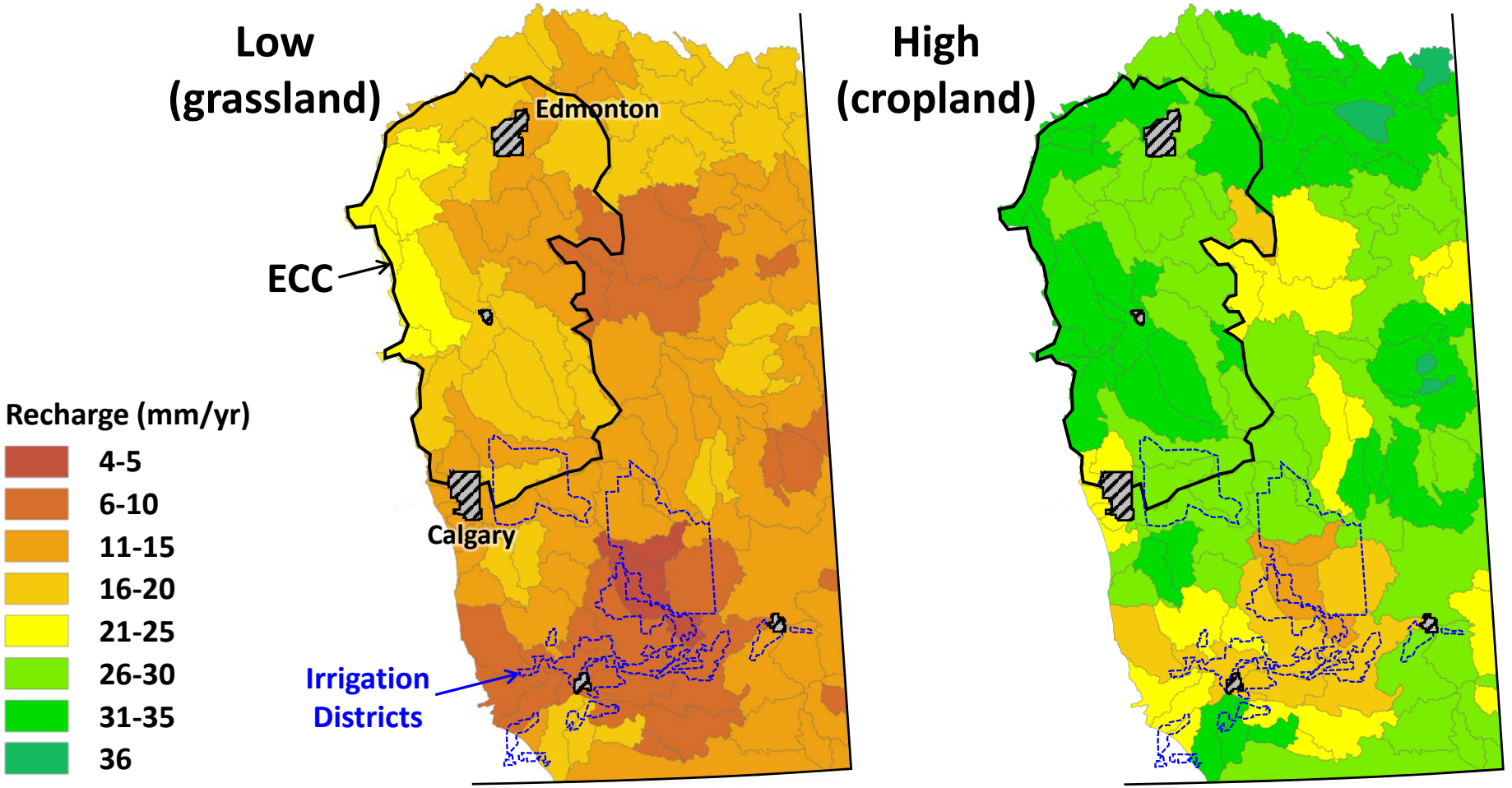


VSMB Depression-Upland System (DUS)

- climate
- catchment geometry
- surficial geology
- land cover

Noorduijn et al. (2018. Vadose Zone J.)

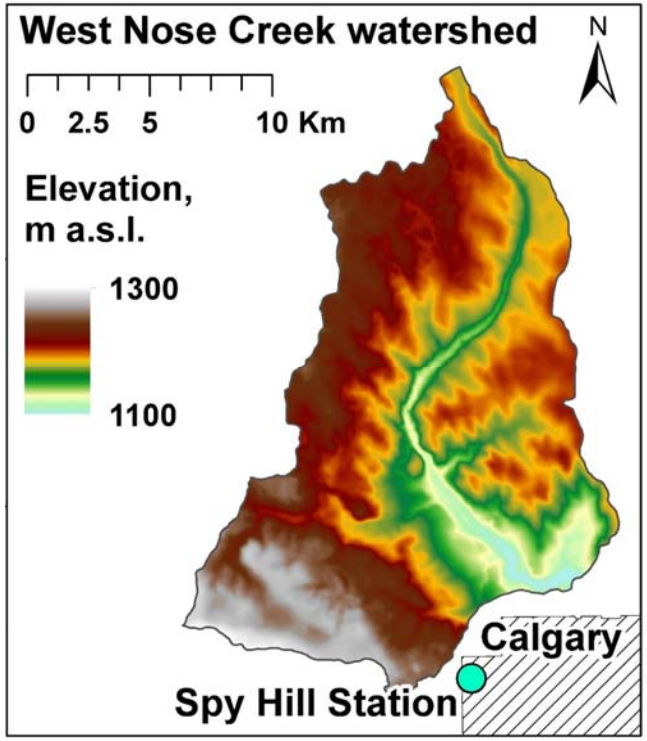
Regional Scale Recharge Estimation - AGS



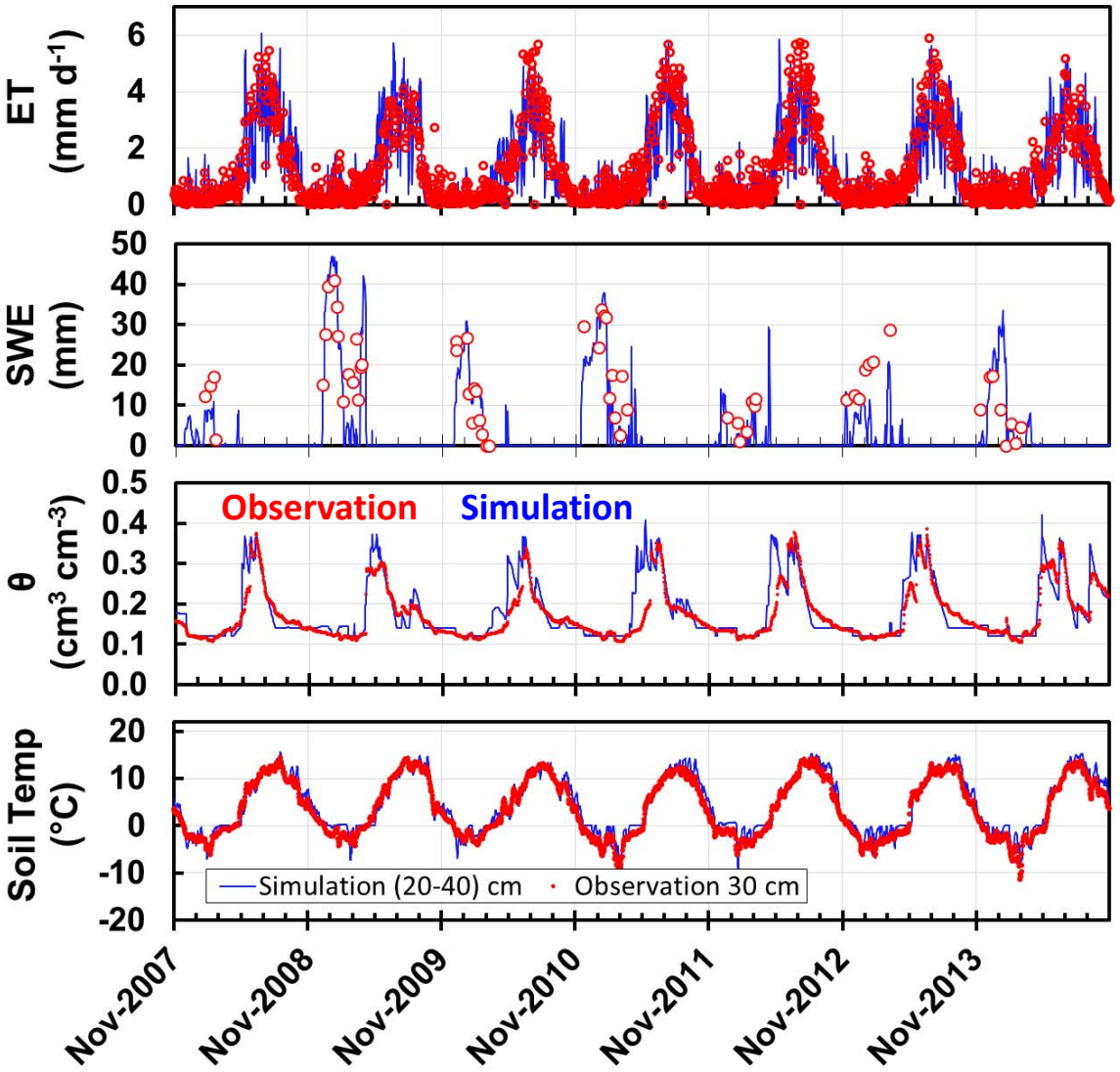
Klassen et al. (2018. AER/AGS Open File Report 2018-09)

Climate Variability

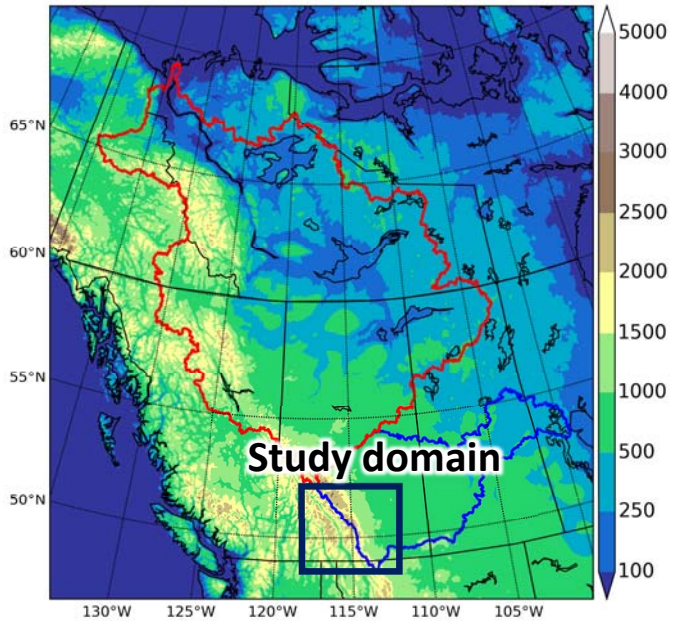
VSMB Simulations Under Present Climate



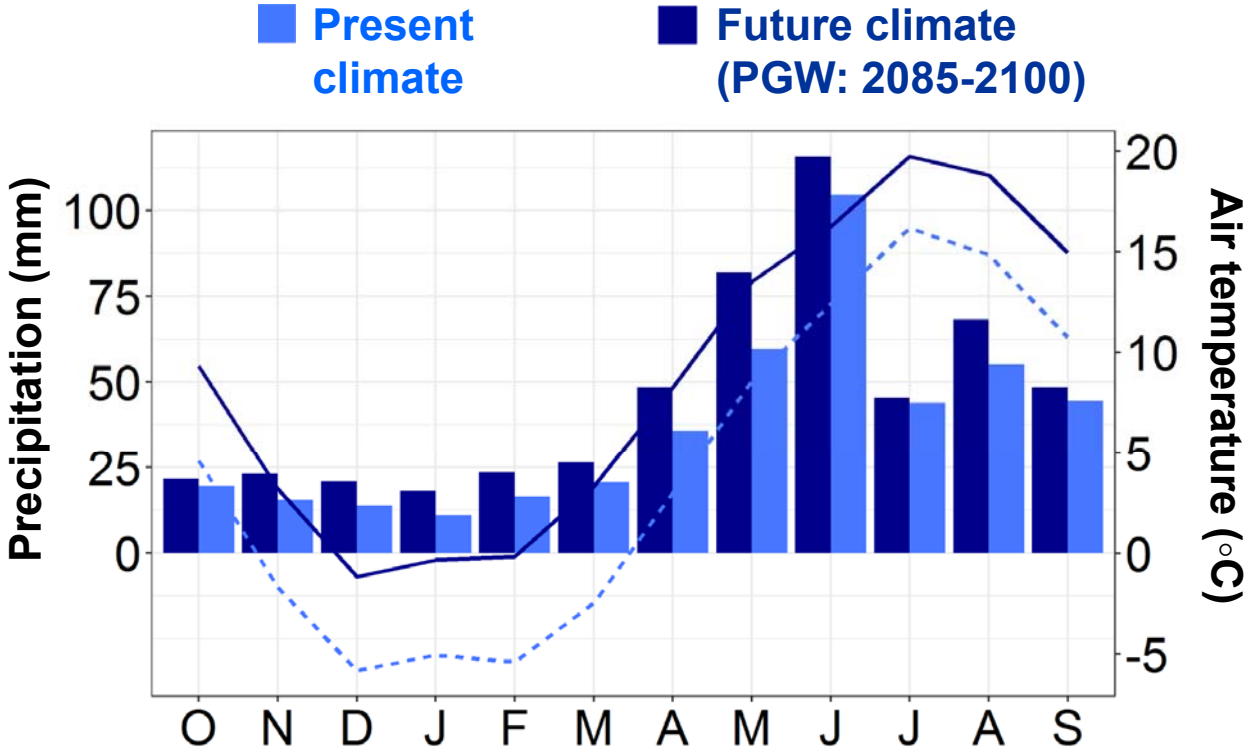
Area: 250 km²

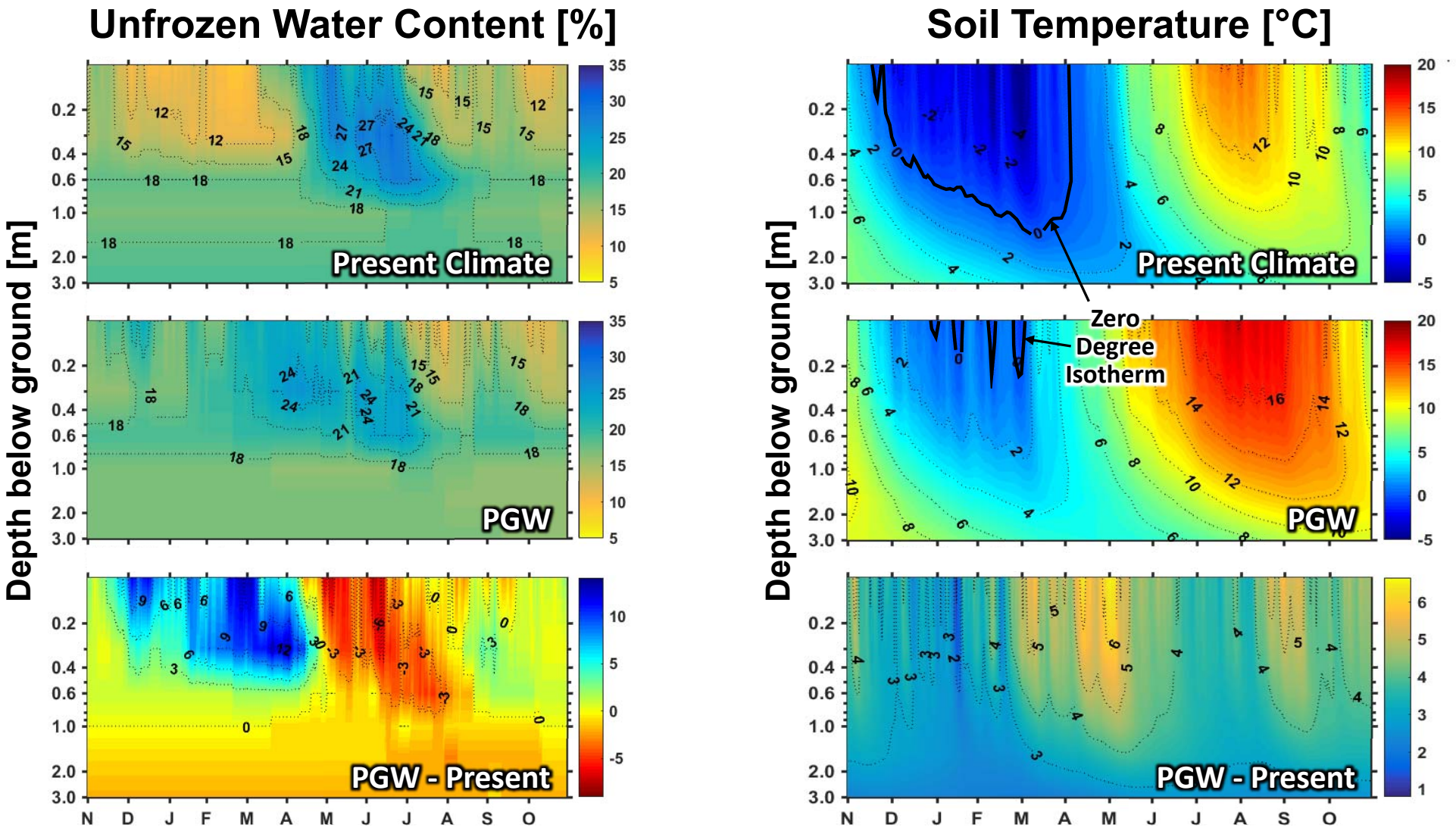


Future Climate - Pseudo Global Warming (PGW)



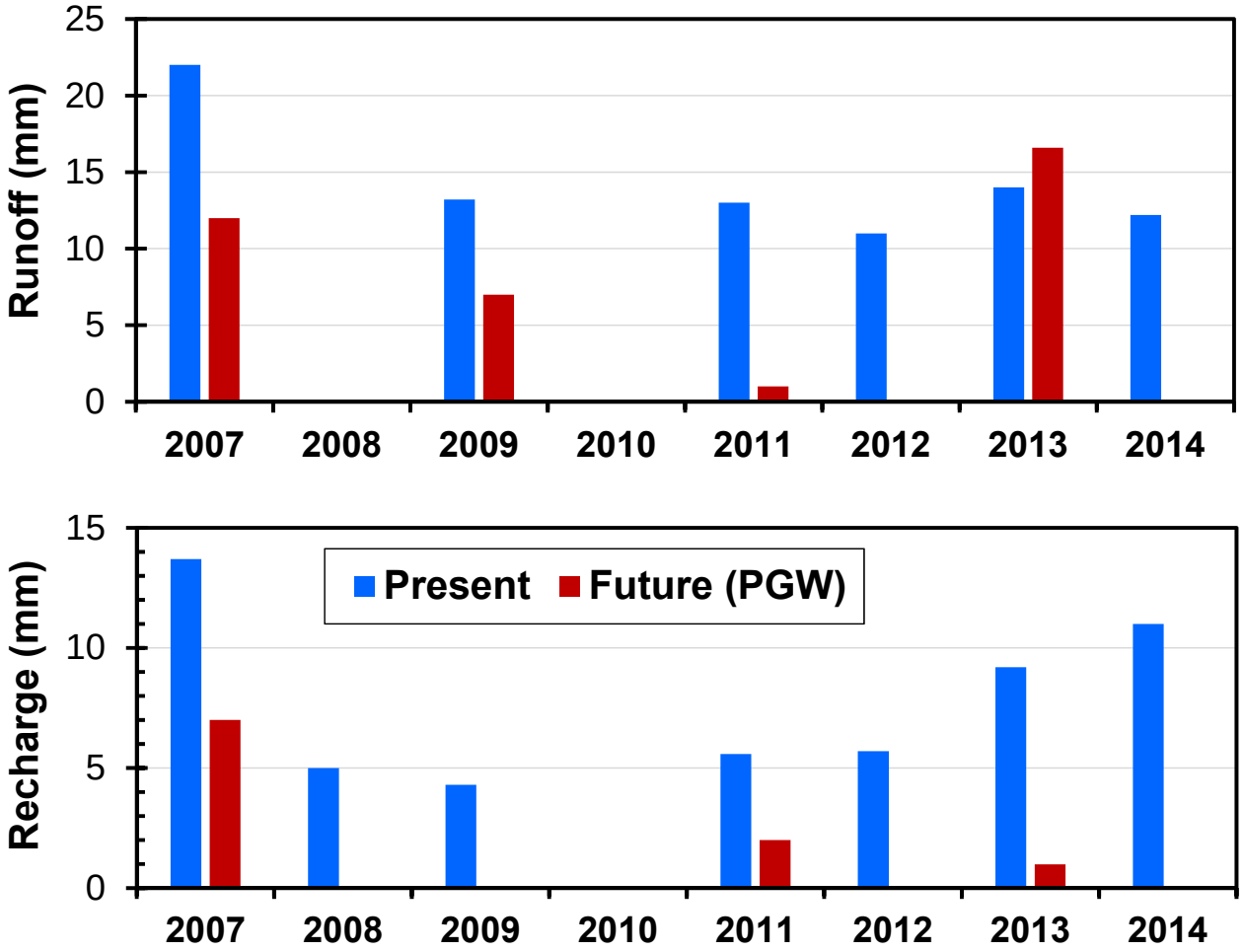
- Climate models are:
  - biased
  - low resolution
- Correct WRF model output with Spyhill data




Unfrozen Water Content [%]
Soil Temperature [°C]
Depth below ground [m]
Present Climate
PGW
PGW - Present
Zero
Degree
Isotherm
N D J F M A M J J A S O

VSMB Simulations Under Future Climate

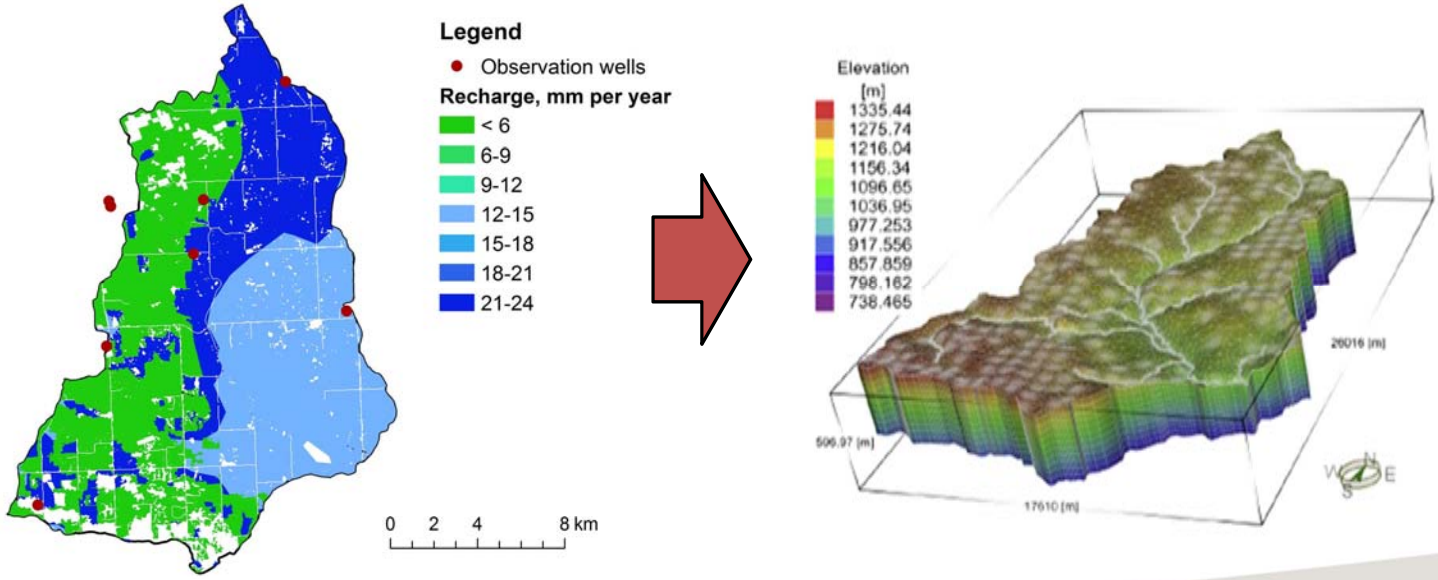
- 50% reduction in annual runoff
- >50% reduction in average GW recharge
- Caution that estimates are preliminary
  - further verification and testing needed



Moving Forward

- Integrate new knowledge
  - much has been learned
- Disseminate findings
- Applications for water management

- Expand and apply results
  - e.g., spatial/temporal recharge applied to 3D groundwater model of West Nose Creek



Research Partners

- Christensen, Perry, Stauffer, and Wooliams families