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An Application of Convection-Permitting Climate Forcing to Simulate Prairie Pothole Wetlands

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Wetlands in Prairie Pothole Region

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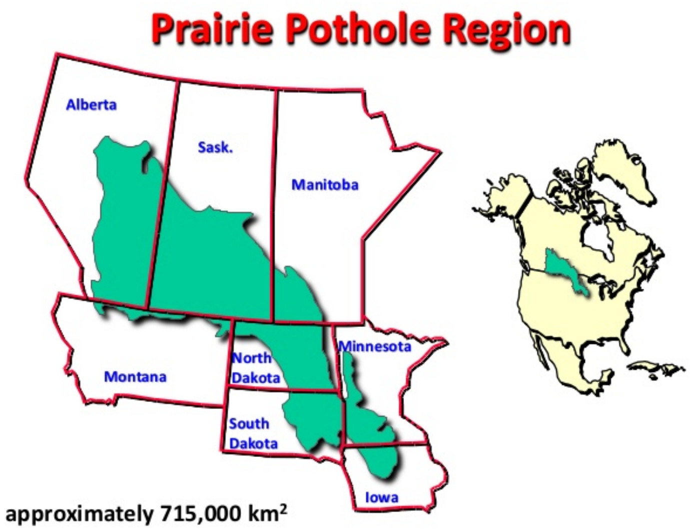

- Large area in the center of North America
- Millions of small poorly-drained wetland depressions
- providing ecosystem services, water purification, flood control, breeding habitats, etc.
- Impacted by Climate Change (precipitation pattern change and evaporation demand increase) (Johnson et al, 2005)

Hydrology background

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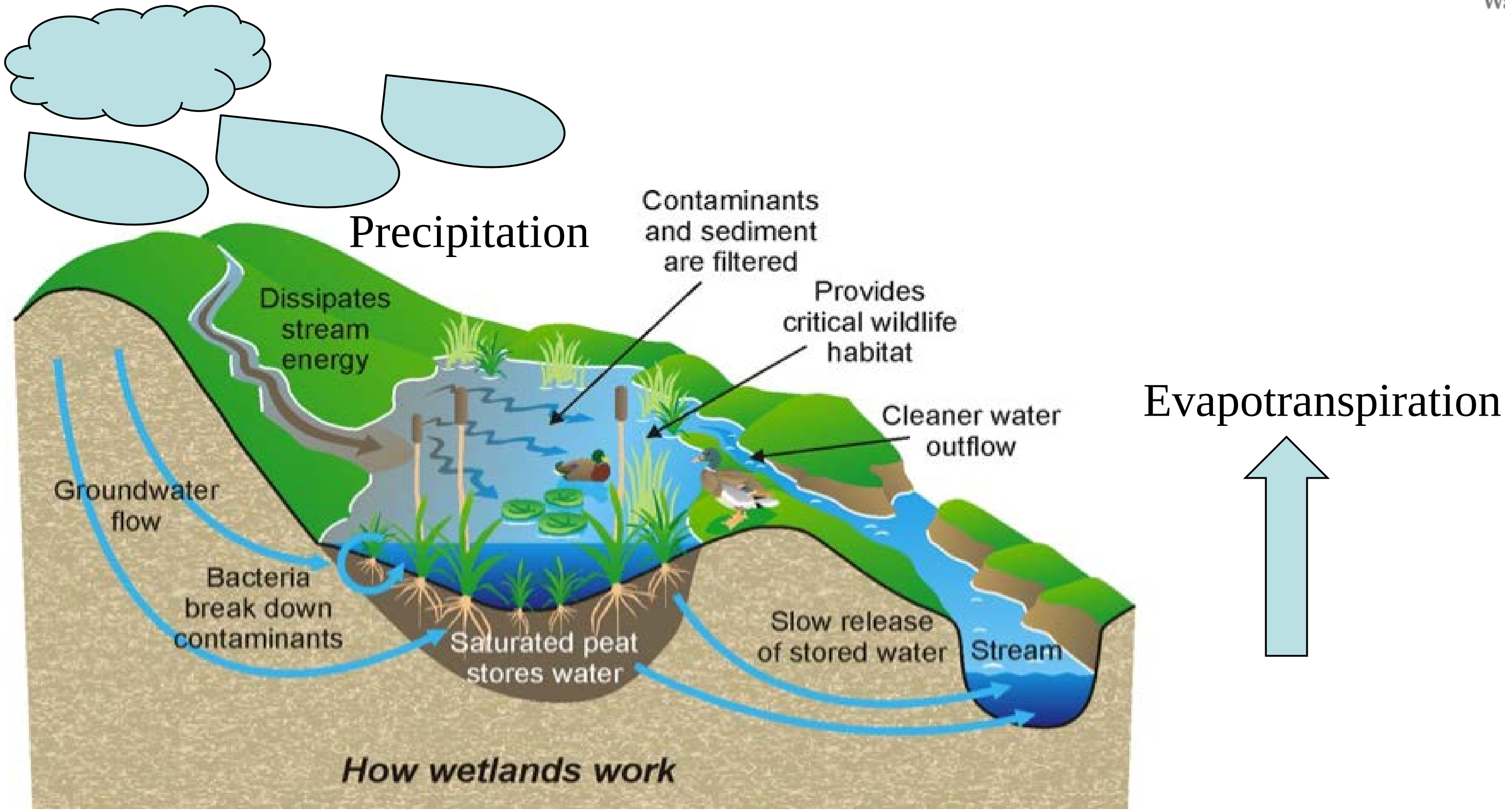

Groundwater plays an important role to sustain these wetland, particularly during dry period.

GOAL: understand impacts of climate change on hydrology components associated with PPR wetlands?

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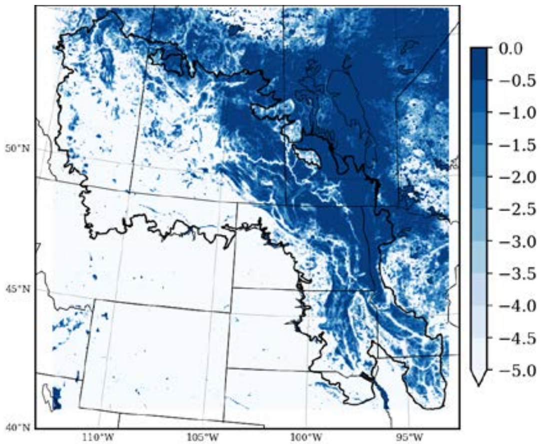
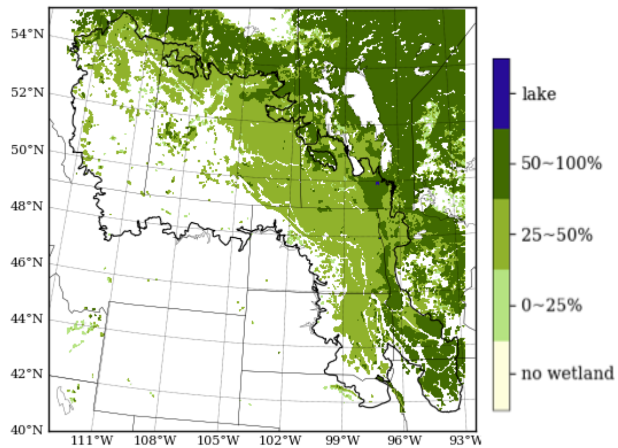
Wetland fraction from soil moisture and water table depth

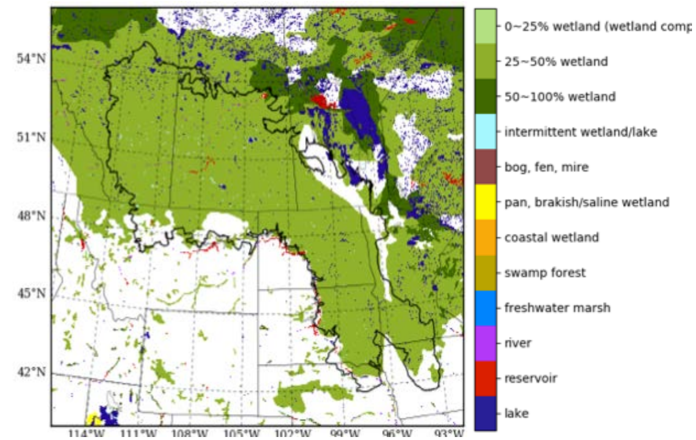
Water table depth (m)



model wetland fraction



wetland survey (observation)



Lehner and Doll (2004), GLWD, global lake wetland database

Soil water content (%)	Wetland fraction (%)
0~50	No wetland
50~60	0~25
60~70	25~50
70~100	50~100

There have been many definition for wetlands:

1. From soil moisture (soil water content, Capehart et al, 2011)
2. From water table depth, within a shallow water table threshold (Fan et al, 2011)

In this study, I use a combination of these two definitions, defining wetland as wet soil with shallow water table (within 5 m)

NoahMP-Groundwater Scheme

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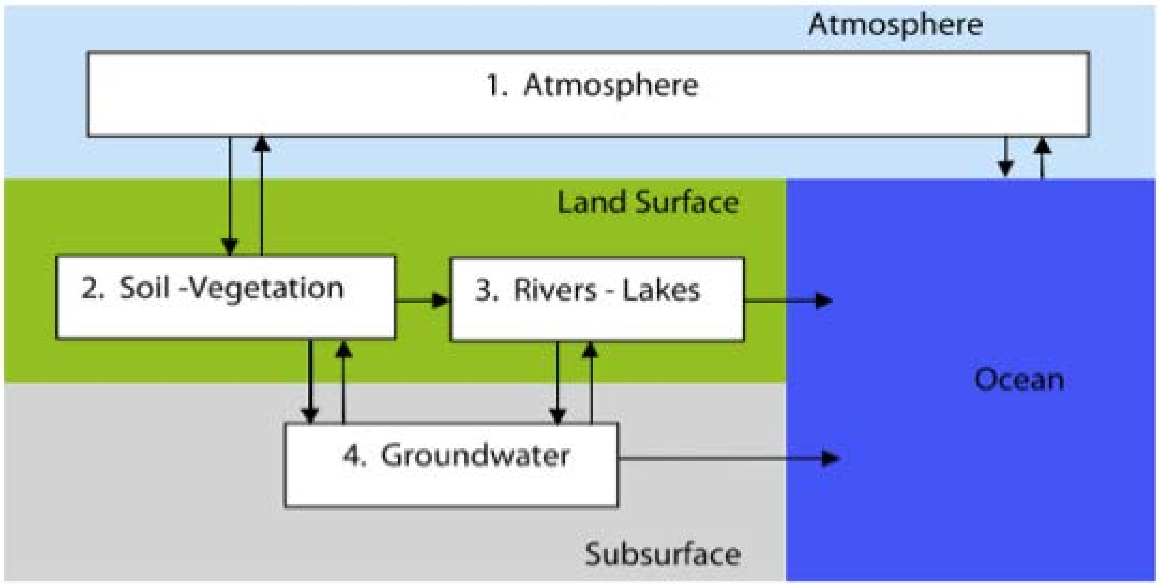
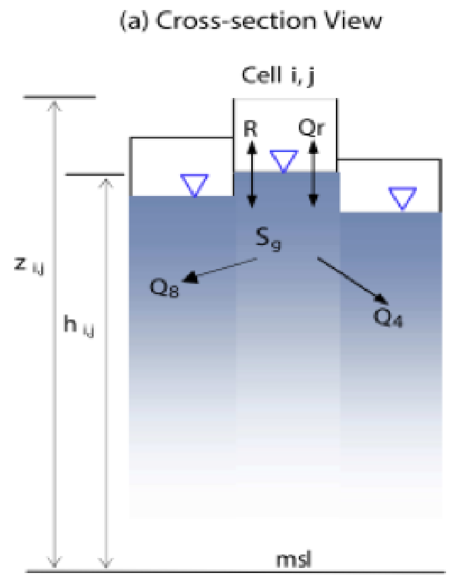
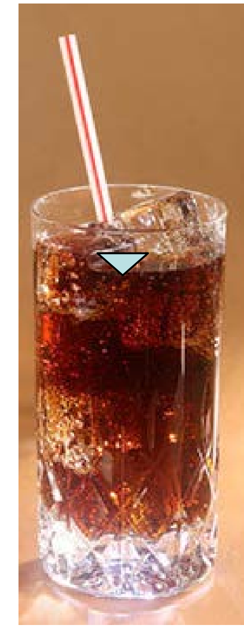
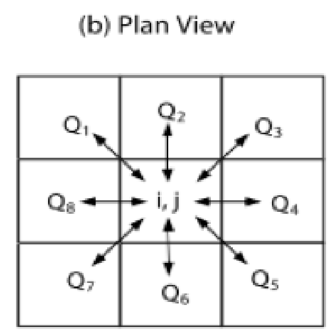






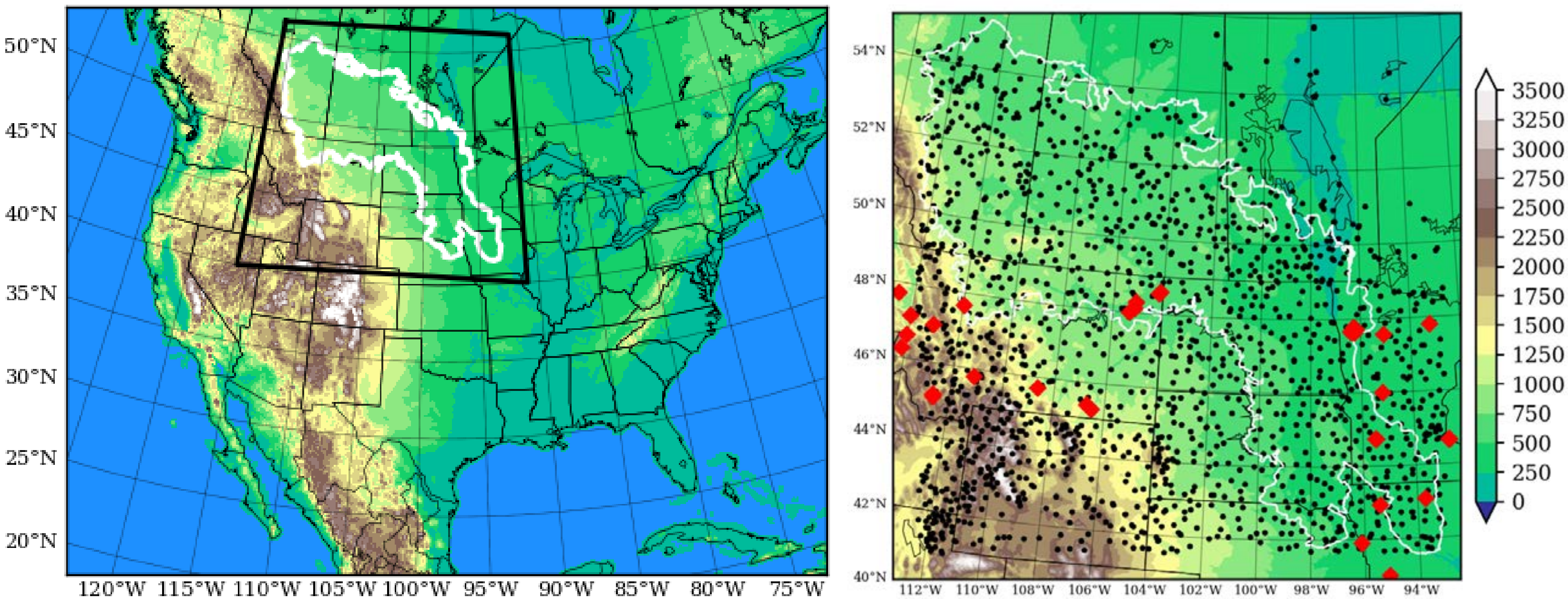


Runoff option = 5 in NoahMP LSM
The water table dynamics are controlled by three terms:

RECH —recharge to groundwater (+), a balance between gravity drainage and capillary effect;
QLAT—groundwater lateral flow;
QRF—groundwater discharge to river (-);
(Fan et al, 2007)

Convection-permitting climate forcing (WRF CONUS current & future climate)

(a) CONUS domain (b) PPR domain



Run two simulations: with CTRL (current climate) and PGW (pseudo global warming) (Liu et al, 2016)
(with 4 years spin-up)
Run from 2000-10-01 to 2010-10-01

Evaluation of Precipitation in WRF CONUS CTRL forcing

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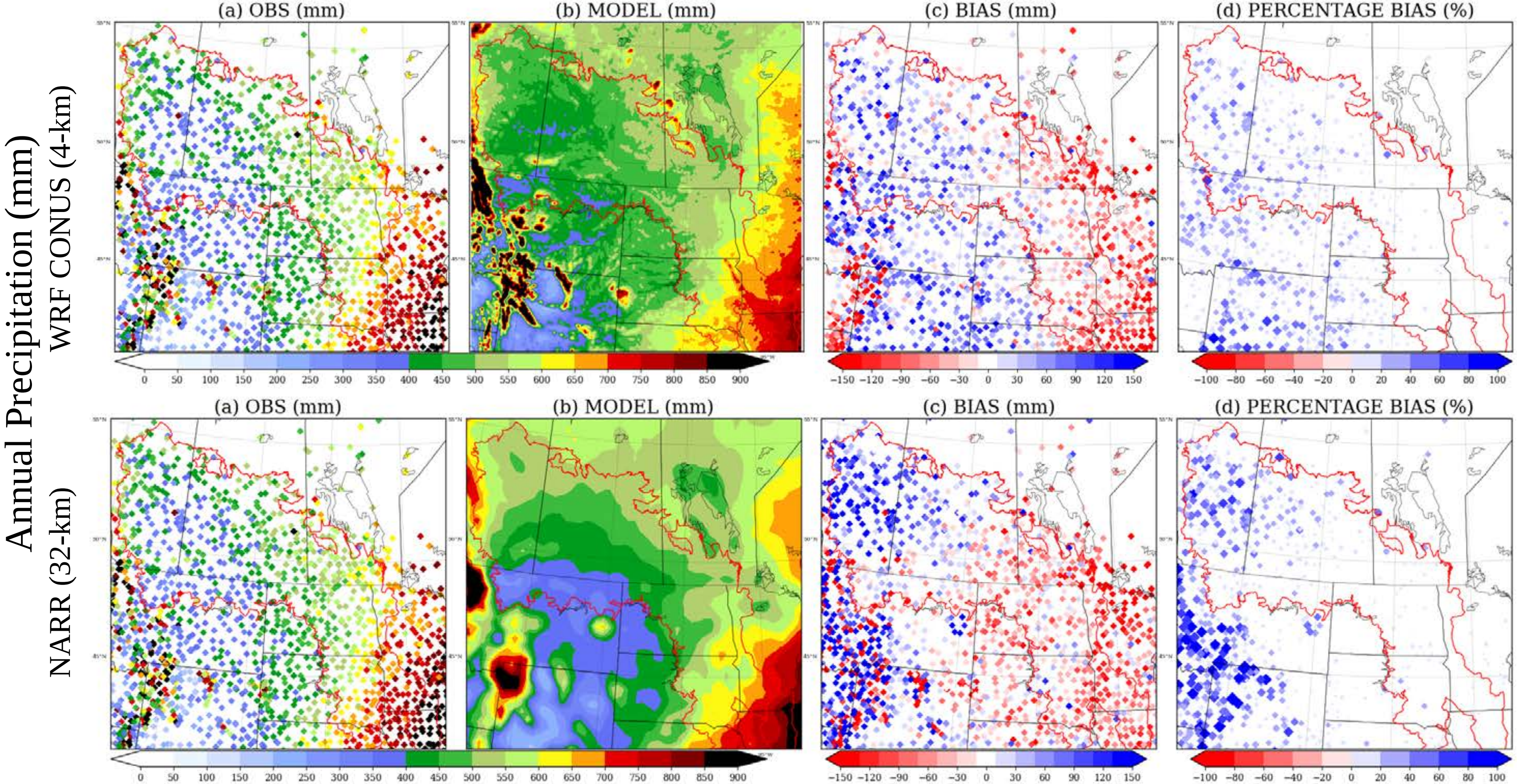
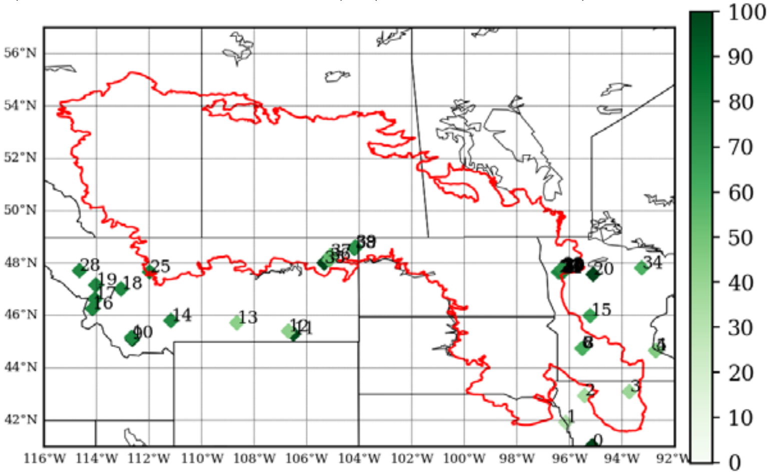
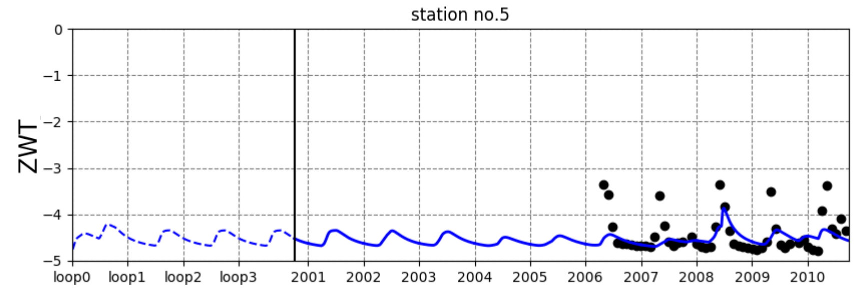


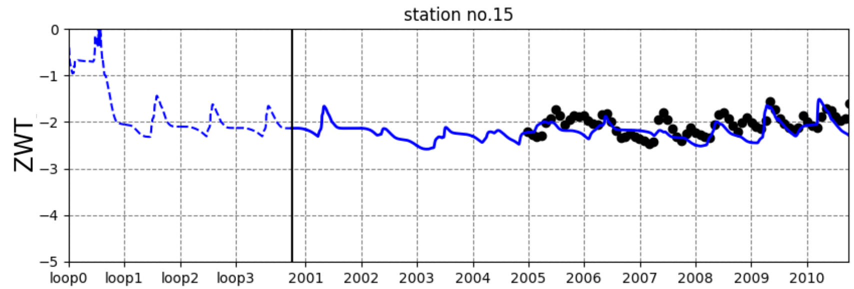
Total precipitation from WRF CONUS (top) and NARR (bottom) compared to station observation. **WRF CONUS has better precipitation forecast with less bias in West part of**

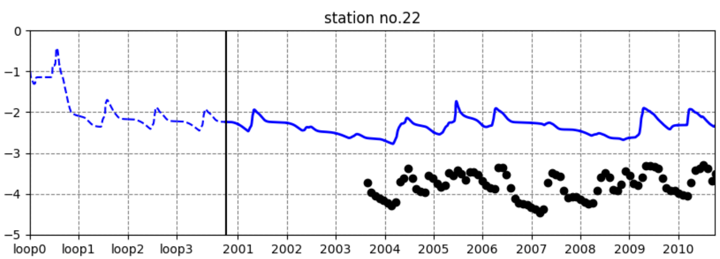
water table depth evaluation

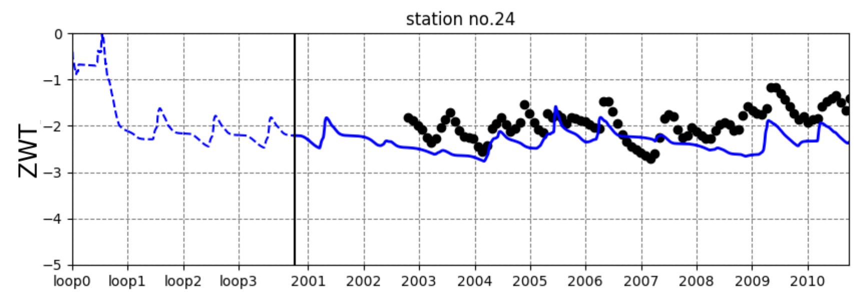
Water table depth (ZWT) observation coverage (%) in the domain (from 2000 to 2010) (from USGS)

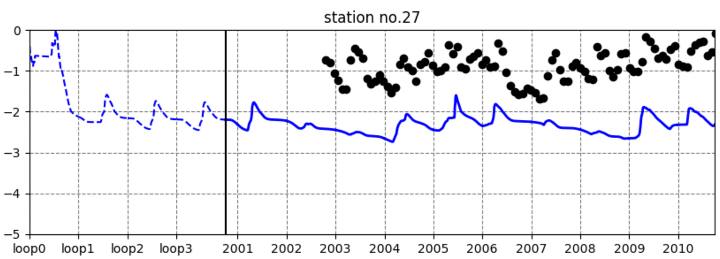


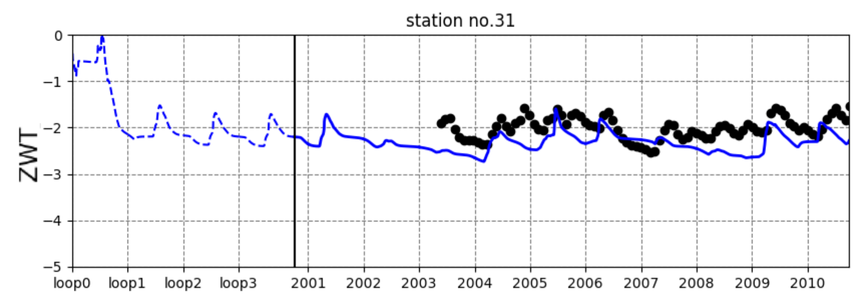






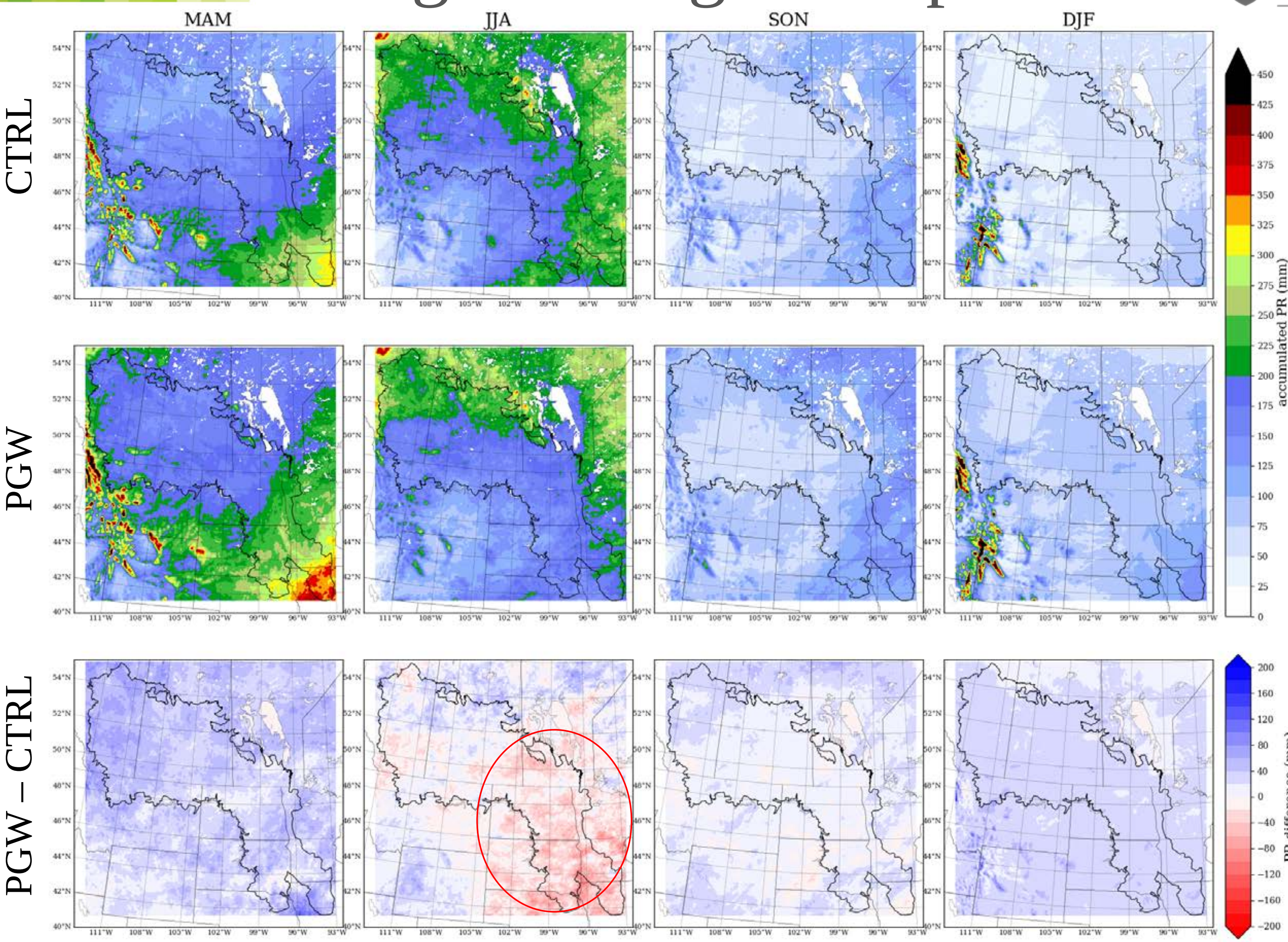






Model reflects well the annual cycle of water table depth dynamics.

Climate change forcing: Precipitation



In general, precipitation increases in PGW, **except in the summer in the southeast of the domain (about 40-80 mm less).**

Climate change forcing: Temperature

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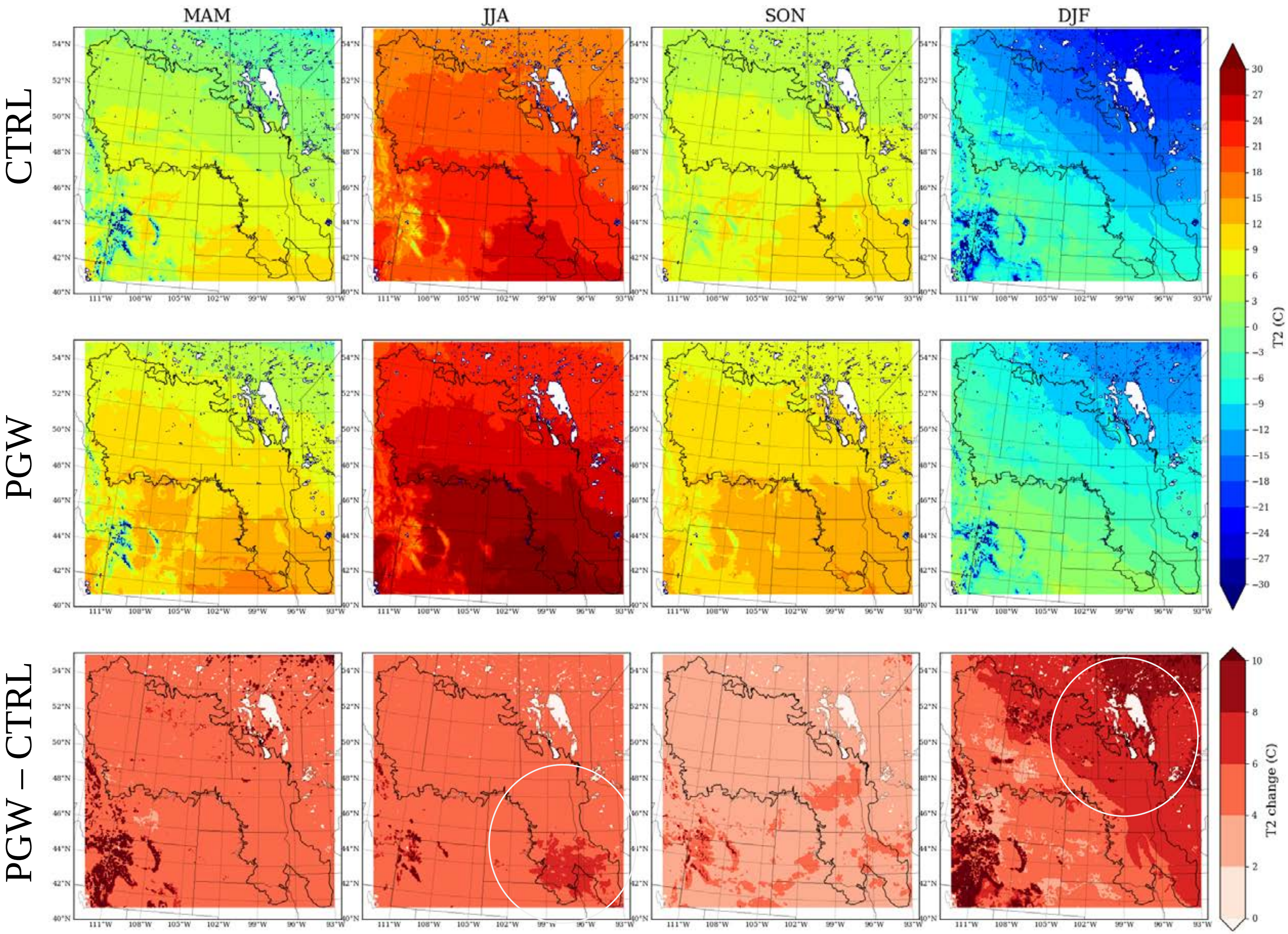
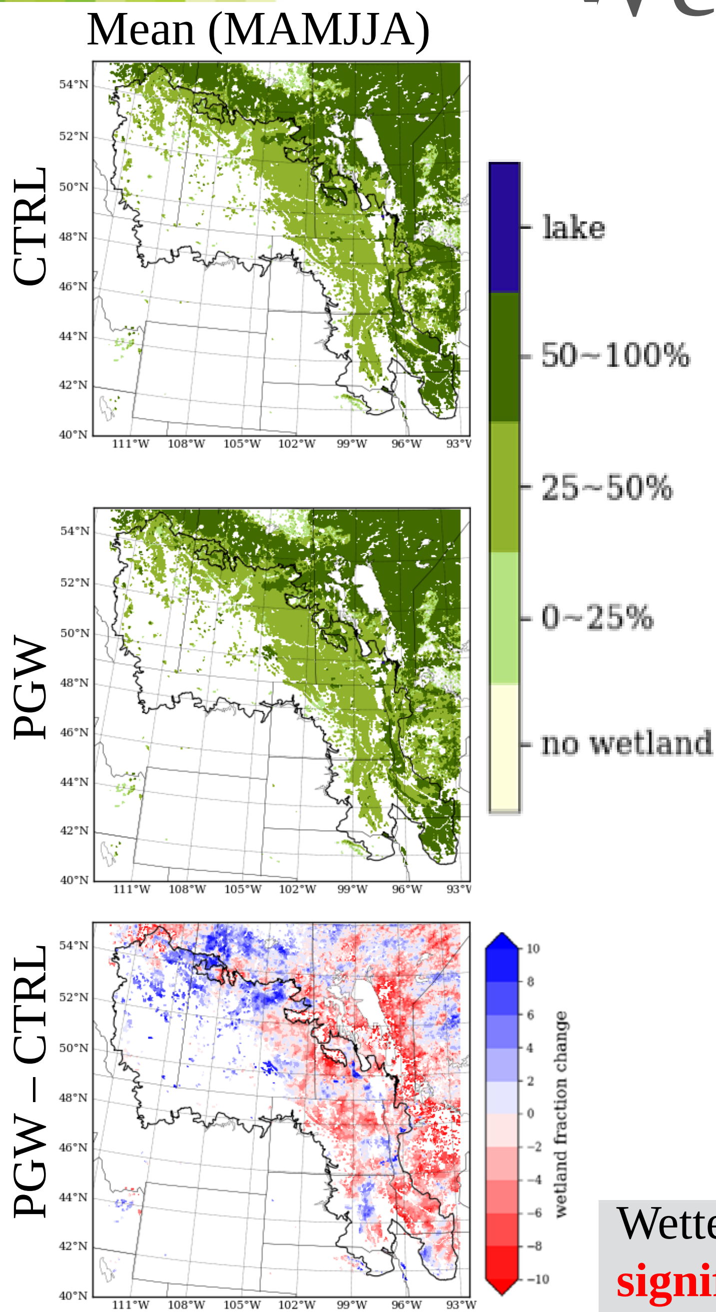
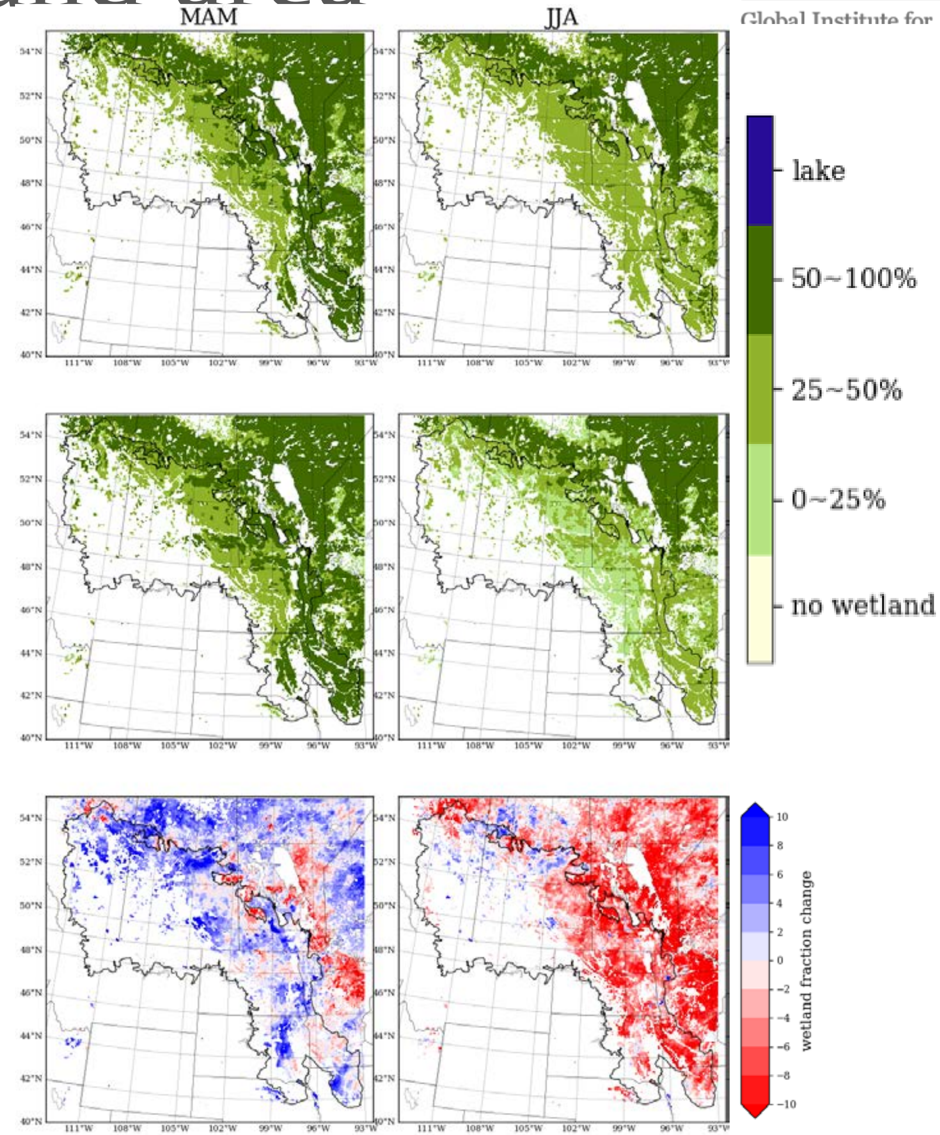


The strongest warming happens in winter (6~10 degrees C), also in the mountainous region. **In summer, southeast of the domain also shows 6~8 degrees of warming.**

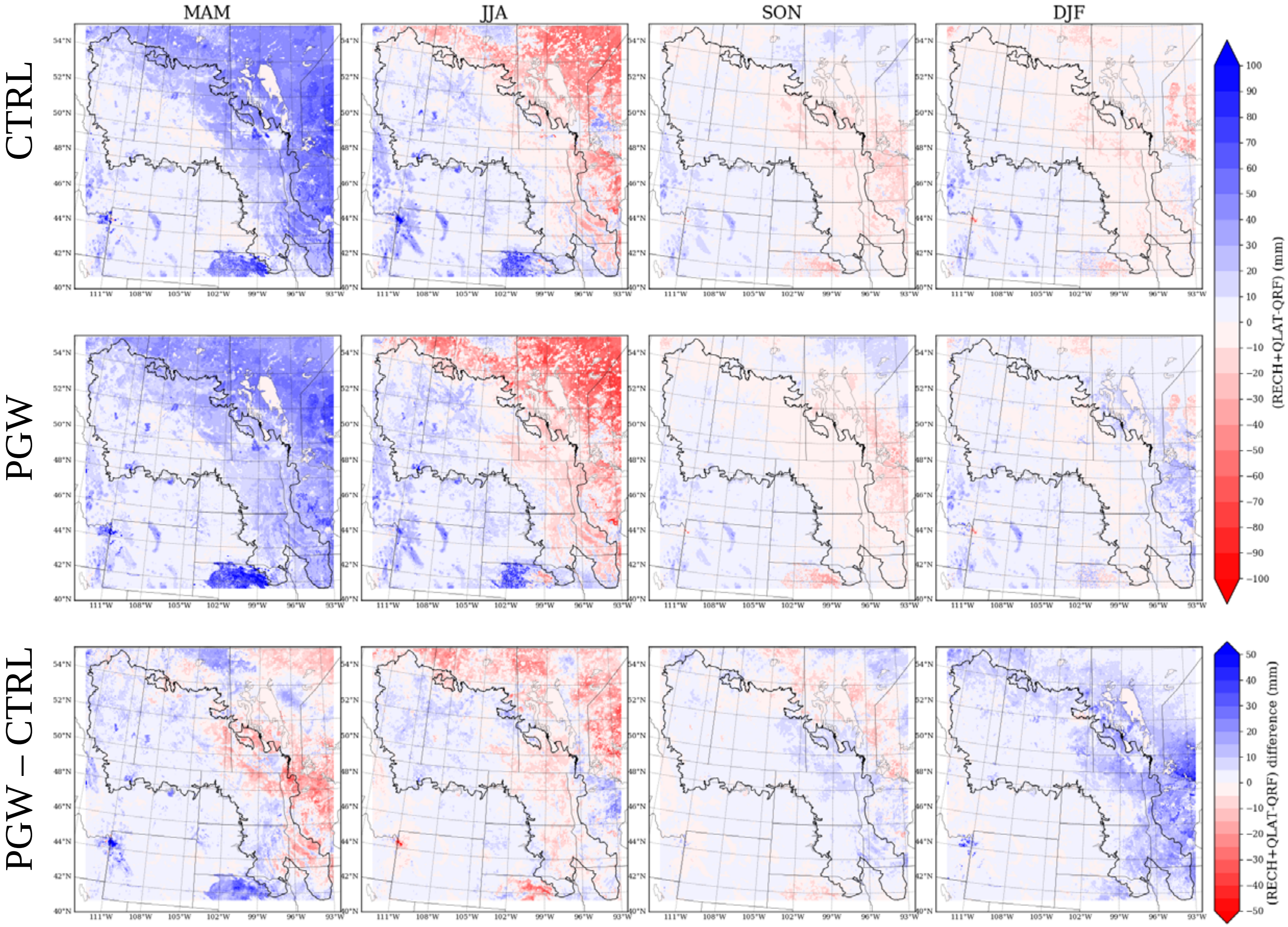
Wetland area

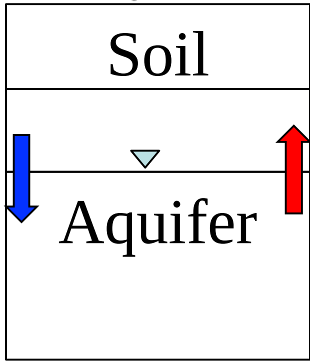




Wetter soil results in wetland increase in spring, but **significant wetland loss in summer in the southeast of PPR**

water flux to aquifer





Water budget ---- east

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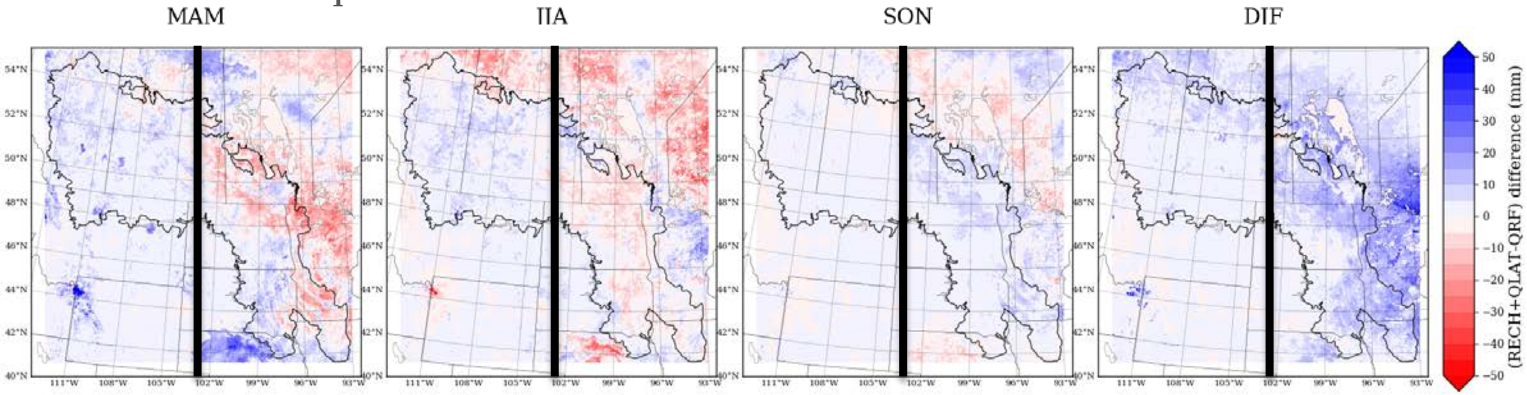
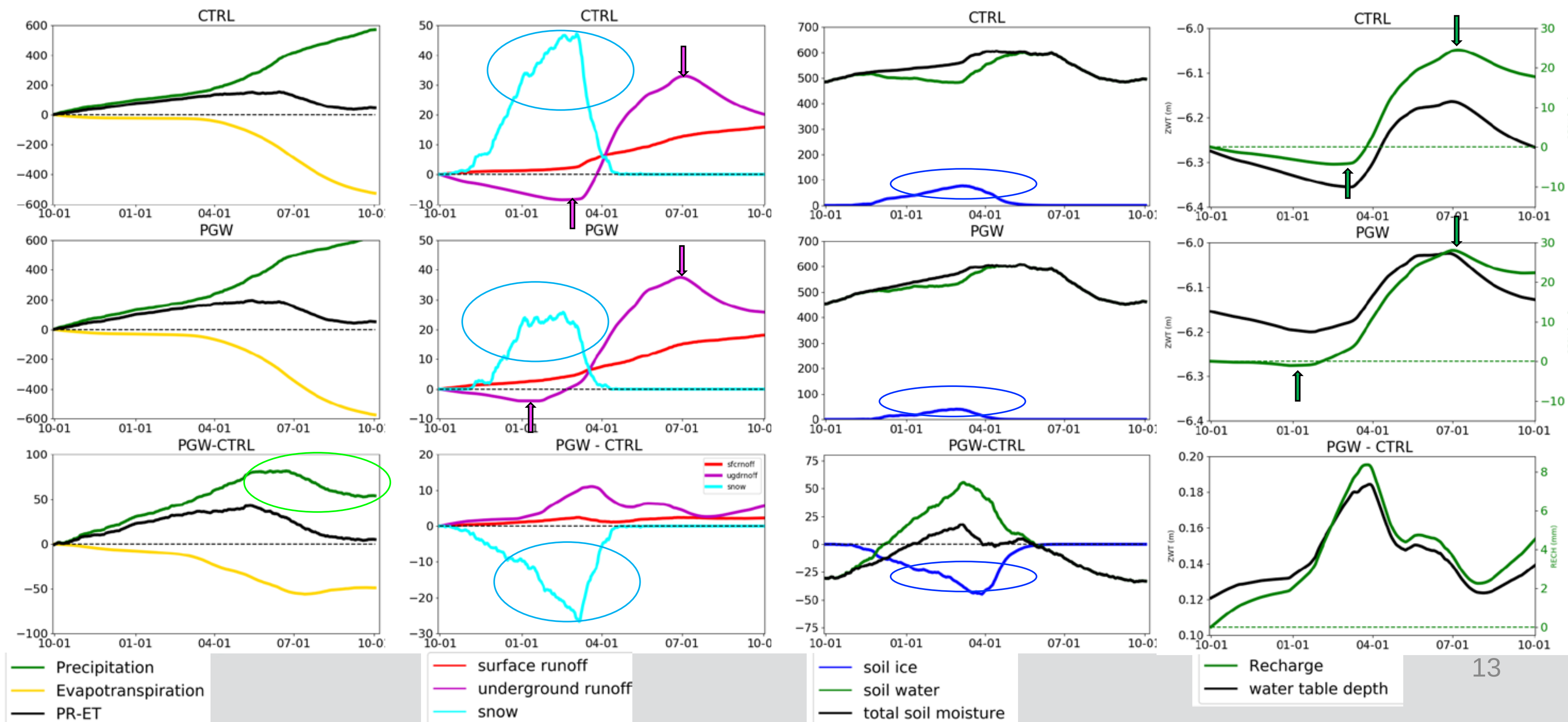
water flux to aquifer: PGW - CTRL





Water budget ---- west

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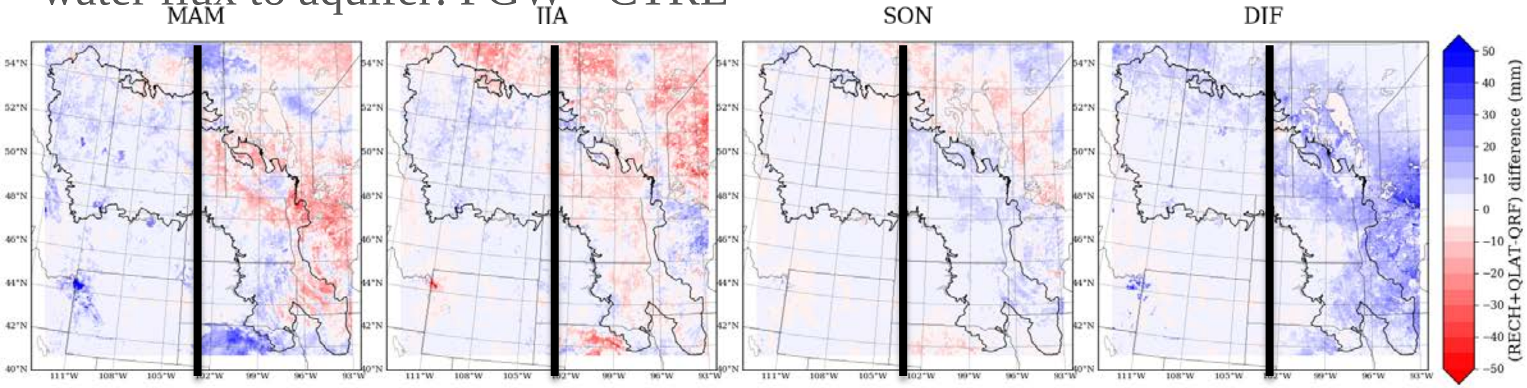
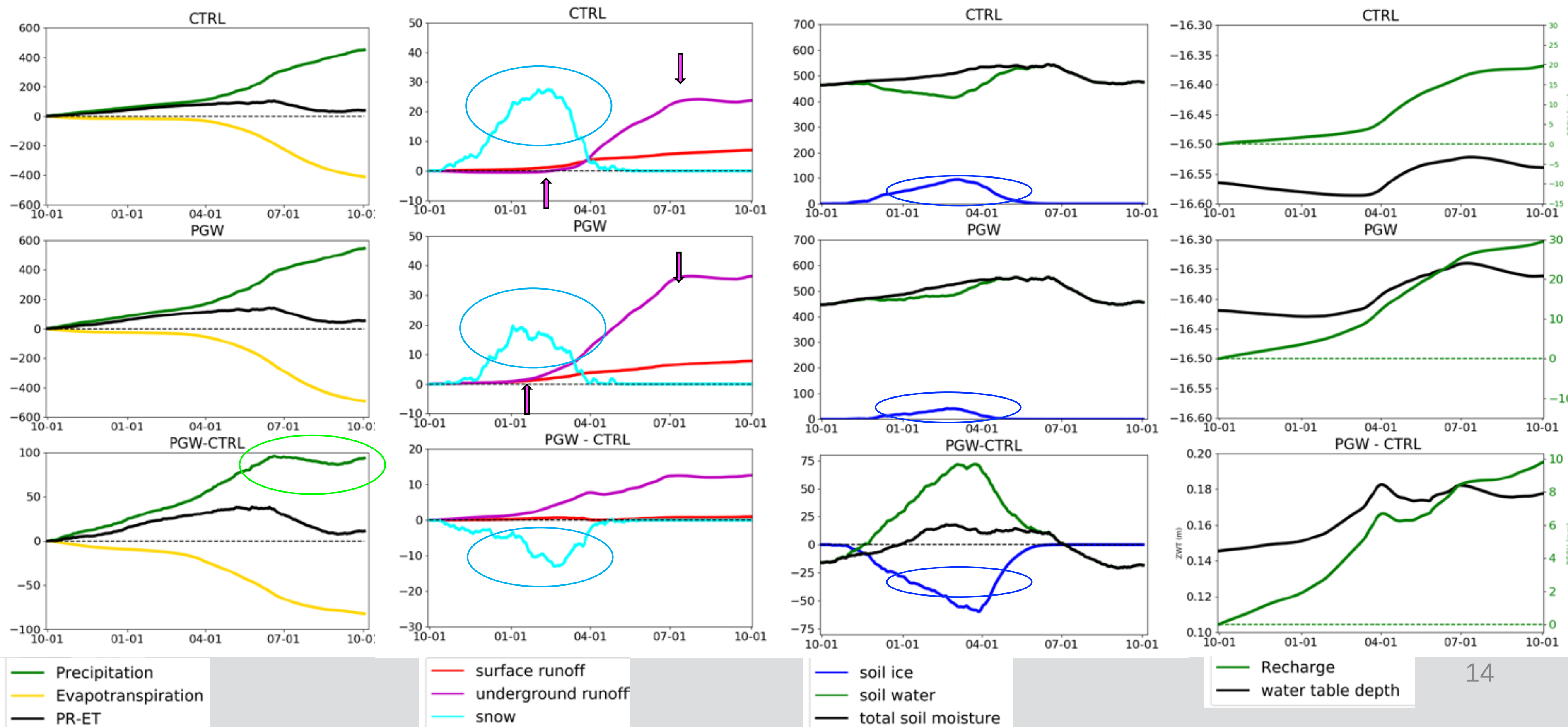
water flux to aquifer: PGW - CTRL





Summary

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- WRF-CONUS CTRL precipitation forcing is better than NARR in mountainous region and Canada.
- model ZWT timeseries reflect the annual fluctuation in observation, when model ZWT is shallow. But not so good for deep water table.
- Warmer winter leads to less snowpack and soil ice, contributing to underground drainage to aquifer, thus a wetter soil than current climate. On the other hand, stronger ET leads to dryer soil and significant water table decline in summer in the southeast.
- Wetland fraction shows increase in spring, **but strong decrease in the southeast in summer, (6-10% loss)**

Summary

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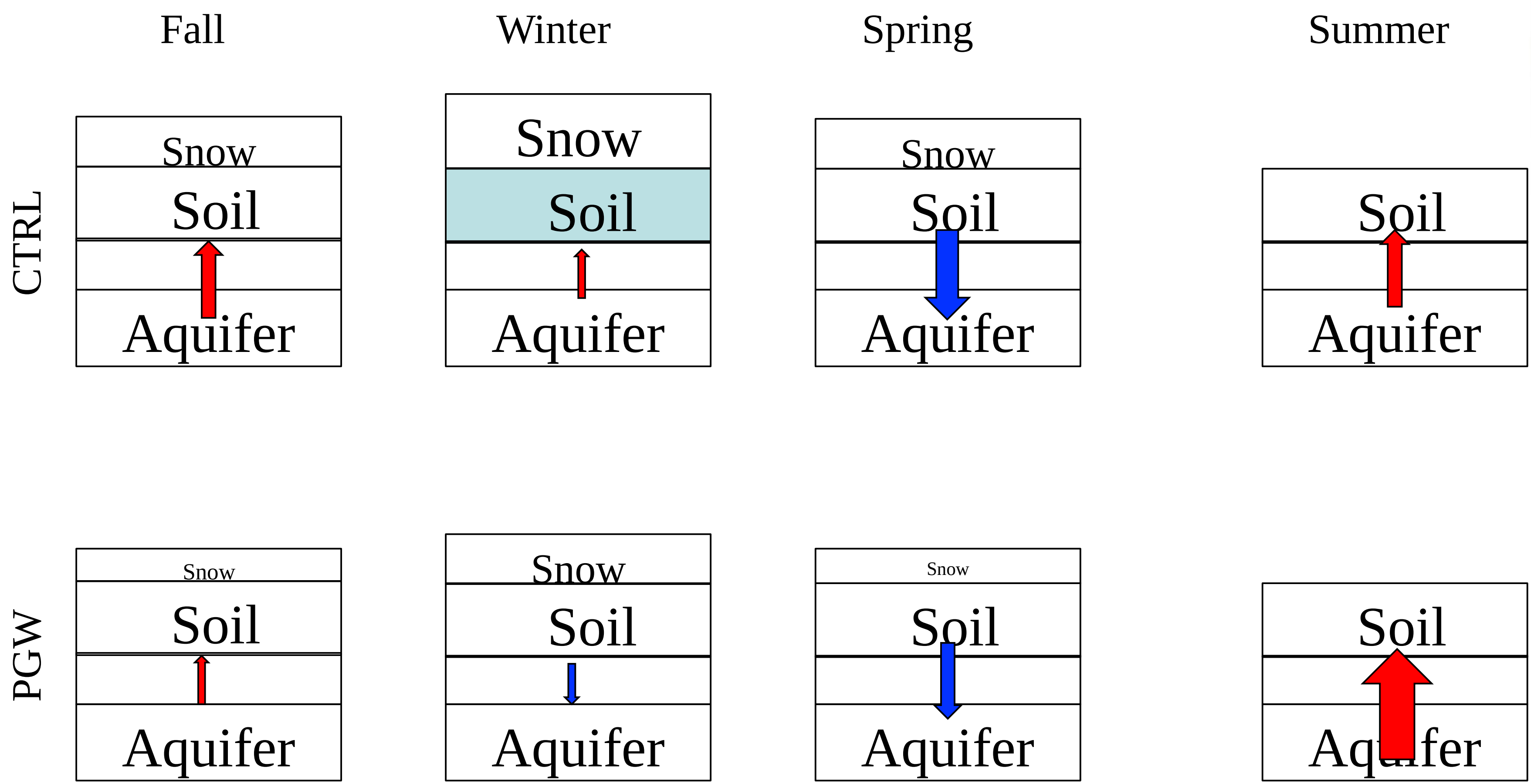

Wetland fraction shows increase in spring, **but strongly decrease in the southeast in summer,**