



UNIVERSITY OF SASKATCHEWAN

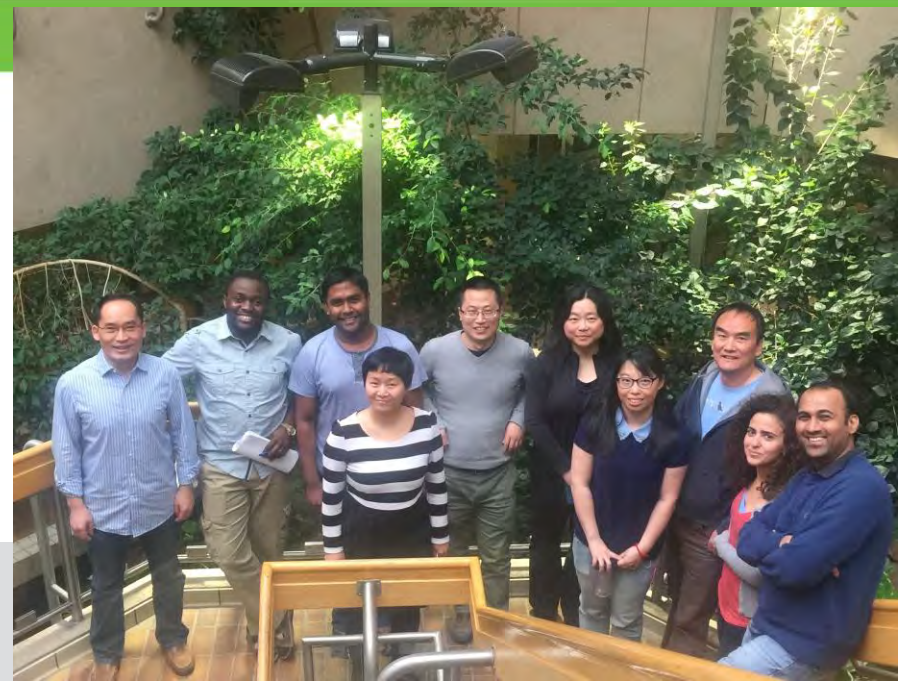
Global Institute for
Water Security

www.usask.ca/water



**Convection-permitting
WRF regional climate
simulations over Western
Canada**

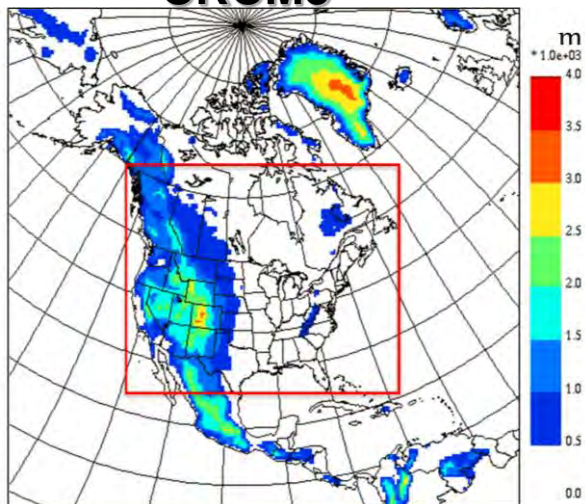
Yanping Li



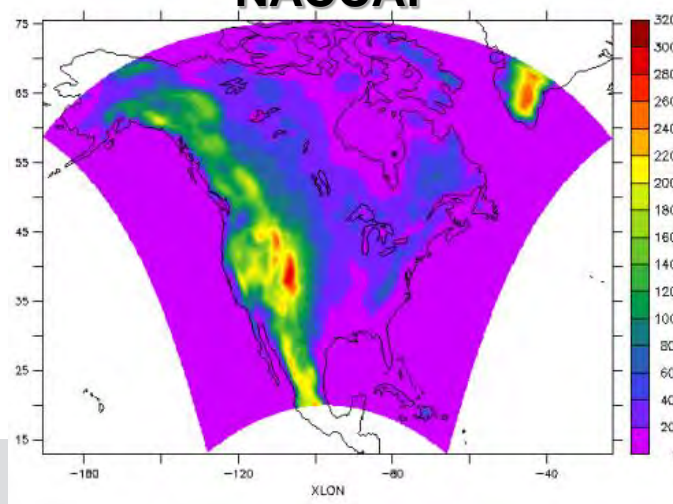
Available RCM output for CCRN region

	CRCM5	CanRCM4	NACCAP	CCRN-WRF
Spatial Resolution	50 km	NAM-22 (25 km) NAM-44 (50 km)	50 km	4 km
Vertical levels	29	4	26	51
Temporal resolution	daily	NAM-22(daily) NAM-44(daily, hourly for Pr)	3-hourly	hourly
Downscale from	CanESM2	CCCma-CanESM2	11 members	CMIP5 models 20 ensemble
Scenario	RCP4.5, RCP8.5	RCP4.5, RCP8.5	SRES A2	RCP8.5
Output available	2006-2100	1950-2005 (historic) 2006-2010 (future)	1971-2000 (historic) 2041-2070 (near future)	2000-2013 (historic) 2086-2099 (PGW equivalent)

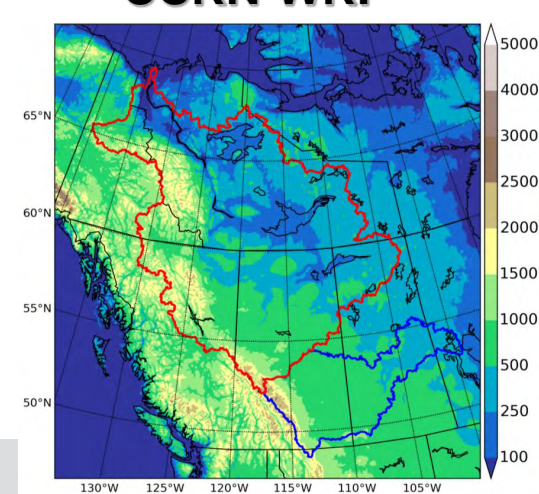
CRCM5



NACCAP



CCRN-WRF



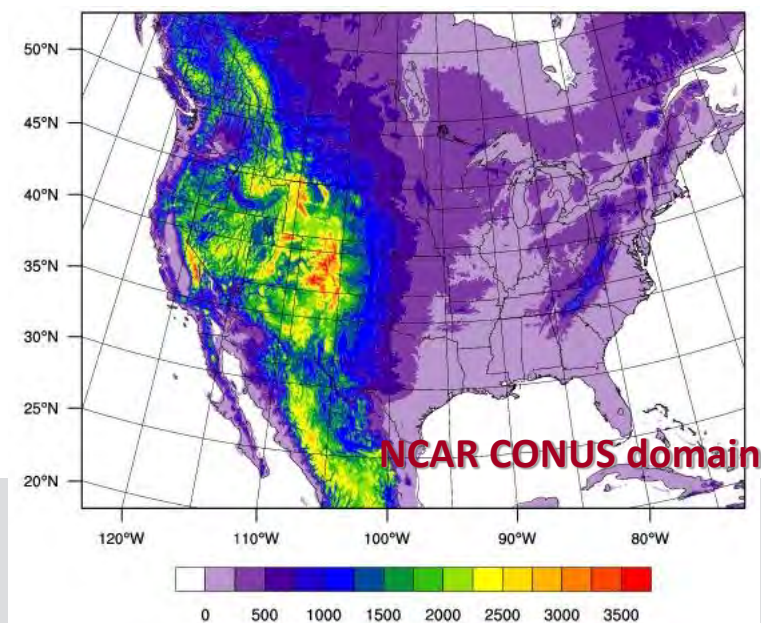
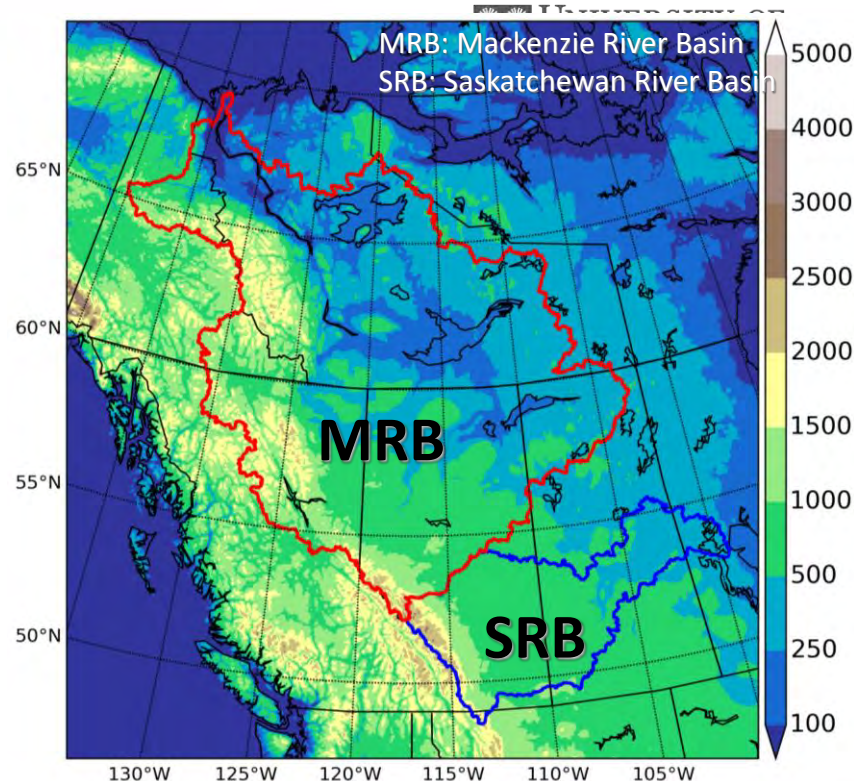
Continental Scale Regional Climate Simulation using 4-KM WRF

WRF Model Setup and Design

- WRF Model (Version 3.4.1)
- A single domain: 2560 x 2800 km²; 4 km grid spacing; 37 levels
- Microphysics Scheme: New Thompson et al.
- PBL scheme: YSU
- RRTMG Long-wave and Short-wave scheme
- No Cumulus parameterization used, assumed explicit

Forcing Data

- The 6-hourly, 0.703° x 0.703° resolution ERA-Interim reanalysis data provide the initial and lateral boundary condition



WRF Dynamical downscaling and PGW method

Historical simulation (CTRL)

OBSERVATION PERIOD 2001-2015

6-hours historical boundary conditions from:
ERA-Interim reanalysis (ERA-I)

- Sea surface temperature and ice
- Air temperature
- Horizontal wind
- Specific humidity
- Air pressure
- Geopotential height

**HIGH-RESOLUTION (4-km) REGIONAL CLIMATE
MODEL**
Weather Research Forecast V3.6

**DYNAMICAL
DOWNSCALING
HINDCAST**

Future simulation (PGW)

GLOBAL FUTURE SCENARIOS

RCP8.5 *"the business as usual"* scenario projects a 3.7°C warming by the end of the 21 century.

CMIP5 models under RCP8.5

ACCESS1-3	GFDL-CM3	IPSL-CM5A-MR
CanESM2	GFDL-ESM2M	MIROC5
CCSM4	GISS-E2-H	MIROC-ESM
CESM1-CAM5	HadGEM2-CC	MPI-ESM-LR
CMCC-CM	HadGEM2-ES	MPI-ESM-MR
CNRM-CM5	Inmcm4	MRI-CGCM3
CSIRO-Mk3-6-0		

Global monthly multi-model average increments:
 ΔCIMP5 = projection ensemble – historical ensemble
(2070 to 2099) (1976 to 2005)

PSEUDO GLOBAL WARMING
ERA-I + ΔCIMP5

**DYNAMICAL DOWNSCALING
FUTURE PGW**

WRF dynamical downscaling for 2000-2013

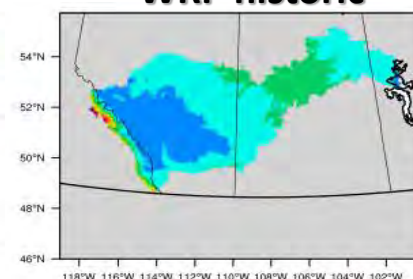
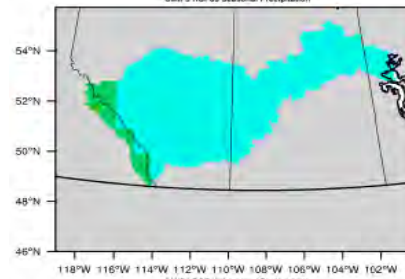
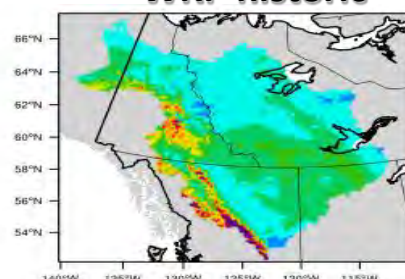
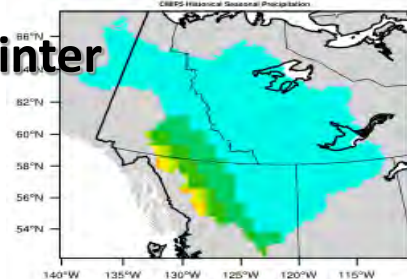
CMIP5-historic

WRF-historic

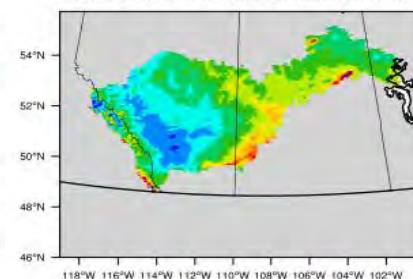
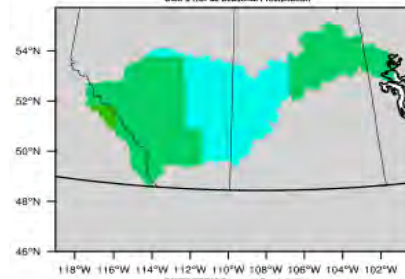
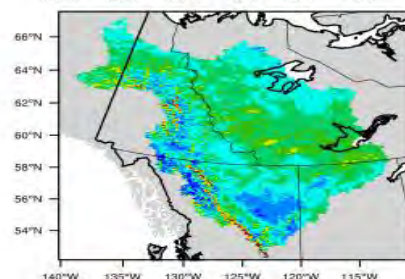
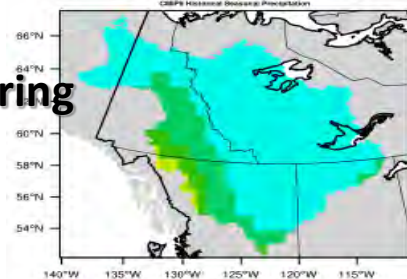
CMIP5-historic

WRF-historic

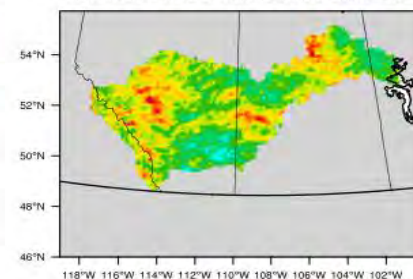
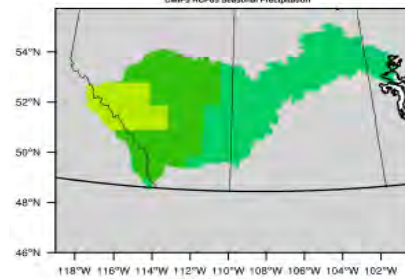
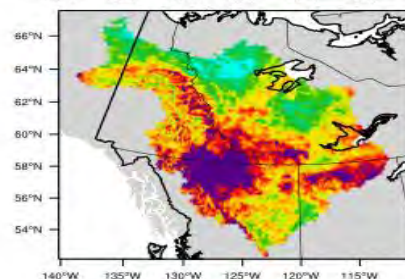
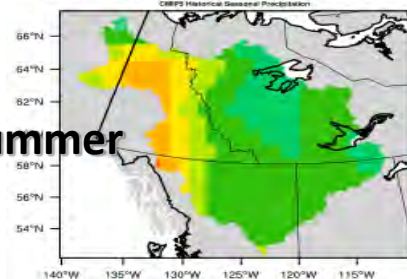
Winter



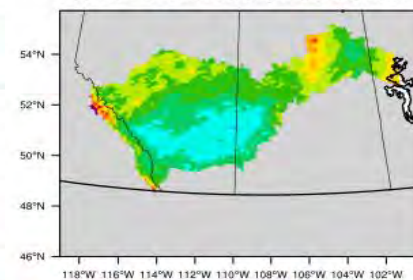
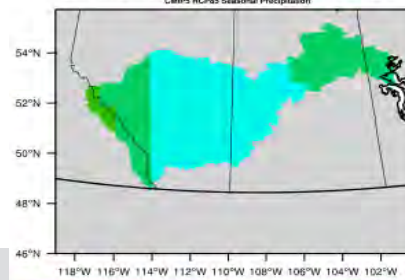
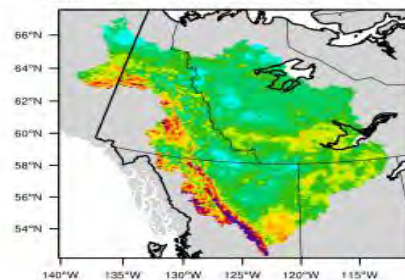
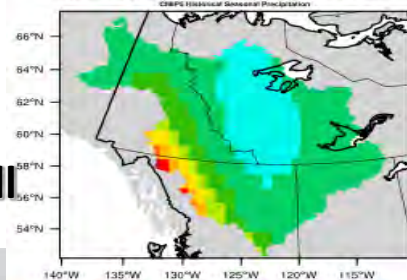
Spring



Summer



Fall



0.5 1 1.5 2 2.5 3 3.5 4 4.5

0 0.5 1 1.5 2 2.5 3 3.5 4 4.5

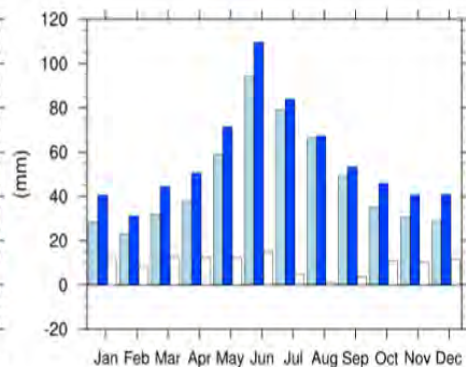
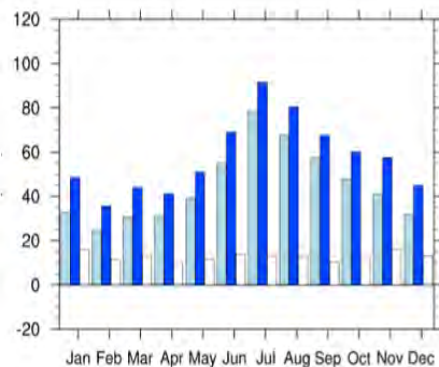
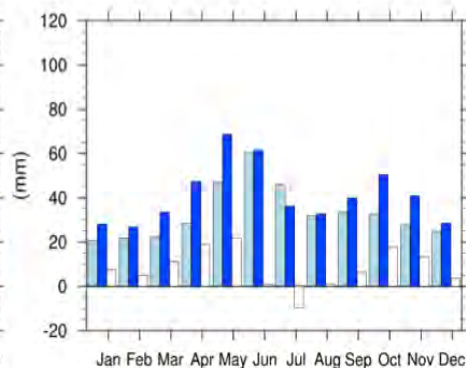
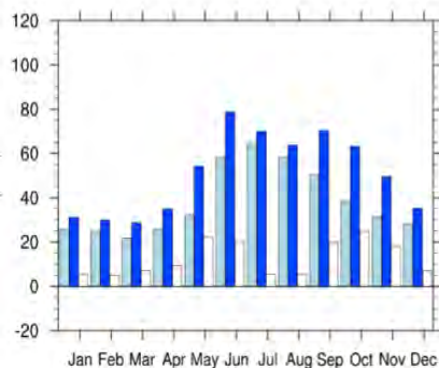
0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

Annual precipitation – CMIP5 vs WRF

MRB

SRB

30 years climatology monthly precipitation

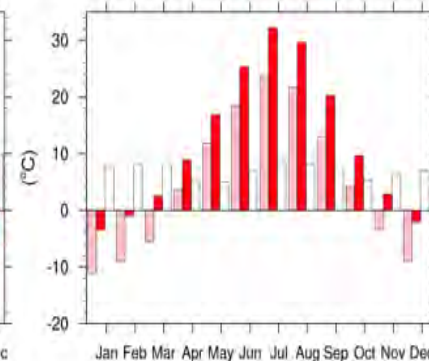
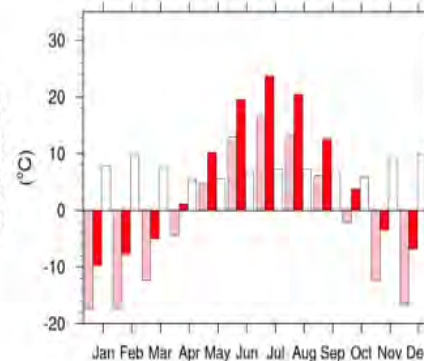


MRB

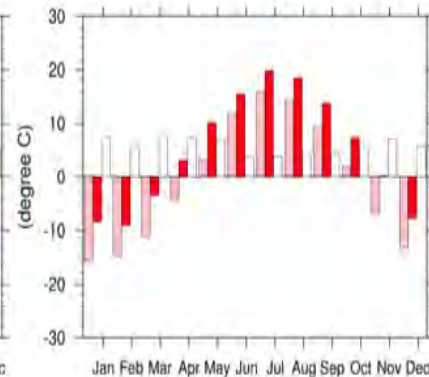
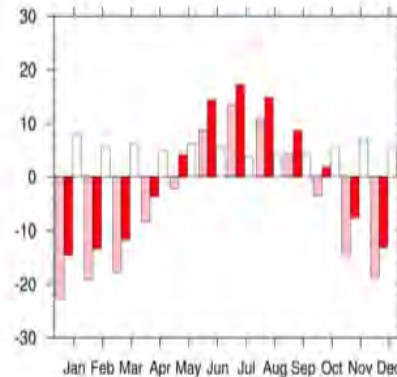
SRB

30 years climatology monthly temperature

CMIP 5



WRF



WRF dynamical downscaling of CMIP5

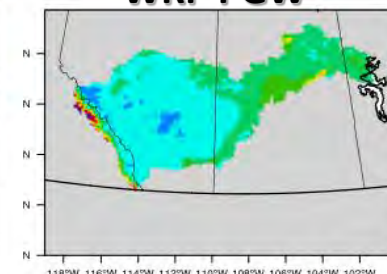
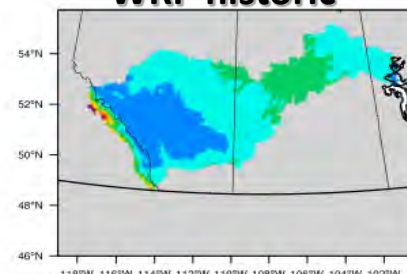
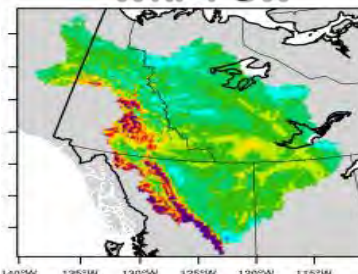
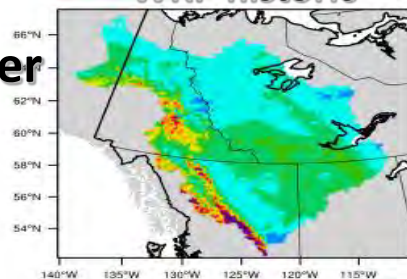
WRF-historic

WRF-PGW

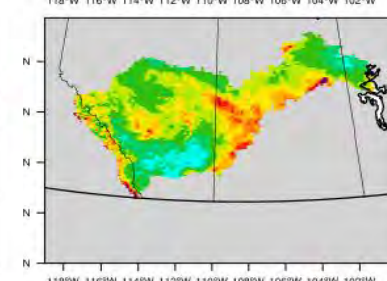
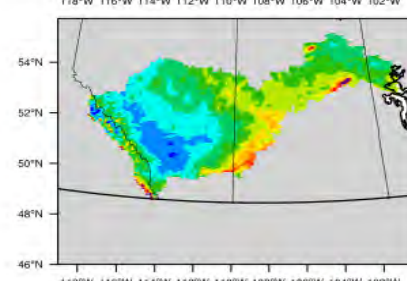
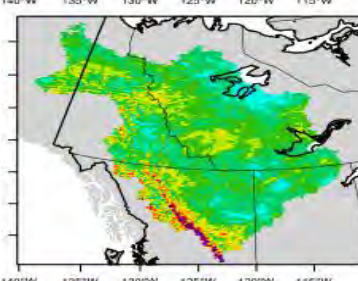
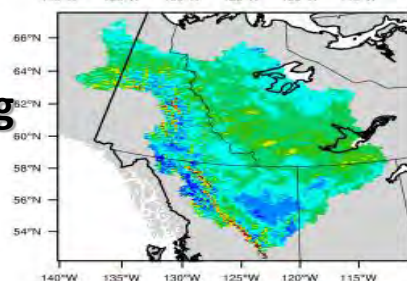
WRF-historic

WRF-PGW

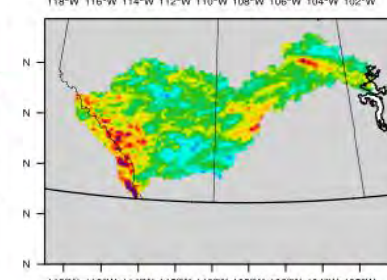
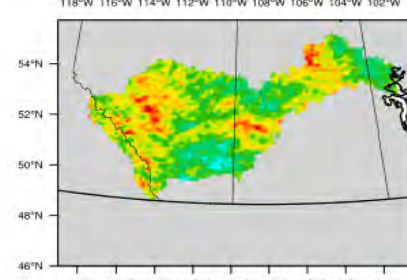
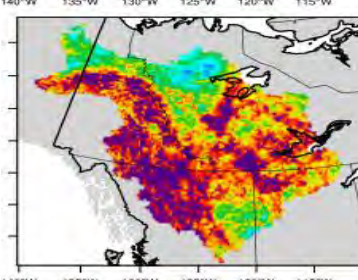
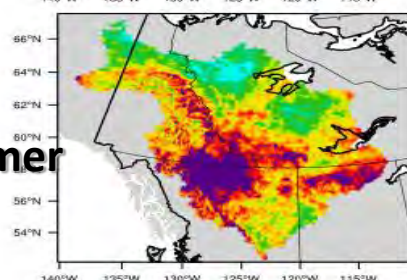
Winter



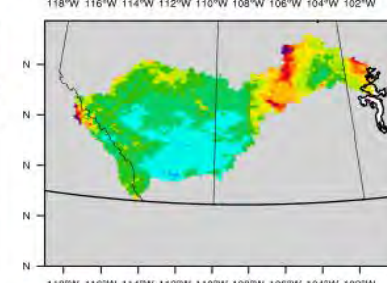
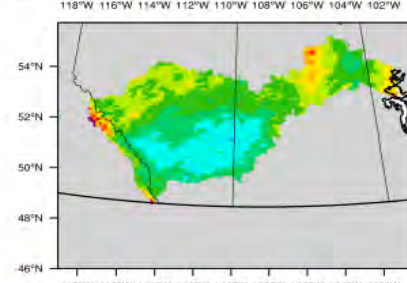
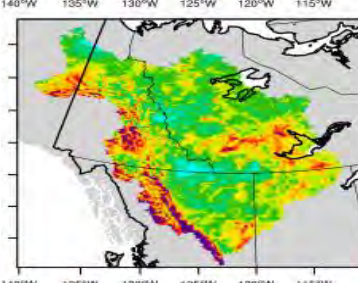
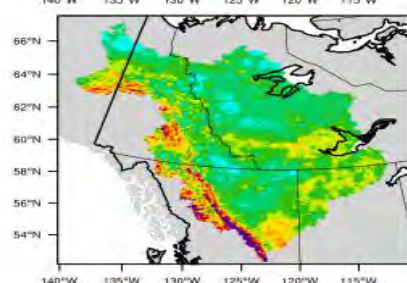
Spring



Summer

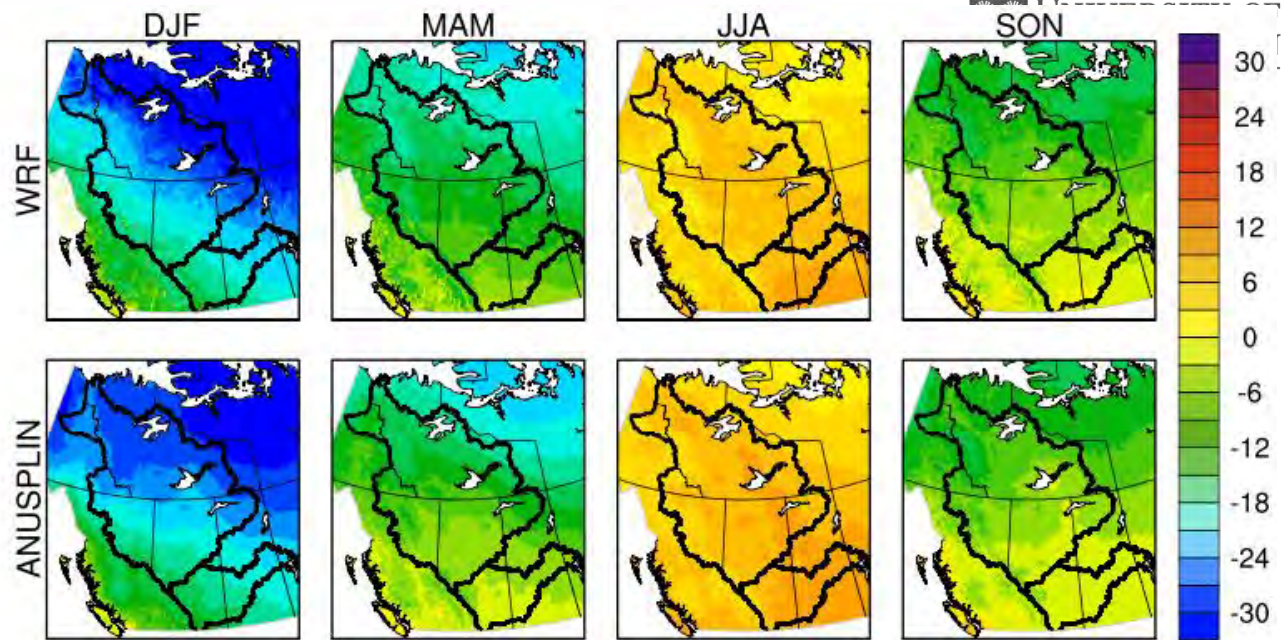


Fall

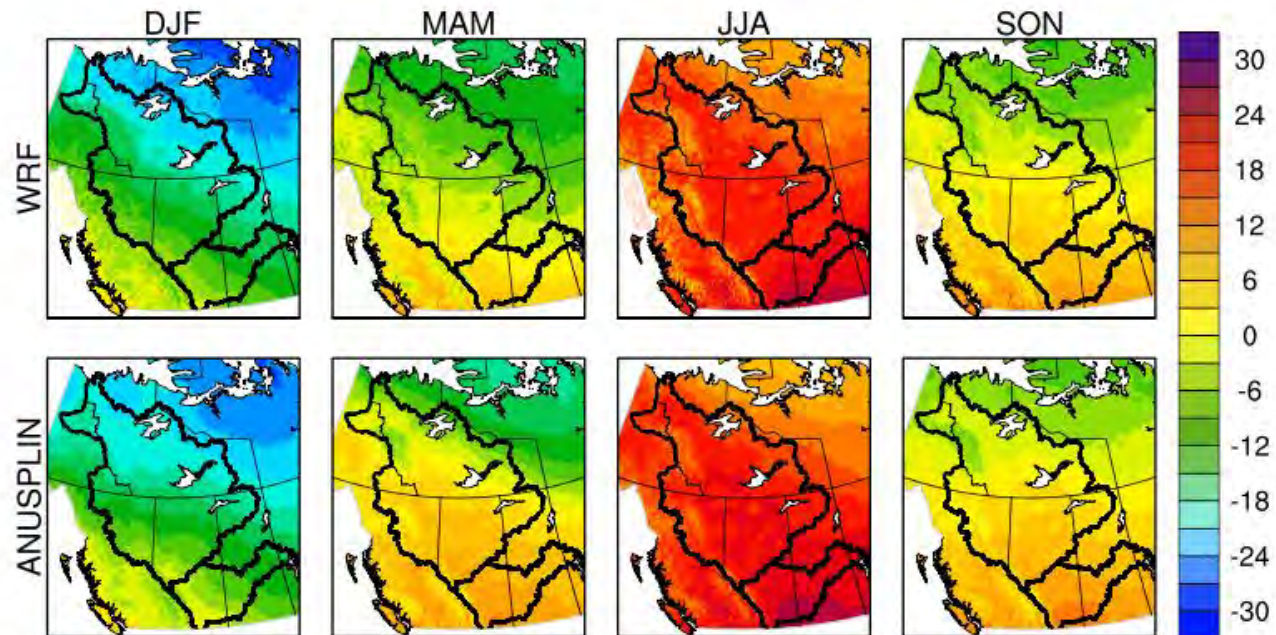


Geographic distribution of seasonal mean precipitation (a), T_{min} (b) and T_{max} (c), over the period from Oct 2000 – Sept 2013 for WRF and ANUSPLIN.

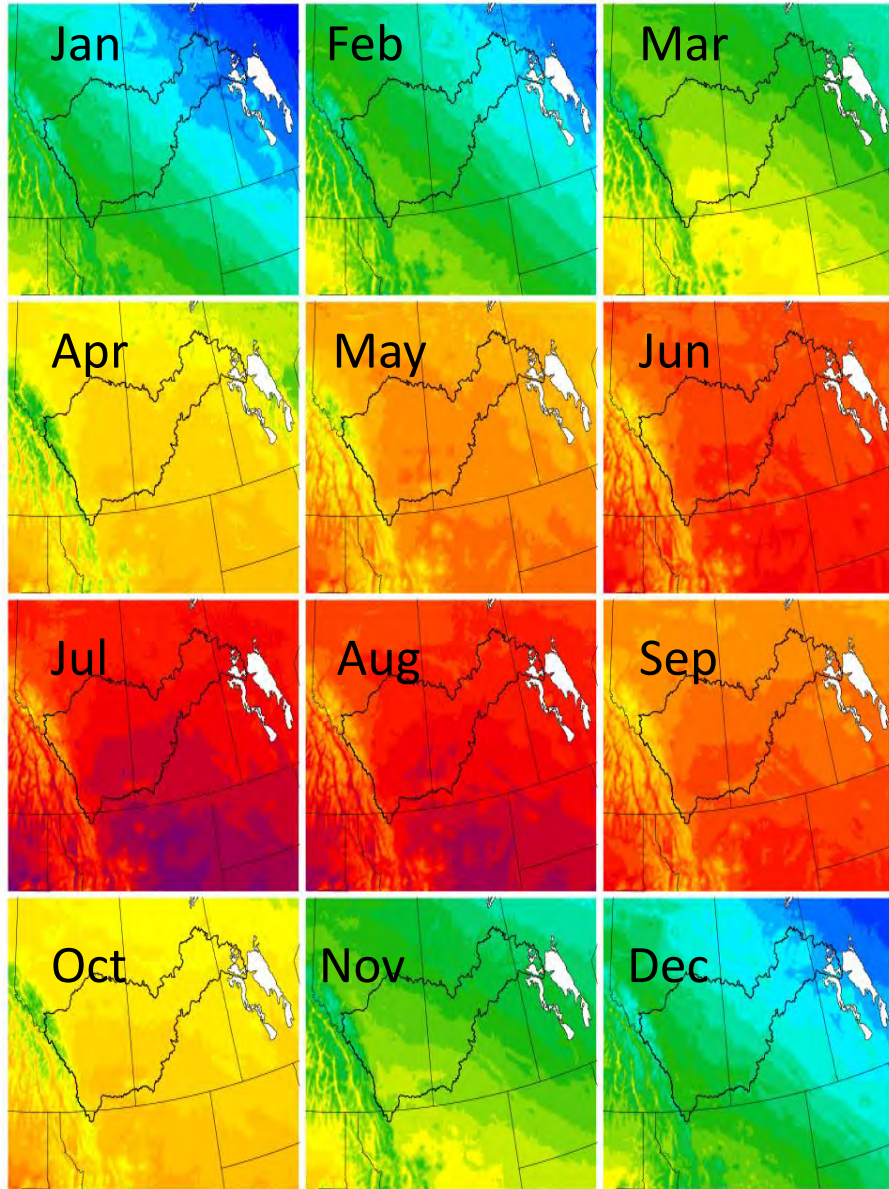
Daily T_{min}



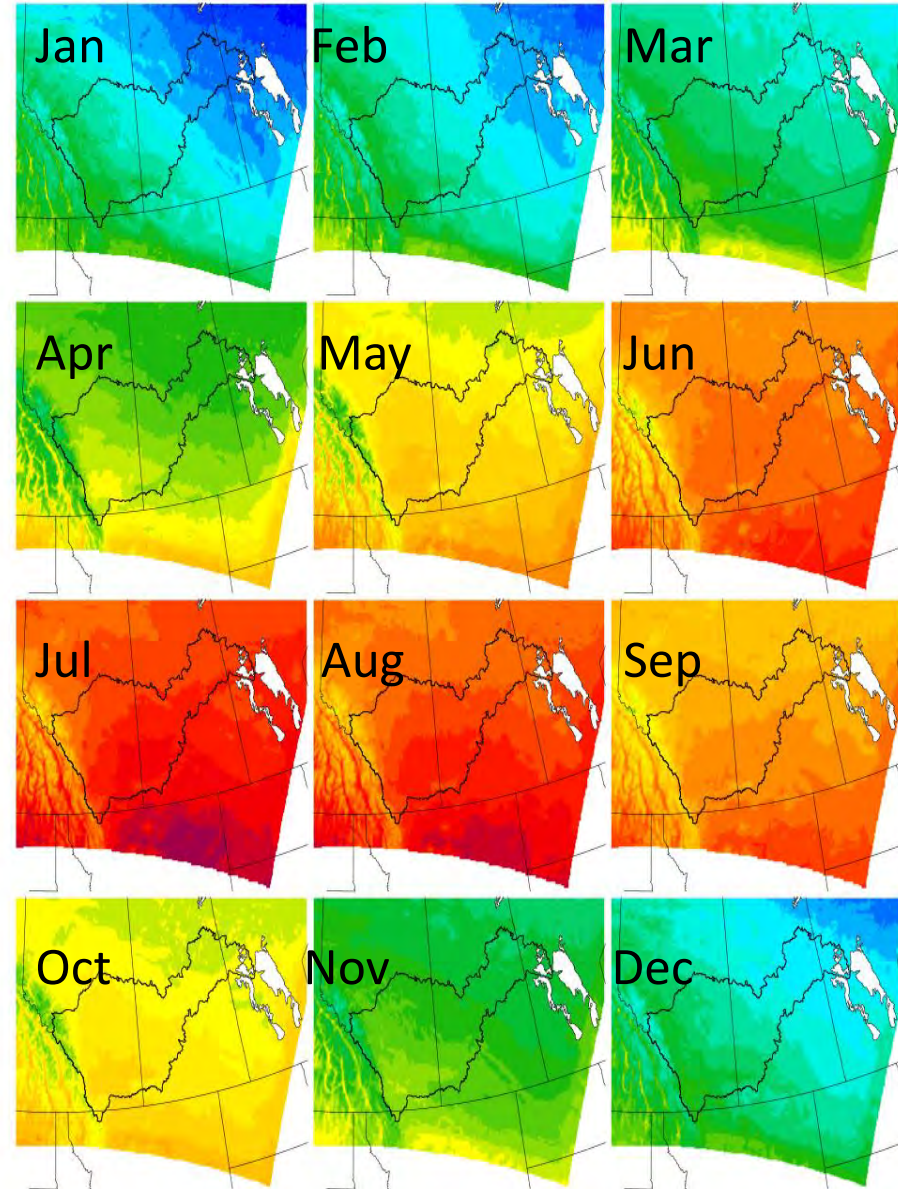
Daily T_{max}



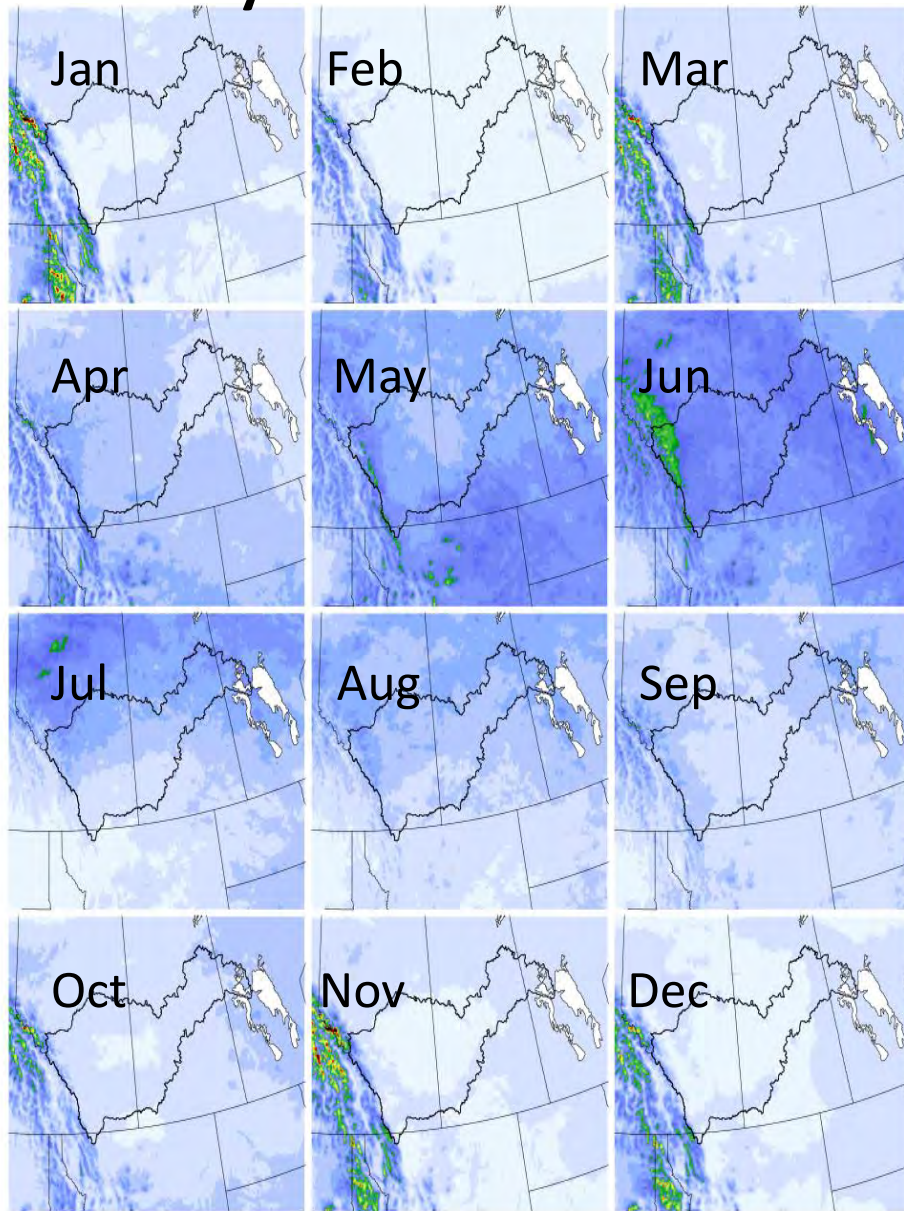
Monthly T2: CONUS-WRF



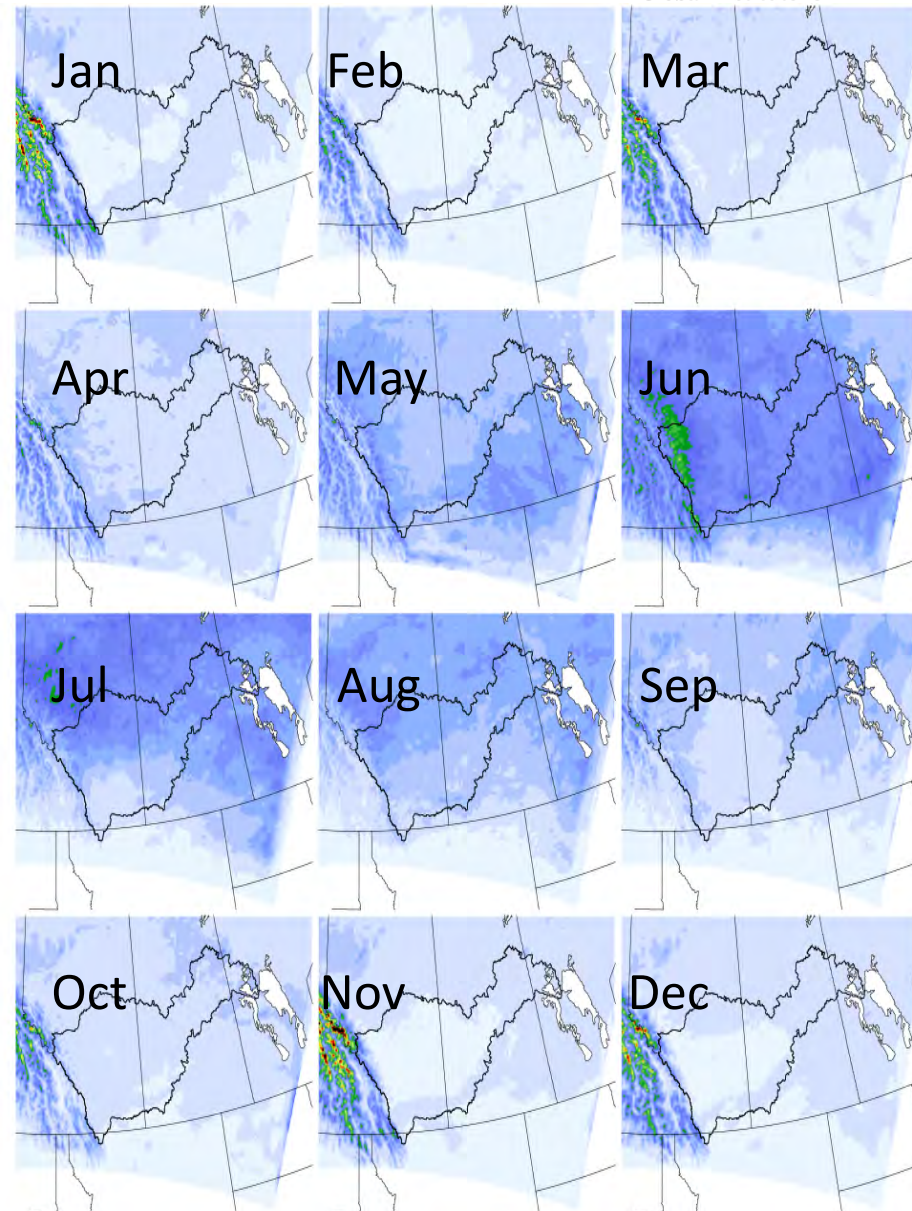
CCRN-WRF



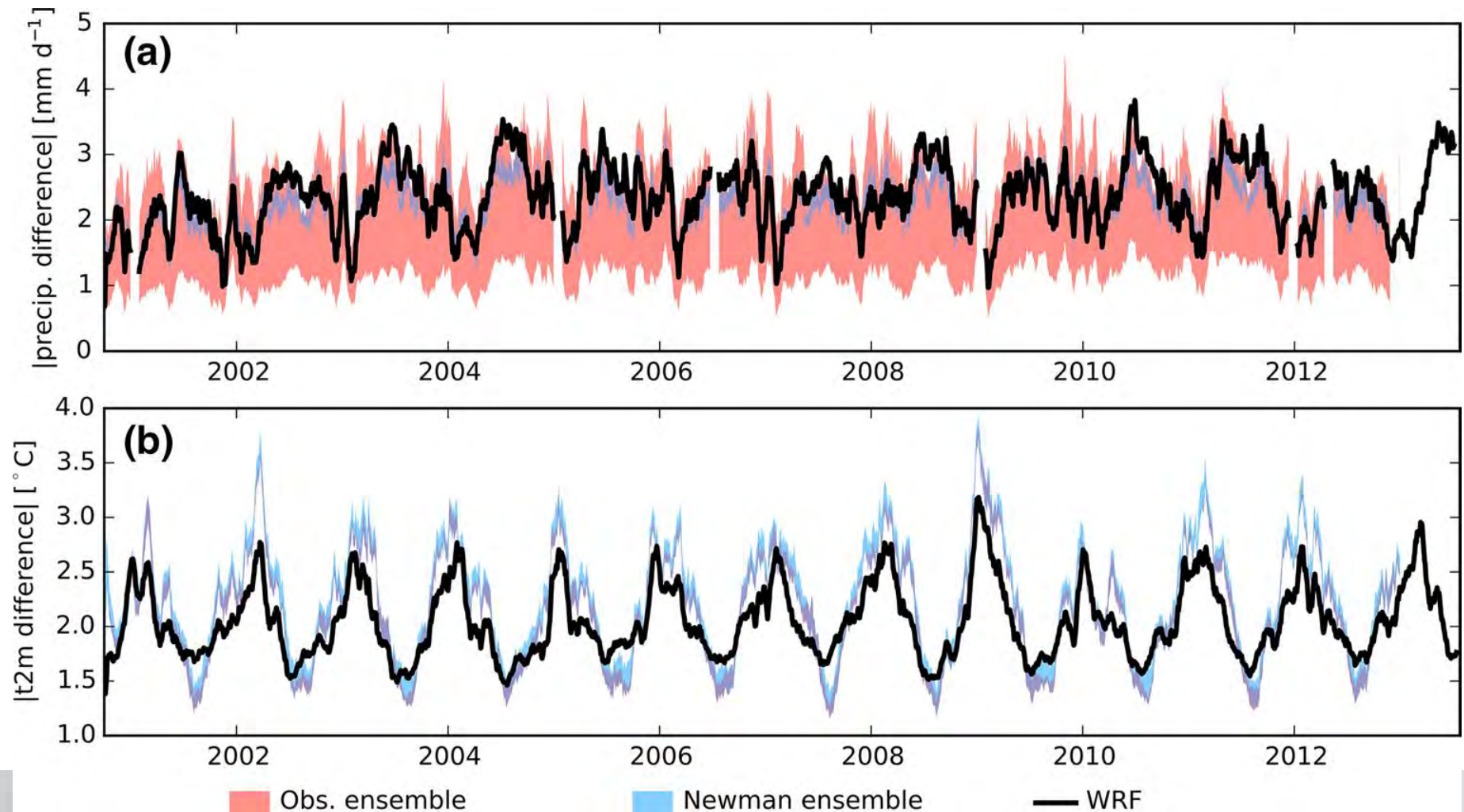
Monthly PR: CONUS-WRF



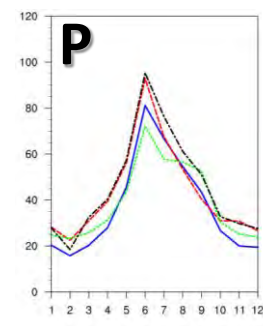
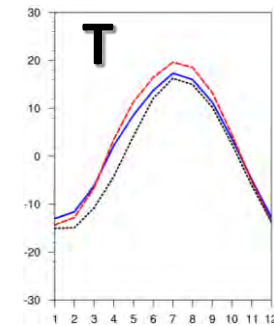
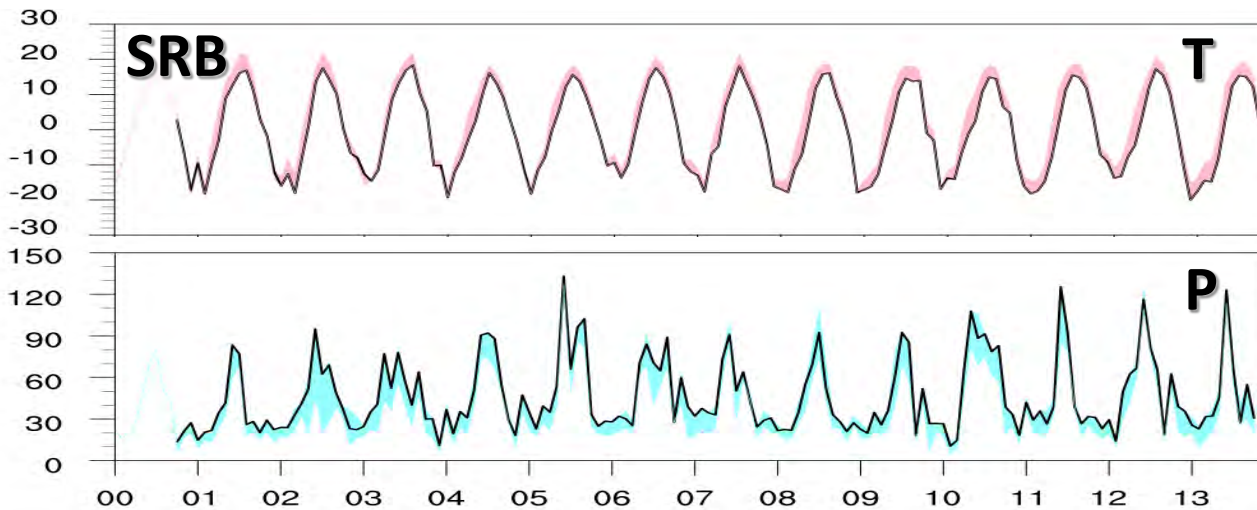
CCRN-WRF



CONUS-WRF precipitation validation



CCRN-WRF Performance Evaluation (Annual cycle)

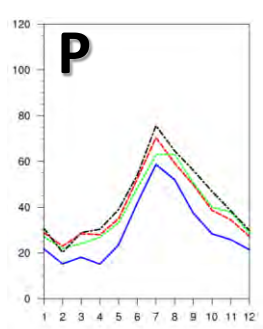
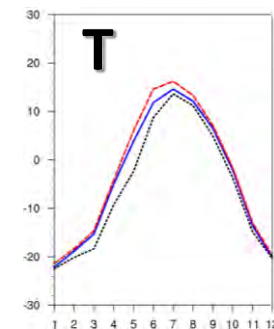
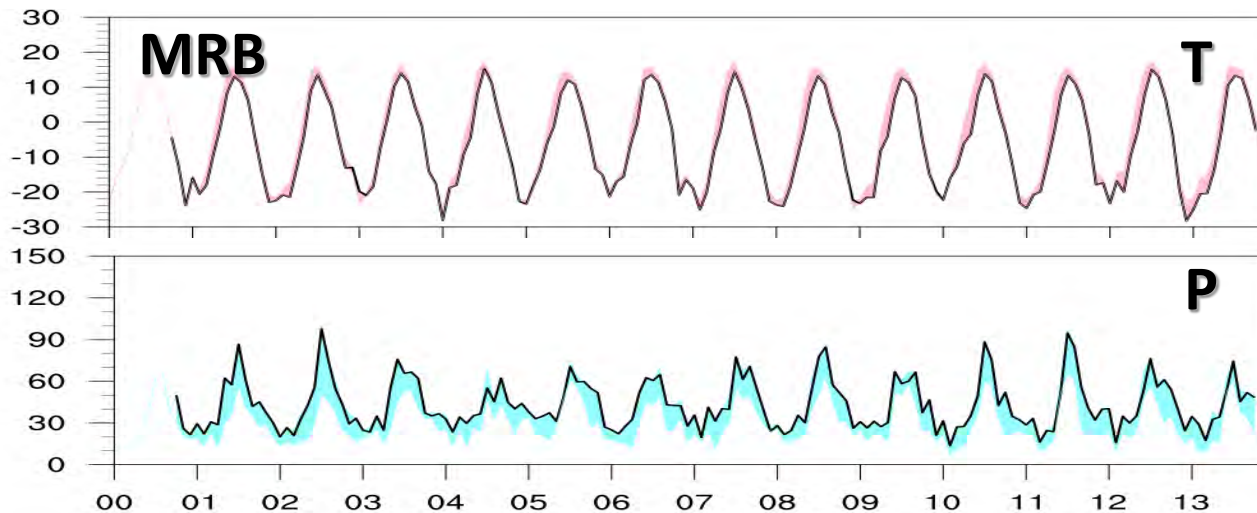


ANUSPLIN

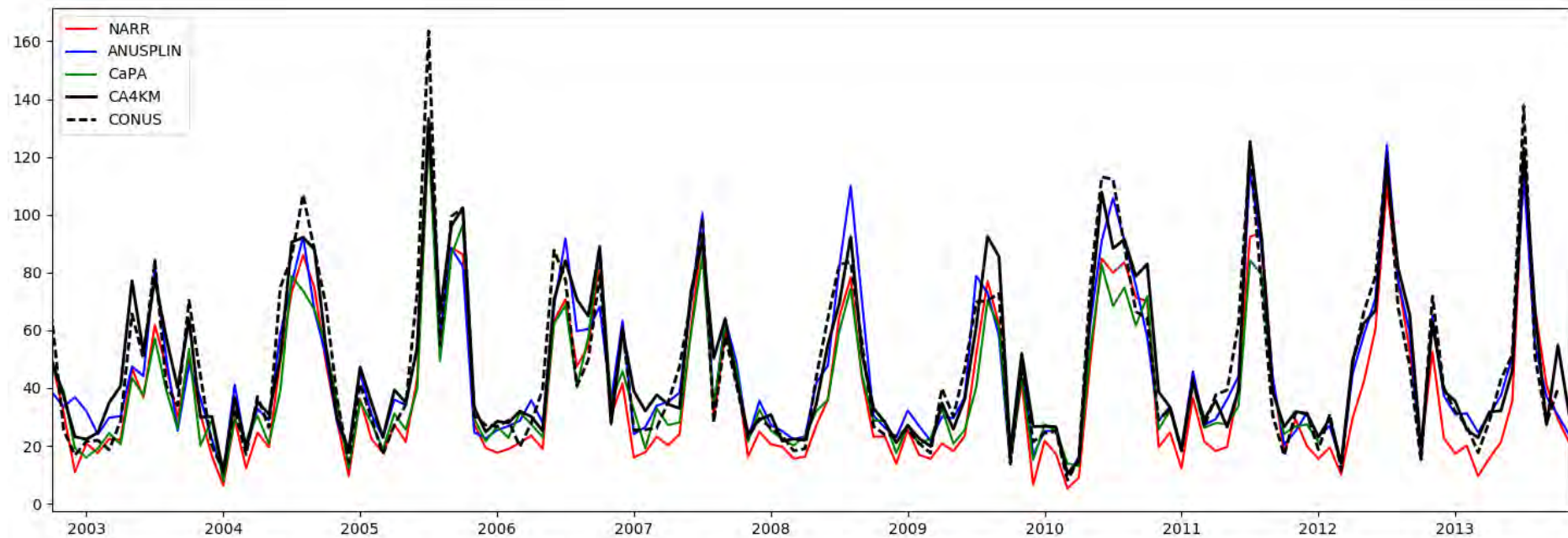
NARR

WRF

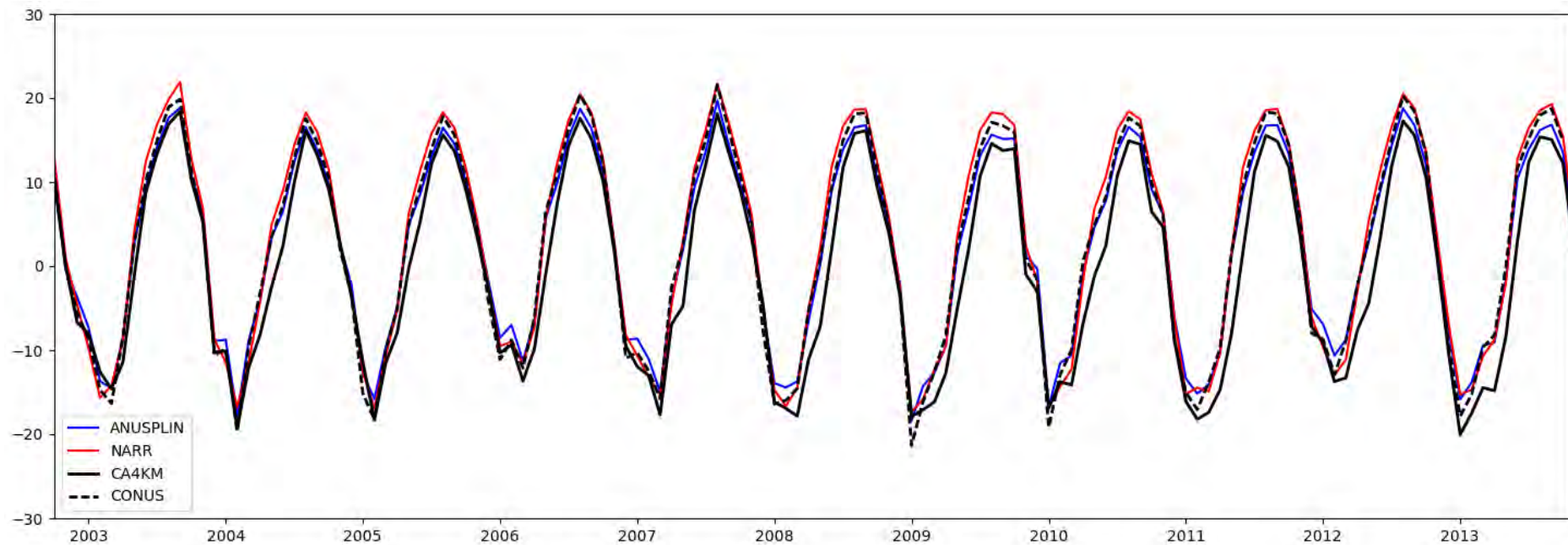
CaPA



WRF Precipitation Annual cycle for SRB

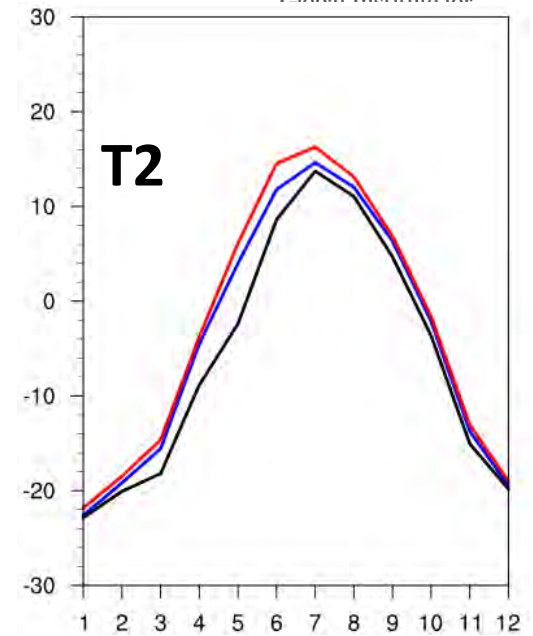
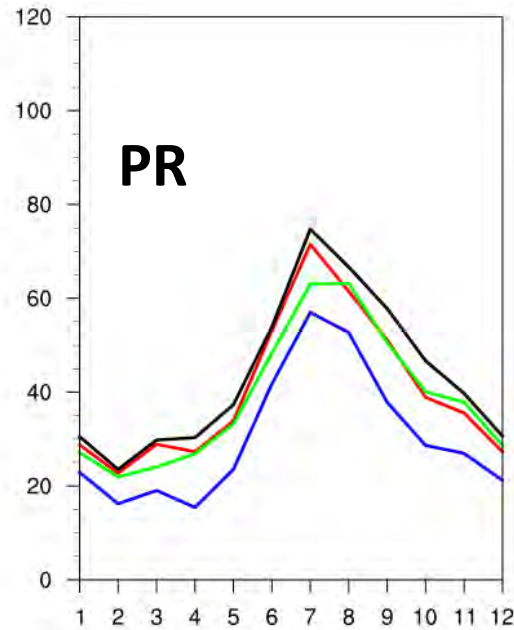


WRF Temperature Annual cycle for SRB

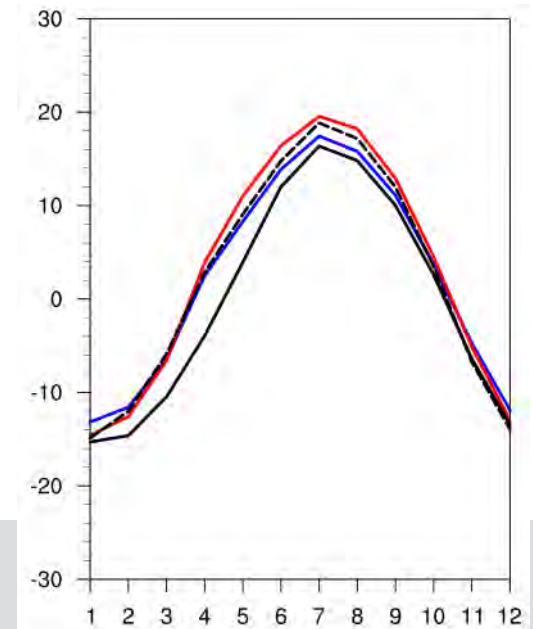
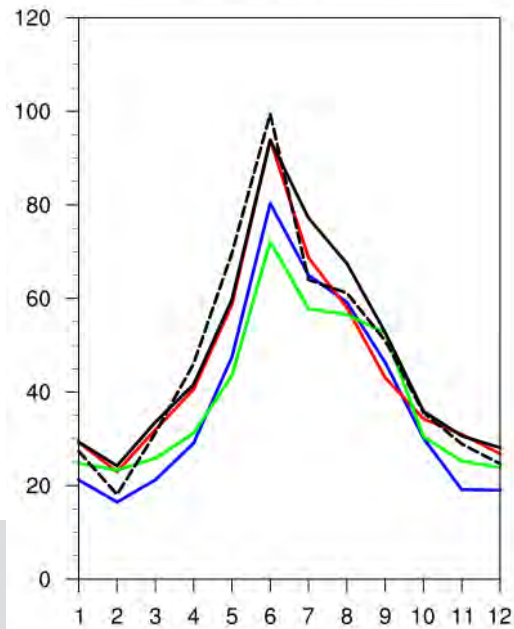


Precipitation, Temperature Annual cycle for MRB, SRB

MRB

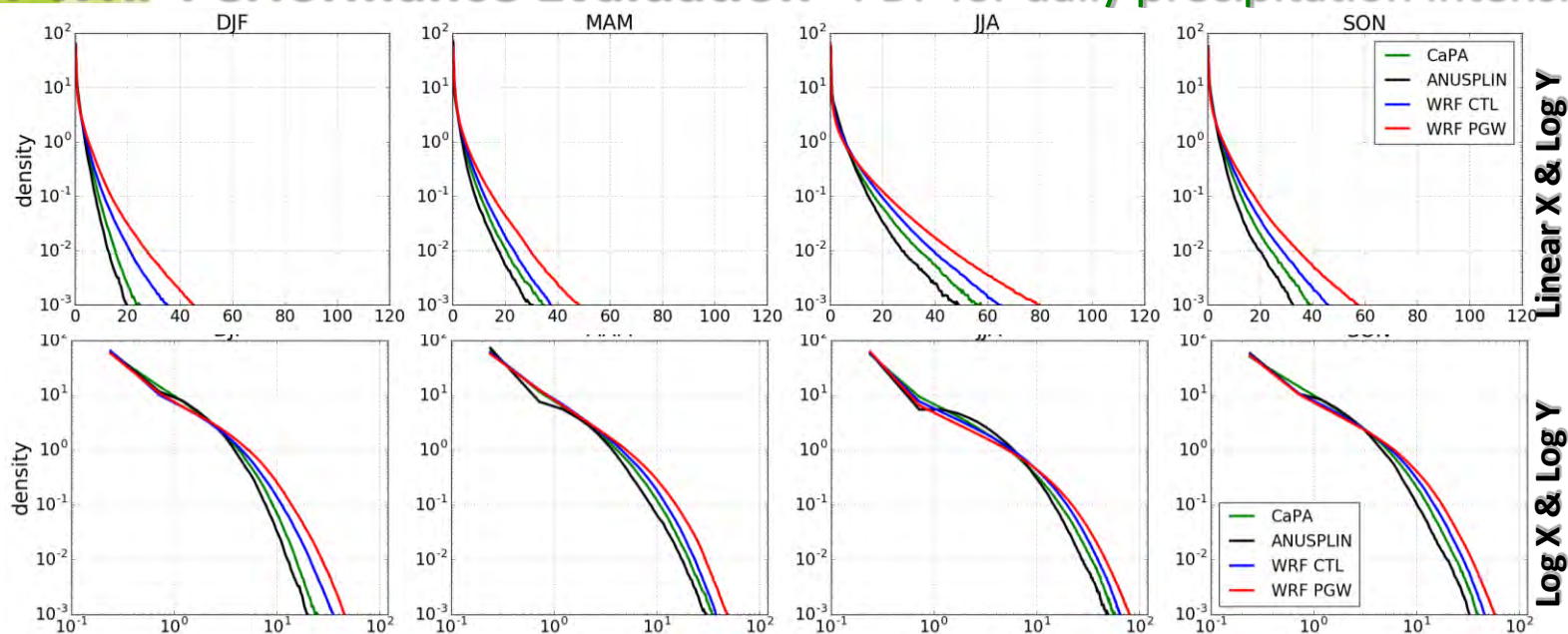


SRB

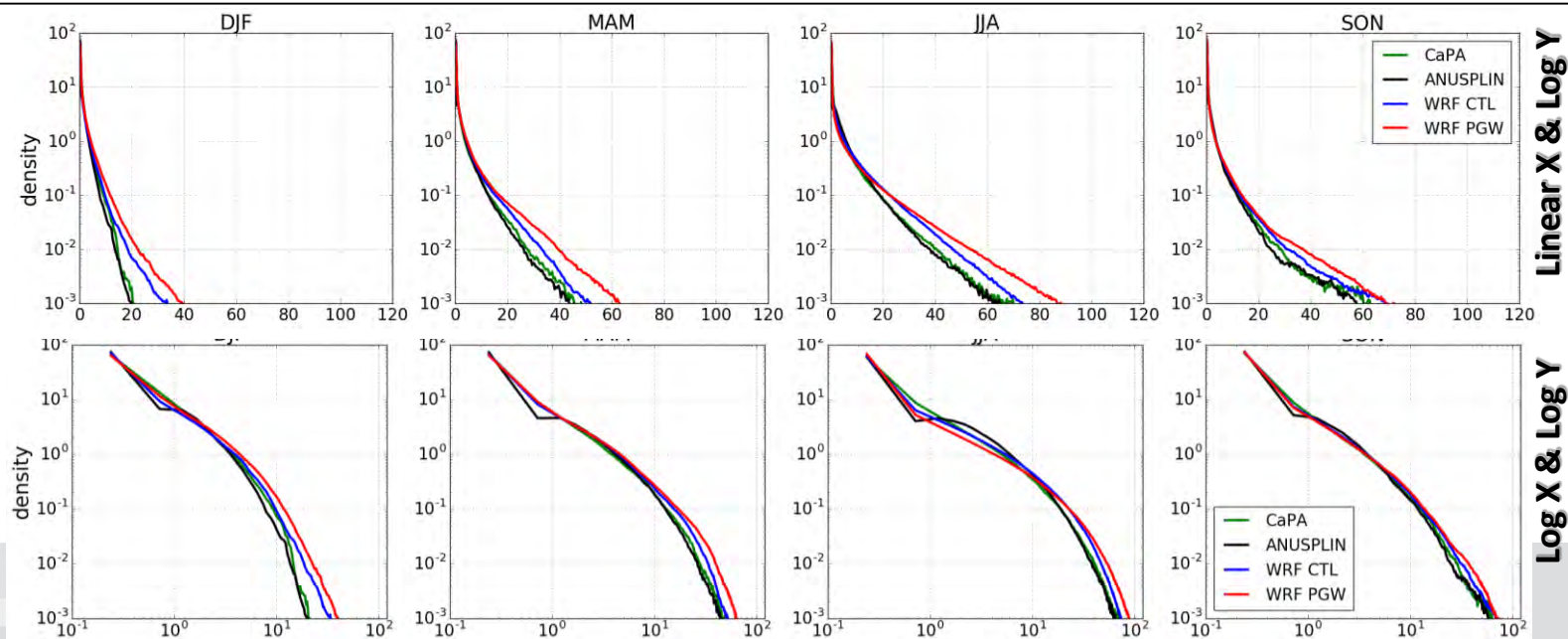


CCRN-WRF Performance Evaluation -PDF for daily precipitation intensity

MRB

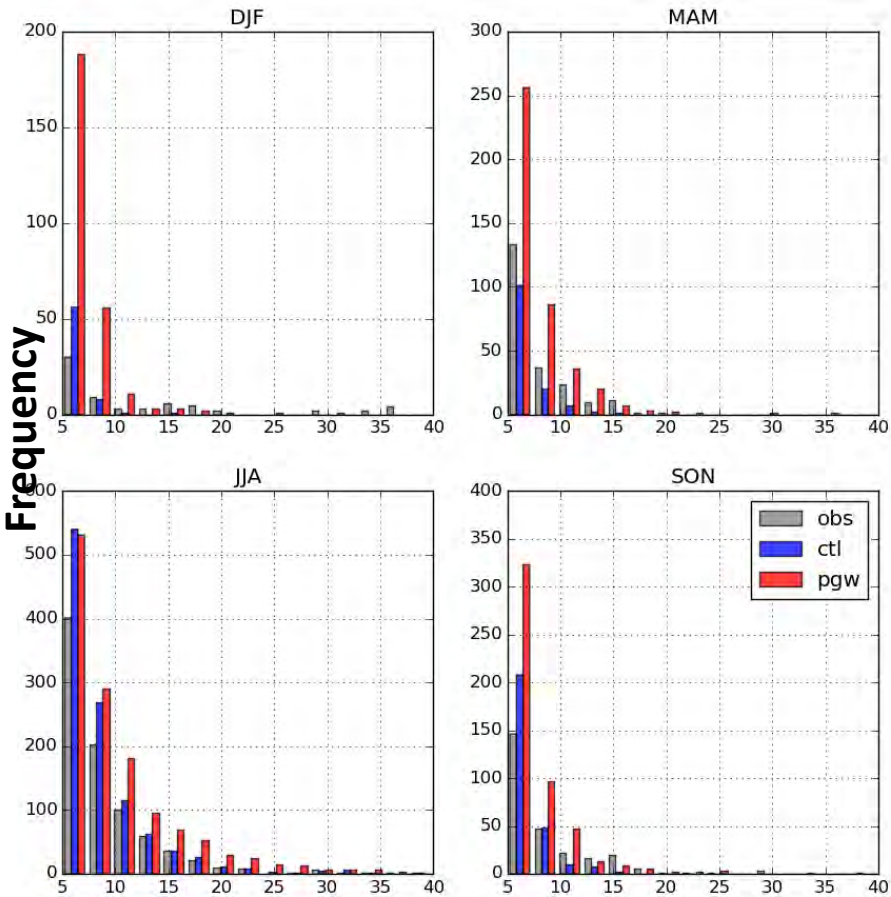


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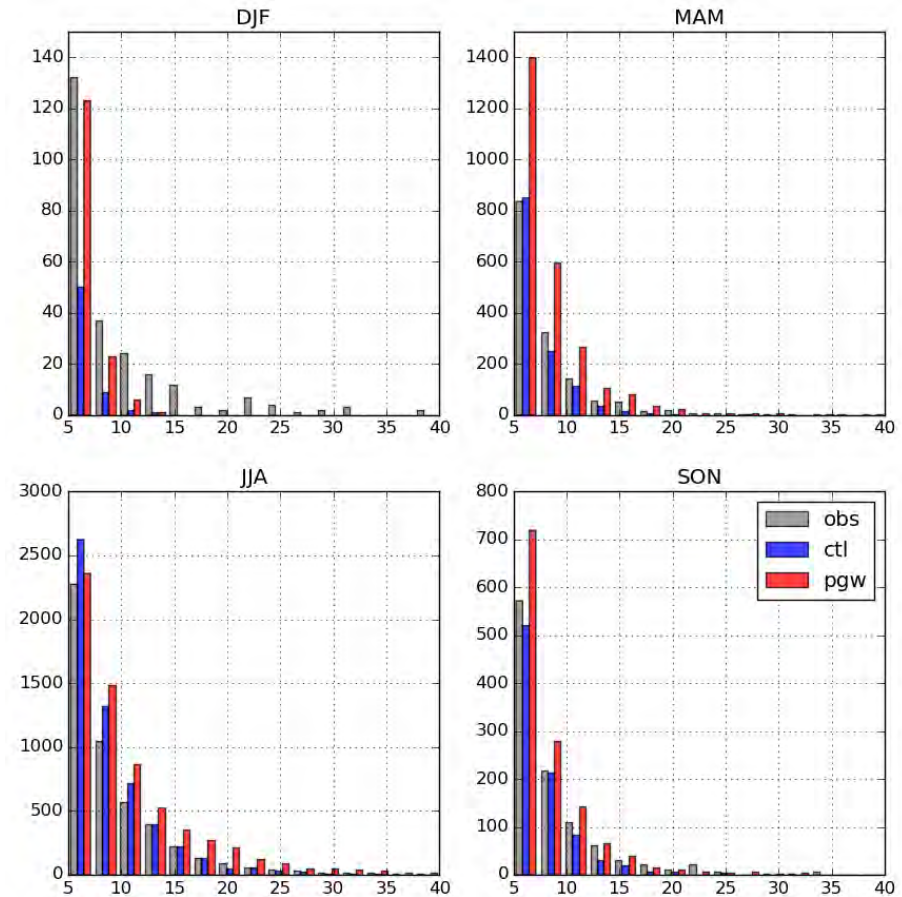


CCRN-WRF Performance Evaluation -PDF for hourly precipitation intensity

MRB



SRB

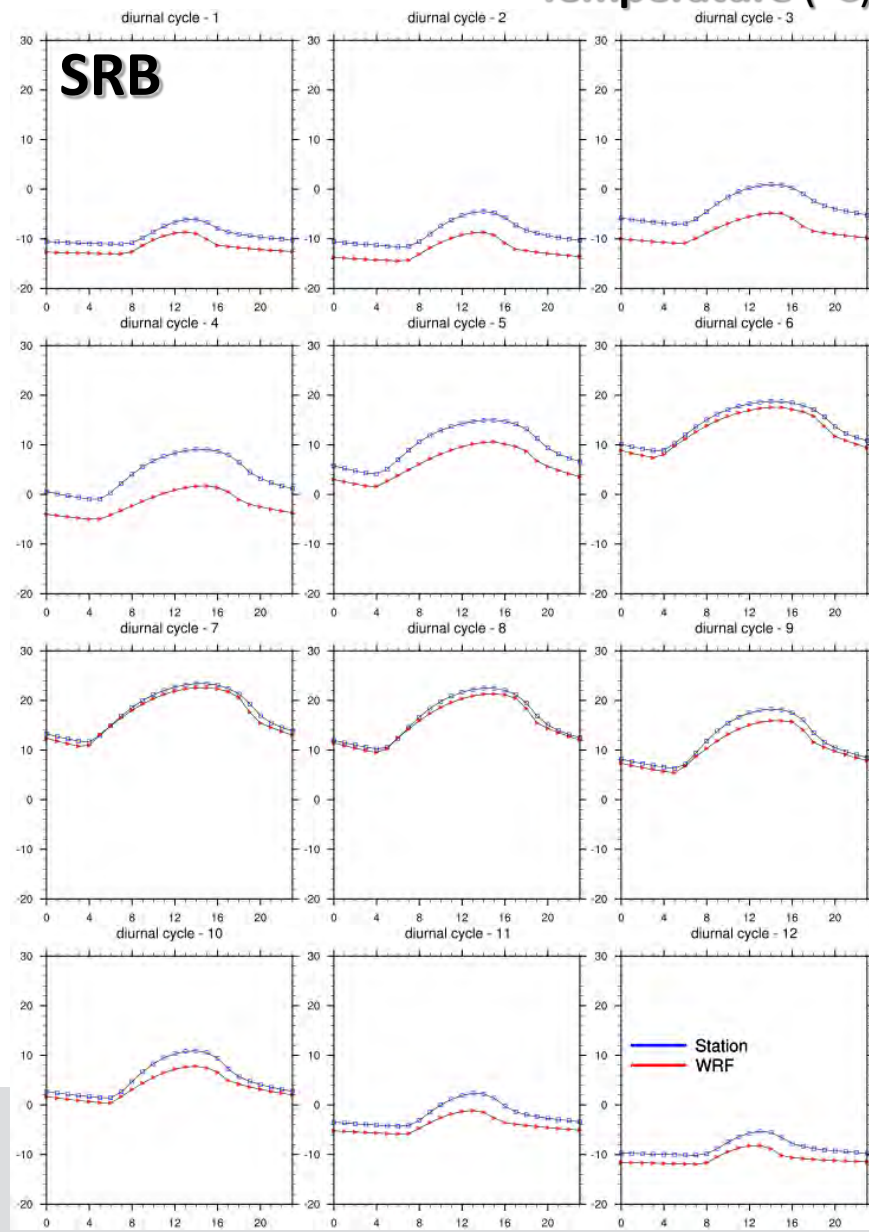
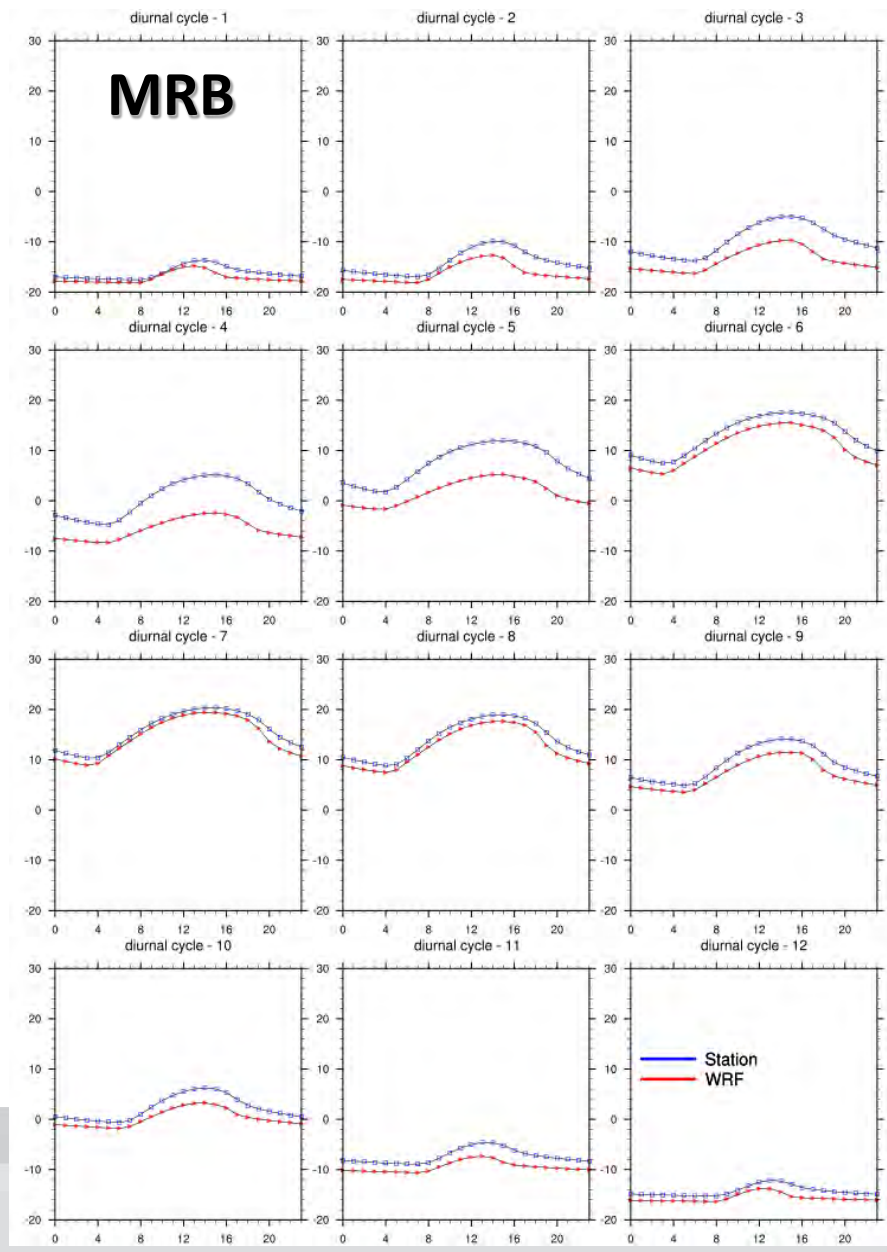


CCRN-WRF Performance Evaluation (Diurnal cycle)

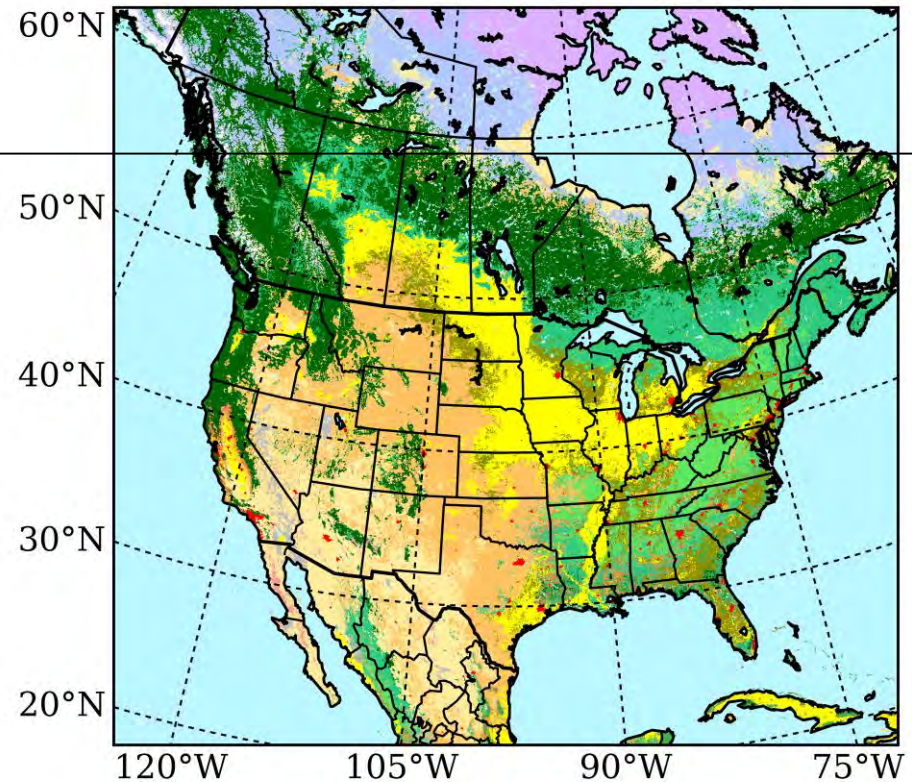
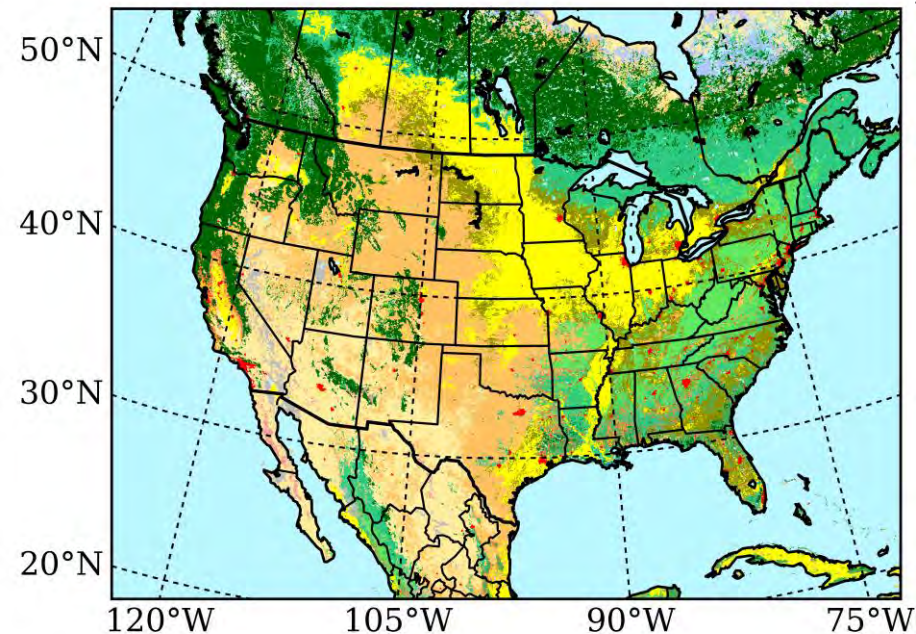
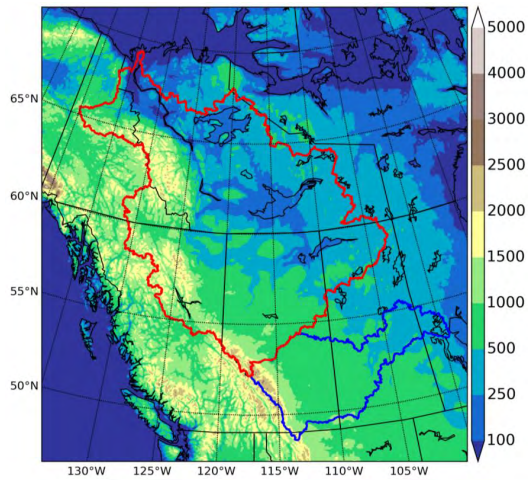
Temperature ($^{\circ}\text{C}$)

MRB

SRB

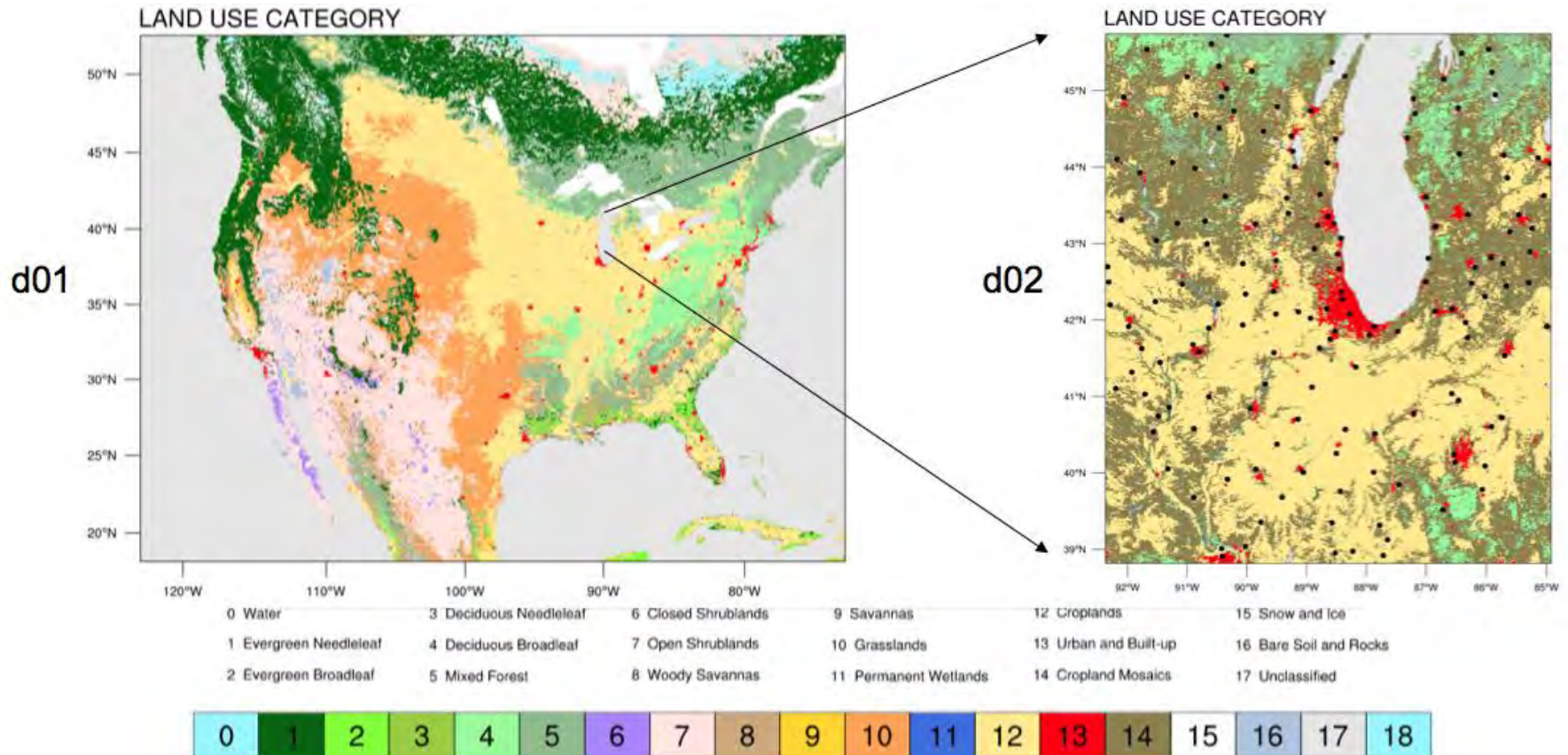
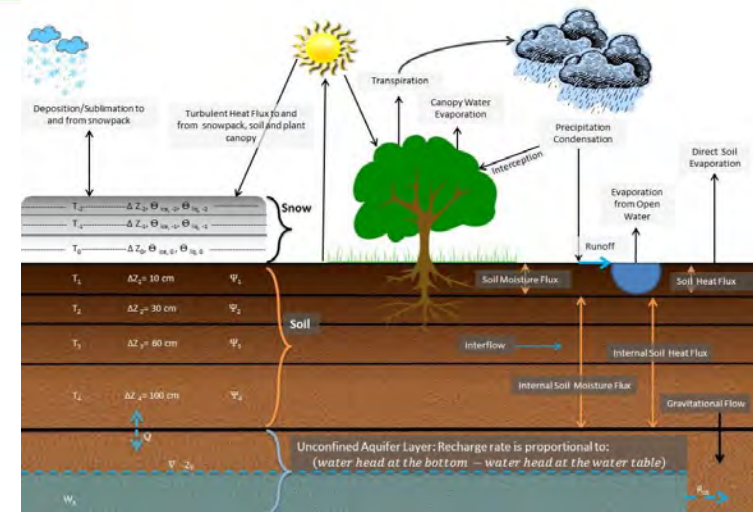


WRF Domain – CCRN + CONUS & Extended GWF



WRF NDOWN

- Sensitivity test for land-atmosphere interaction



Using 4-km WRF CONUS simulations to diagnose surface coupling strength

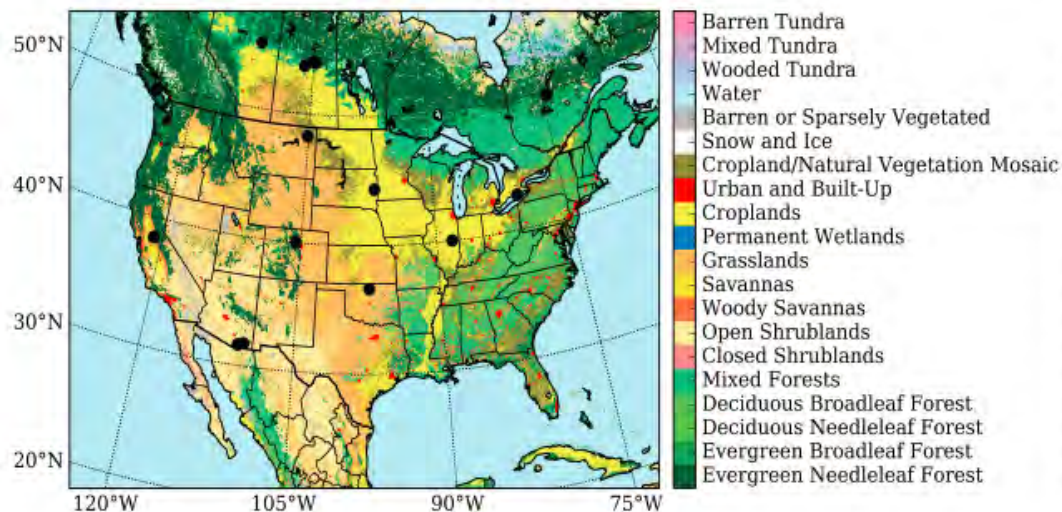
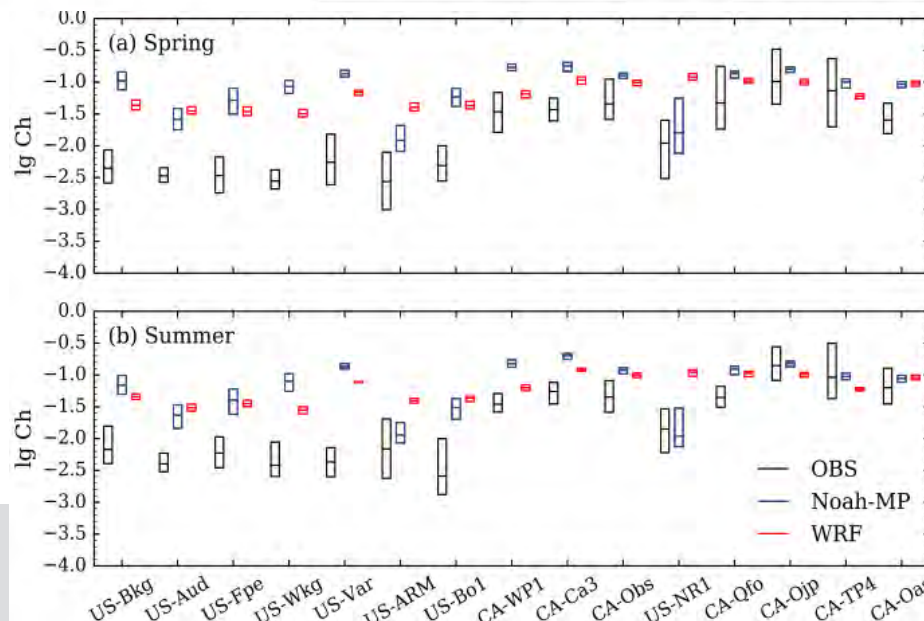


Table 1. General Information About 15 FLUXNET Sites Used in This Study

Site Location	Latitude, Longitude	Elevation(m)	Land-Cover Type	Canopy Height(m)	Years of Data Used
US-Bkg	44.35, -96.83	510	Croplands	0.2-0.4	2005-2007
US-Aud	31.59, -110.51	1469	Open Shrublands	0.1-0.2	2003-2007
US-Fpe	48.31, -105.10	634	Grasslands	0.2-0.4	2001-2007
US-Wkg	31.74, -109.94	1531	Grasslands	0.5	2005-2007
US-Var	38.41, -120.95	129	Woody Savannas	0.55+/-0.12	2001-2007
US-ARM	36.61, -97.49	311	Croplands	0-0.5	2003-2007
US-Bo1	40.01, -88.29	219	Croplands	3.0(mz)0.9(sb)	2001-2007
CA-WP1	54.95, -112.47	549	Permanent Wetlands	3.4	2004-2007
CA-Ca3	49.53, -124.90	153	Evergreen Needleleaf	7.6	2001-2007
CA-Obs	53.99, -105.12	598	Evergreen Needleleaf	9.4	2001-2007
US-NR1	40.03, -105.55	3050	Evergreen Needleleaf	11.5	2001-2007
CA-Qfo	49.69, -74.34	390	Evergreen Needleleaf	13.8	2004-2007
CA-Ojp	53.92, -104.69	518	Evergreen Needleleaf	16.7	2001-2007
CA-TP4	42.71, -80.36	219	Mixed Forest	20.3	2002-2007
CA-Oas	53.63, -106.20	580	Deciduous Broadleaf	21.5	2001-2007



Precipitation measurements across Canada-US border



Lucia Scaff
PhD Student

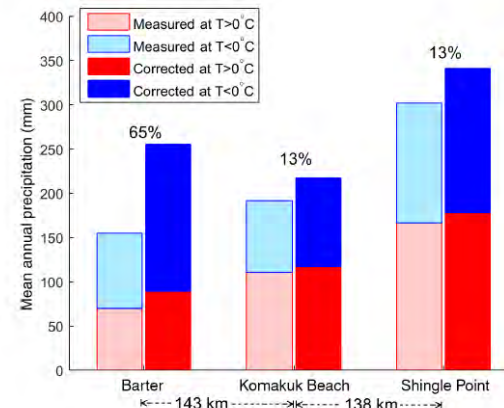
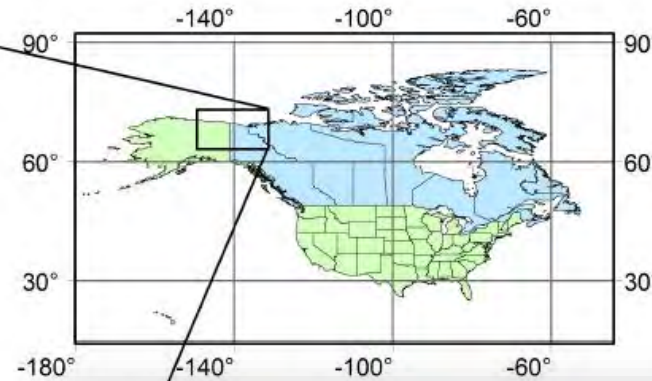
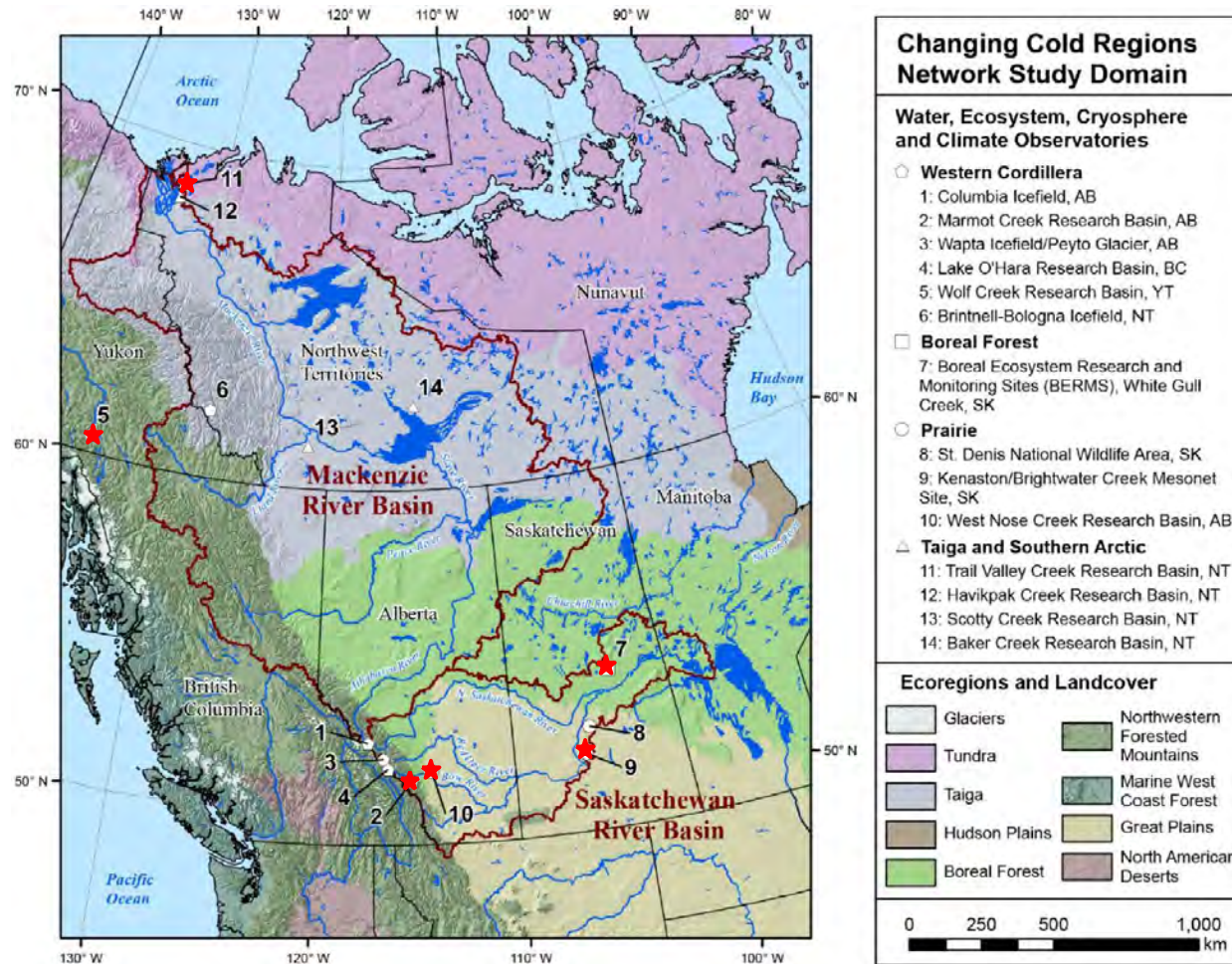


Figure 7. Mean annual (1978–1988) measured and corrected precipitation for cold ($T < 0^\circ\text{C}$) and warm ($T > 0^\circ\text{C}$) months. The percentages are the changes from measured to corrected precipitation. The approximate horizontal distance between the stations is displayed at the bottom.

Bias Corrections of Precipitation measurements across different ecoclimate regions



Xicai Pan
PDF



Xicai Pan, Daqing Yang, **Yanping Li***, Alan Barr, Warren Helgason, Masaki Hayashi, Philip Marsh, John Pomeroy, Richard Janowicz, 2016: Bias Corrections of Precipitation Measurements across Experimental Sites in Different Ecoclimatic Regions of Western Canada, *The Cryosphere*, 10, 2347-2360