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Continental Scale Convection-permitting WRF regional climate simulation over western Canada

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Available RCM output for CCRN region

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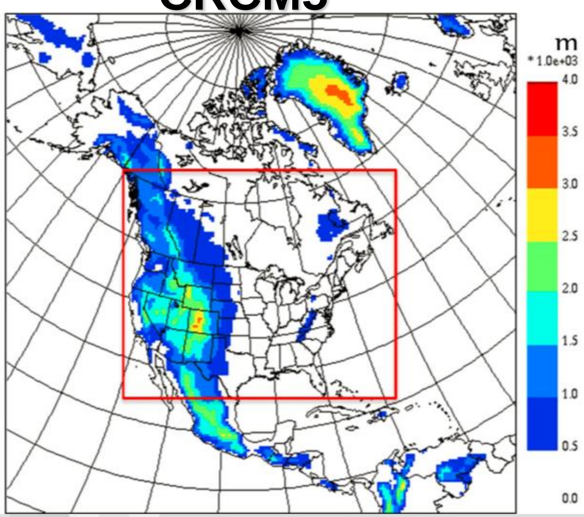
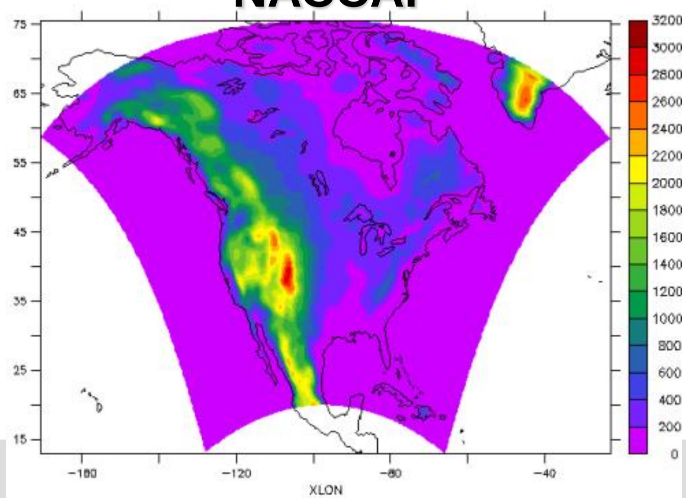
	CRCM5	CanRCM4	NACCAP	CCRN-WRF
Spatial Resolution	**50 km**	NAM-22 (**25 km**) NAM-44 (50 km)	**50 km**	**4 km**
Vertical levels	29	4	26	51
Temporal resolution	**daily**	NAM-22(**daily**) NAM-44(daily, hourly for Pr)	**3-hourly**	**hourly**
Downscale from	CanESM2	CCCma-CanESM2	11 members	CMIP5 models 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)

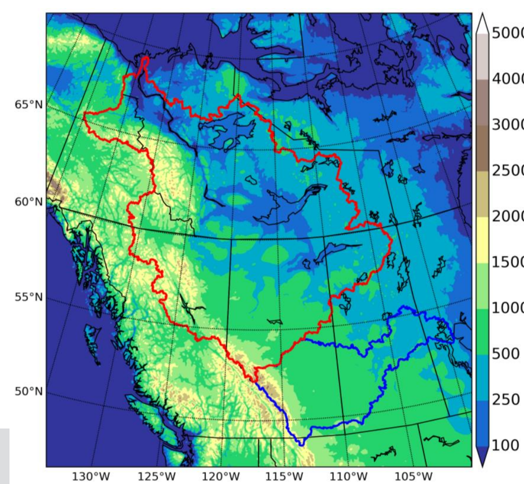
CRCM5



NACCAP



CCRN-WRF



Continental Scale Regional Climate Simulation using 4-KM WRF

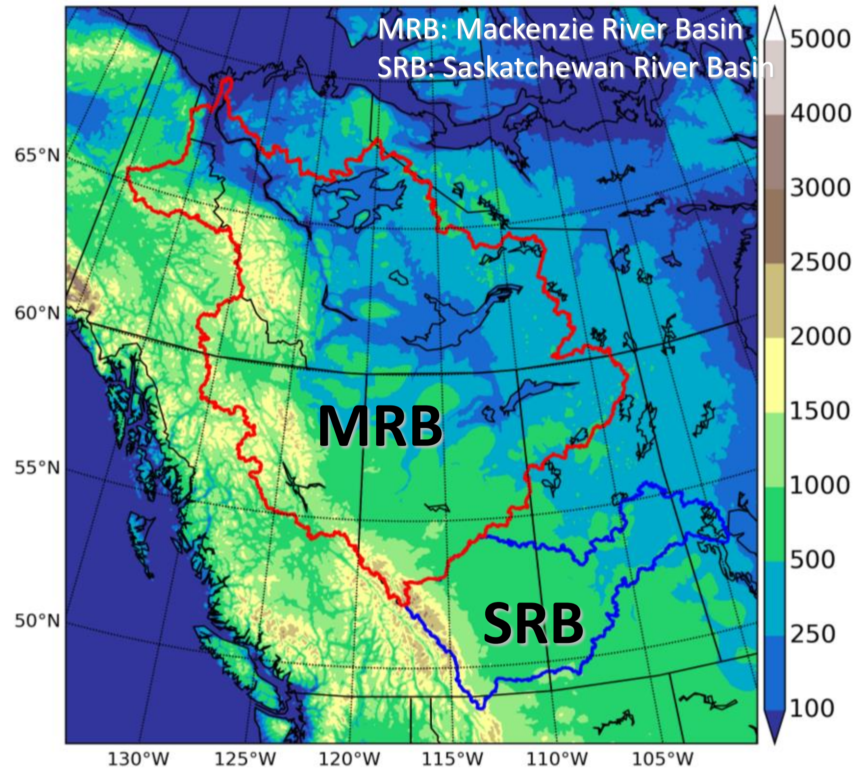
WRF Model Setup and Design

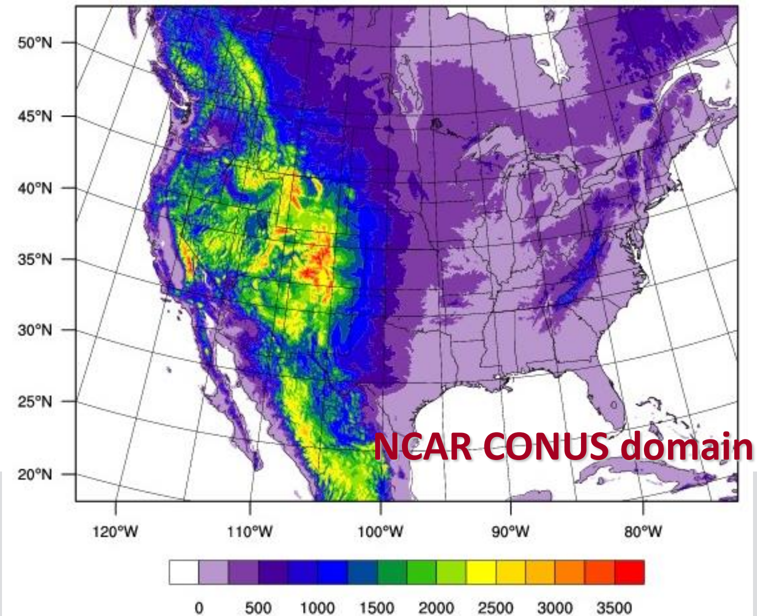
- WRF Model (Version 3.4.1)
- A single domain: 2560 x 2800 km^2

  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, 0.703^0 x 0.703^0 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

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

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

PSEUDO GLOBAL WARMING
ERA-I + ΔCIMP5

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

DYNAMICAL DOWNSCALING HINDCAST

DYNAMICAL DOWNSCALING FUTURE PGW

WRF dynamical downscaling for 2000-2013

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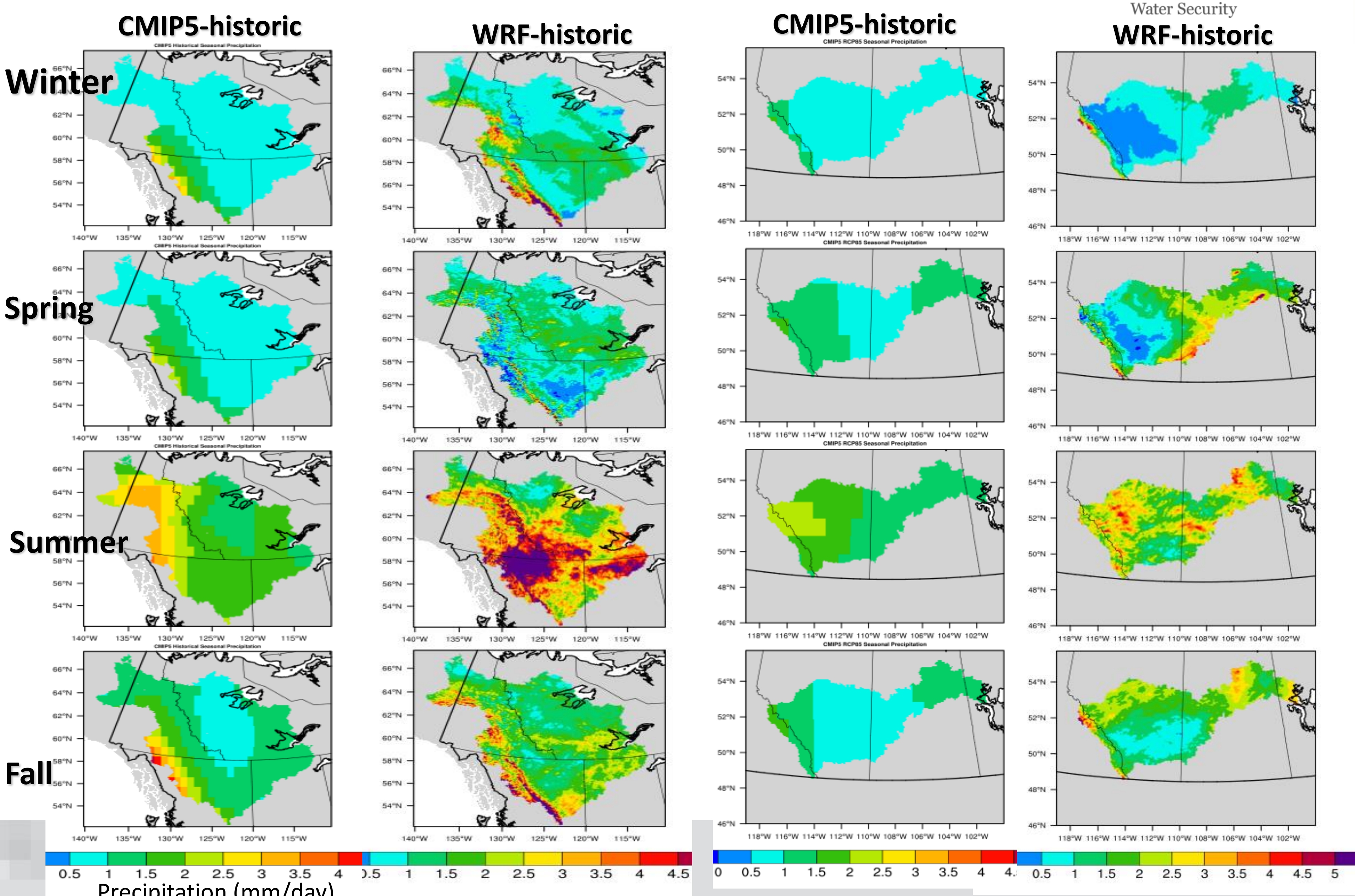

WRF dynamical downscaling of CMIP5

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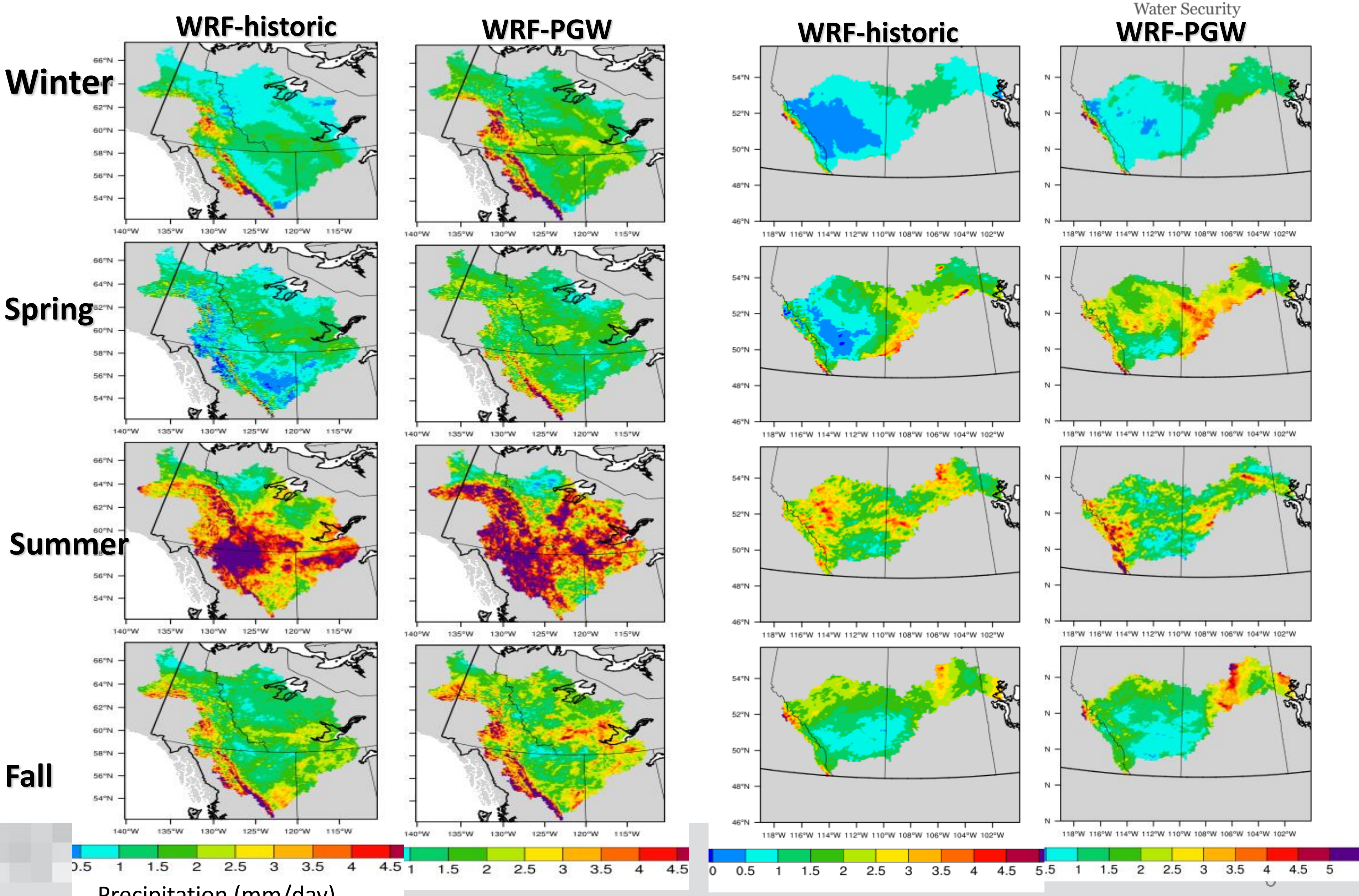

Annual precipitation/Temperature

CMIP5 vs WRF

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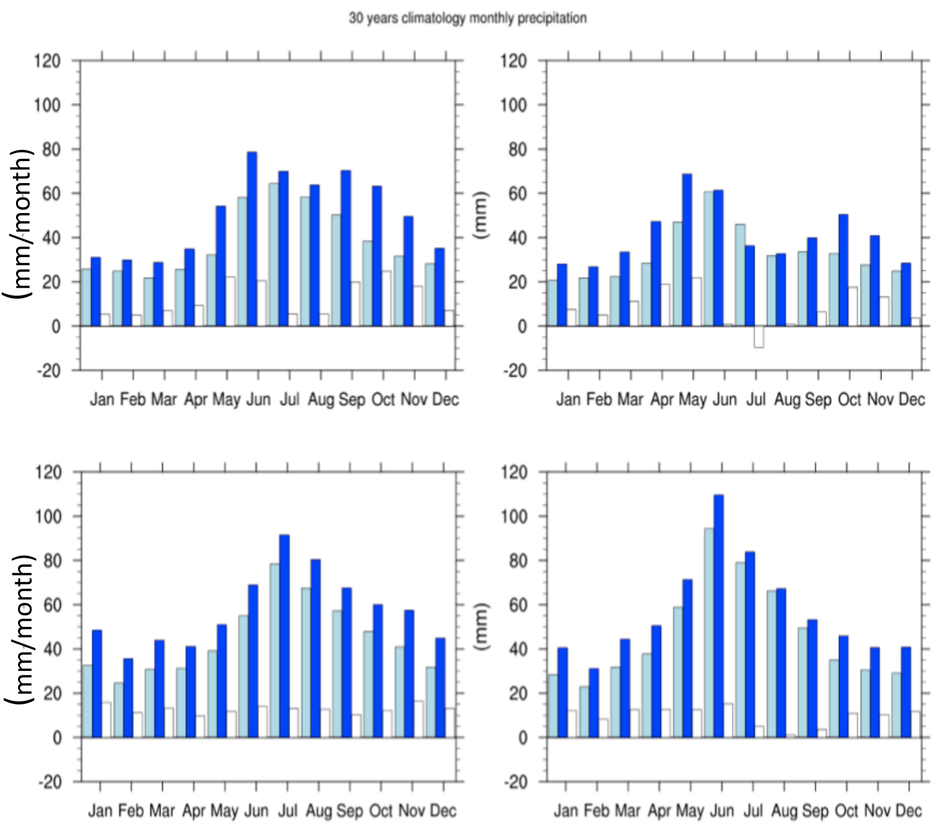
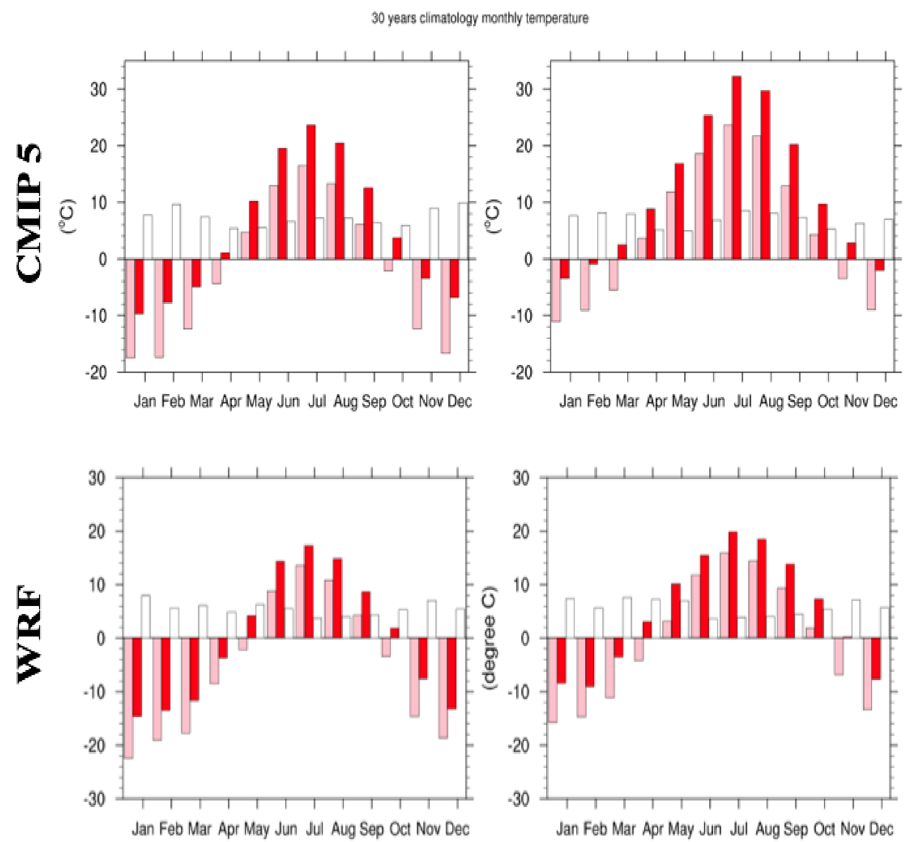
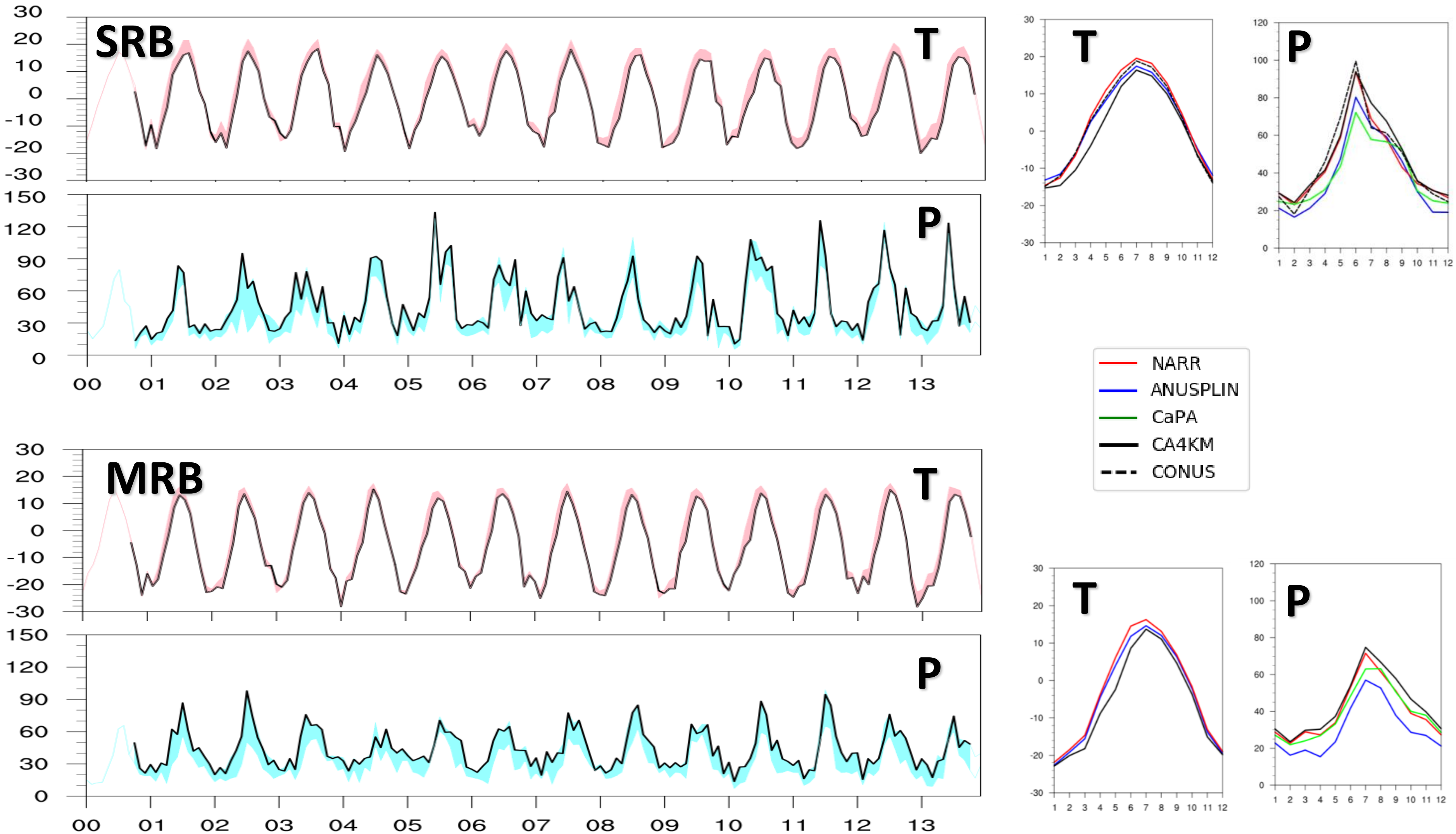
MRB SRB



MRB SRB

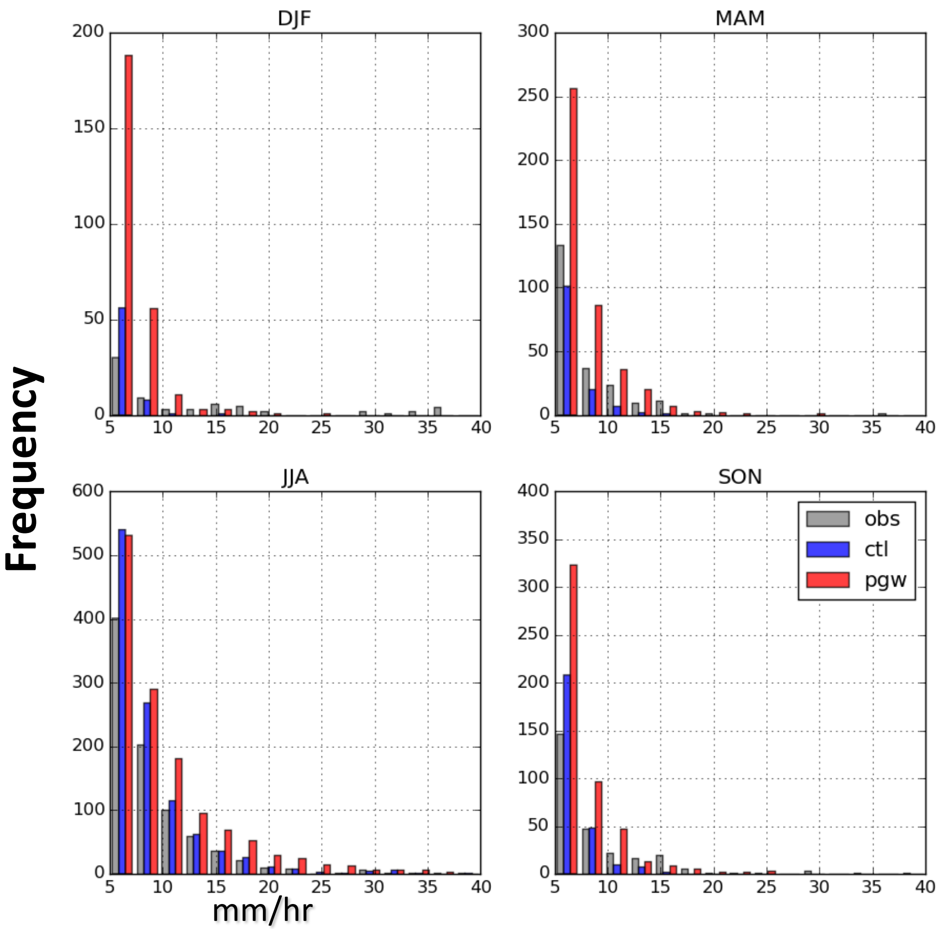


CCRN-WRF Performance Evaluation (Annual cycle)

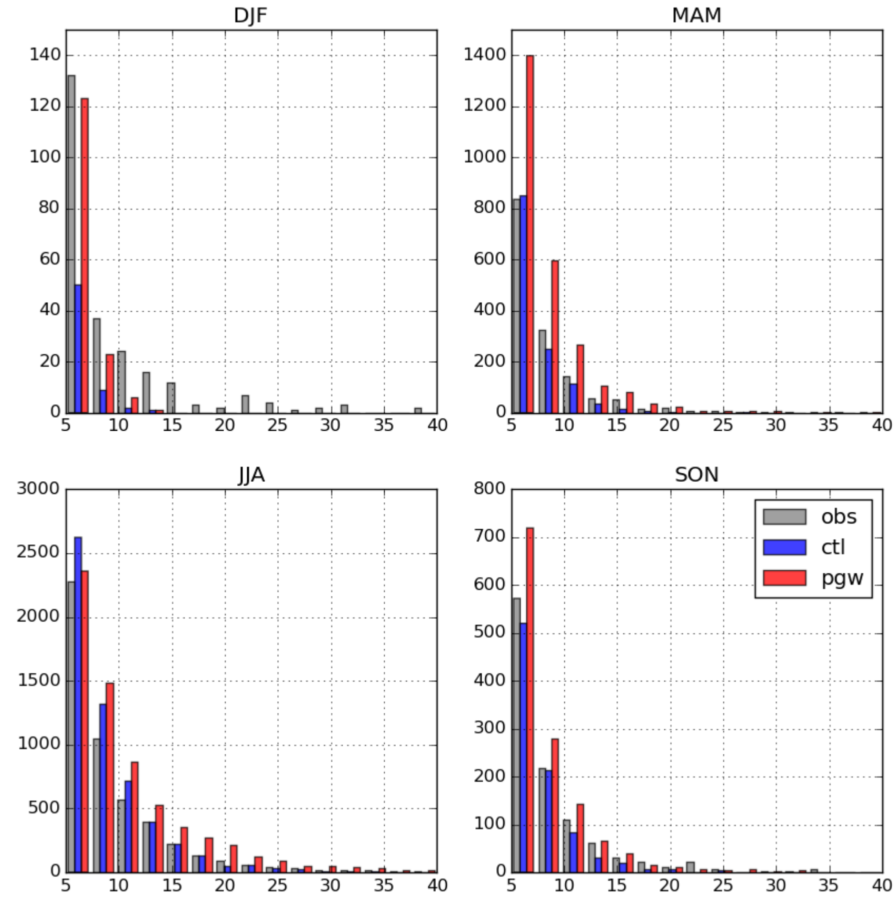


CA4KM-WRF Performance Evaluation -PDF for hourly precipitation intensity

MRB



SRB



Present and future probability of meteorological and hydrological hazards (over CCRN domain)

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Objective: to provide a consistent examination of present and future atmospheric-related hazards across the CCRN domain

Datasets: ECCC StationObs, ANUSPLIN, CaPA, NCEP, NARCCAP, CMIP5 scenarios, CRCM5, CanRCM4, WRF 4-km…

Collaborators: Univ of Manitoba: Ron Stewart, John Hanesiak

Univ of Quebec at Montreal: Julie Theriault

ECCC: Kit Szeto, Barrie Bonsal, Xuebin Zhang, Bob Kochtubajda, Julian Brimelow

Pacific Climate Impacts Consortium, University of Victoria : Francis Zwiers

Extremes to be analyzed:

- Meteorology floods
- Drought
- Sub-daily precipitation extremes
- Large hail
- Convective vs Stratiform rainstorms
- Winter phenomena
  - Heavy snowfall
  - Blizzards (snow storms)
  - Freezing rain (0^{o}C)
- Windstorms
- Tornadoes
- Lightning (thunderstorms)
- Wildfires

CONUS-II simulations for Global Water Future

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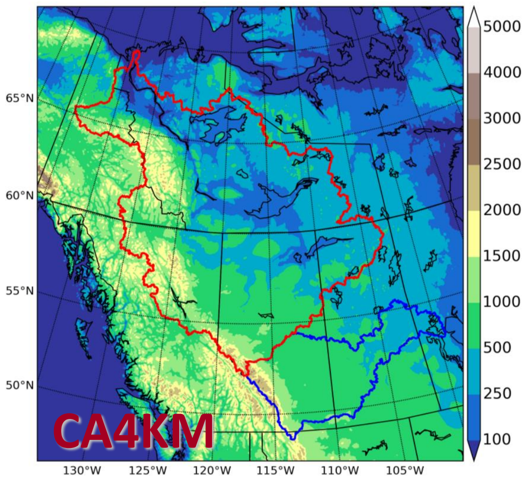
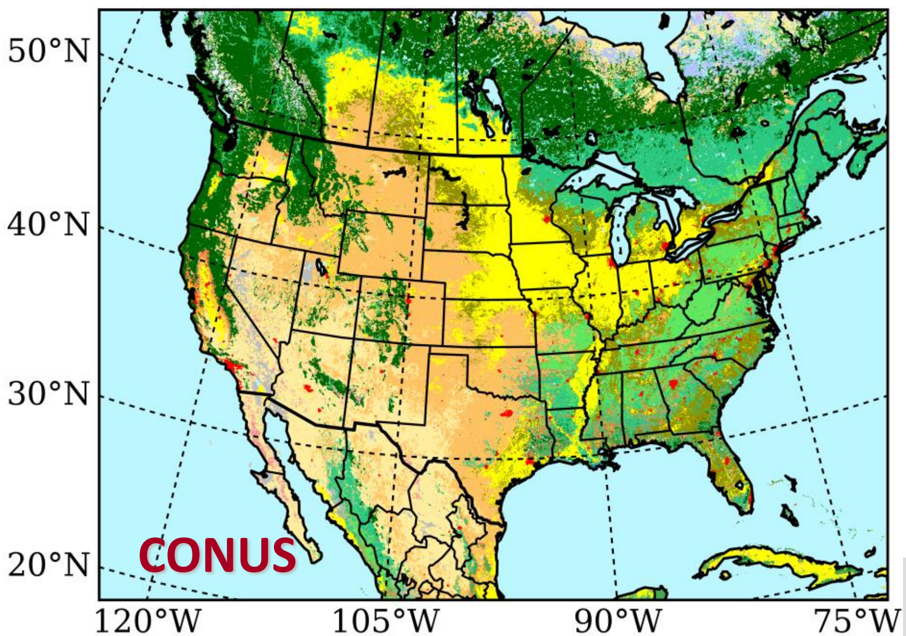
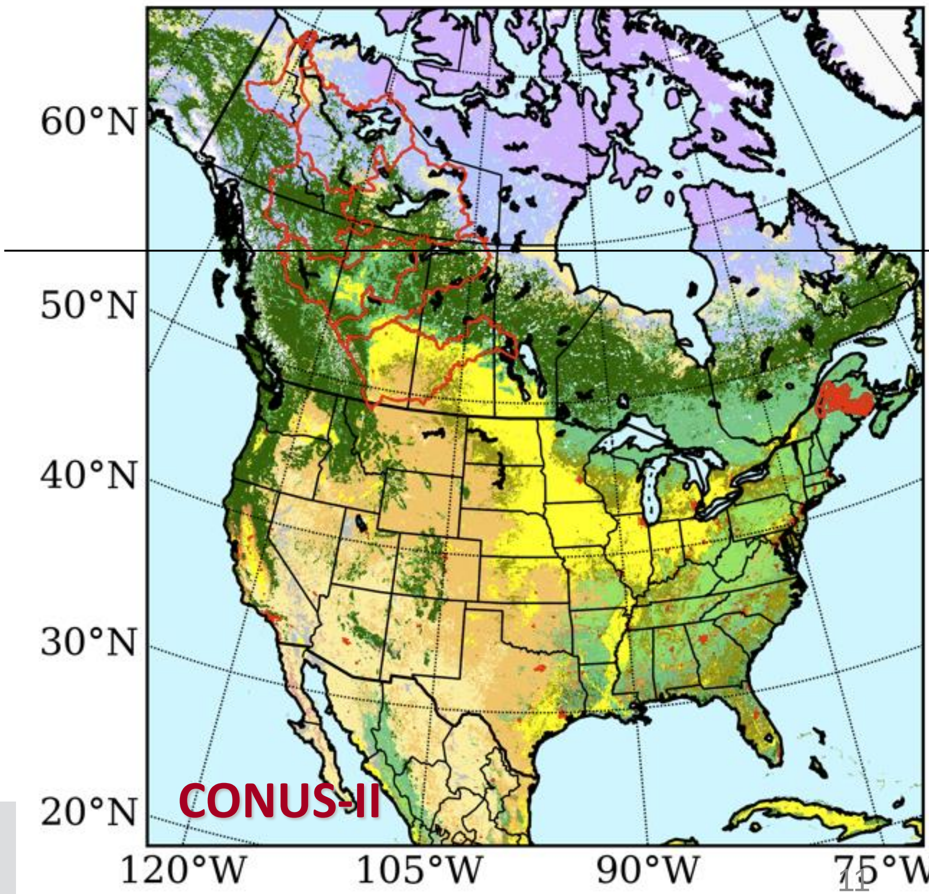
Collaborating with Hydrometeorology group at National Center for Atmospheric Research (NCAR)



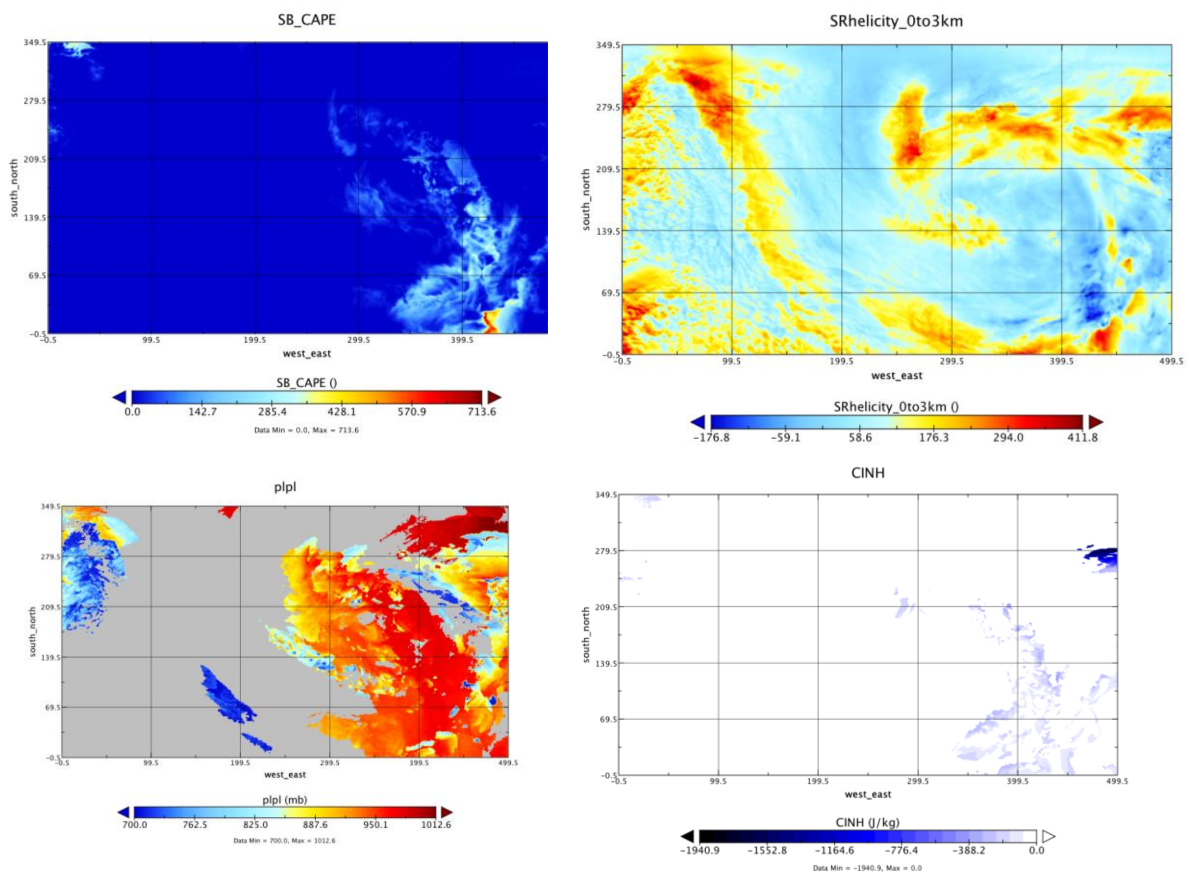
WRF Domain –

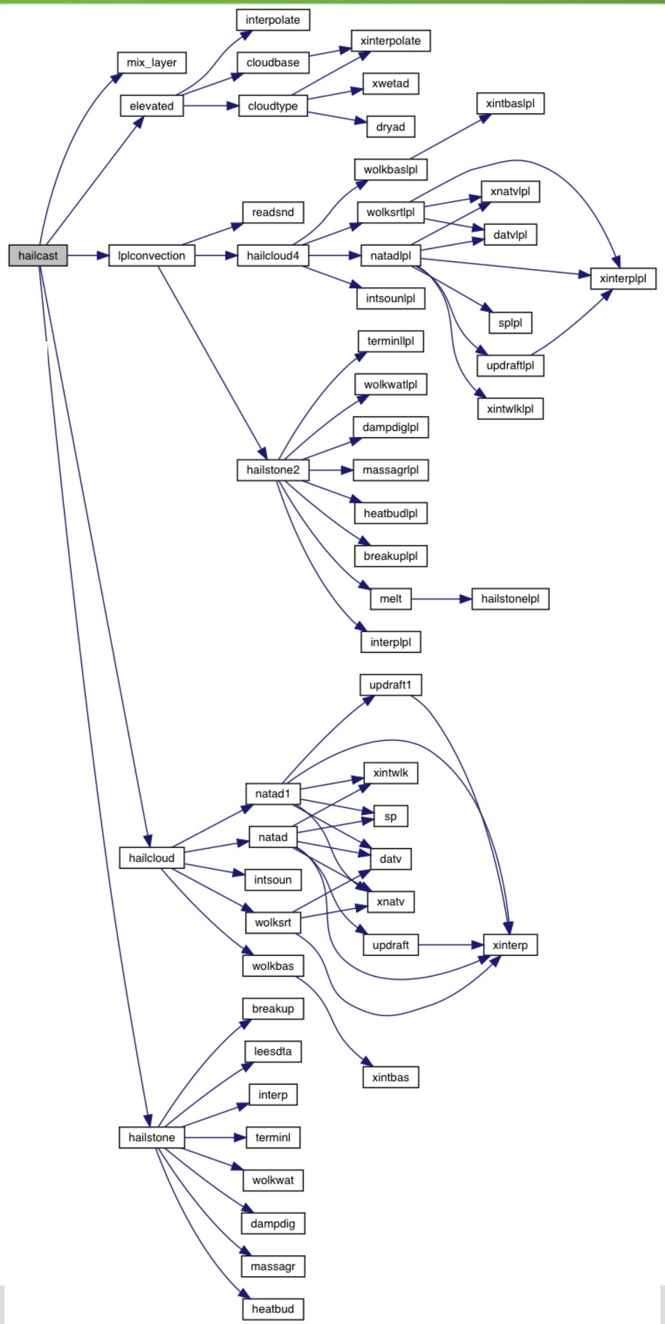
CA4KM + CONUS & Extended GWF





Future projection of Hail and severe weather parameter





Working together with John Hanesiak's Group at U of Manitoba,
using 1-d cloud model to process WRF 3d output to generate hail and severe weather related parameters

WRF output to derive different precipitation species

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We adapted the code compare2meter[Thompson et al. 2017] to extract WRF 2d precipitation data according to METAR station location (over 1400+ in Canada), a small patch of near-surface (as in METAR comparison) or full vertical columns (as in PIREP comparison), then **derive icing accretion or cloud ceiling and visibility** for direct comparisons to the observation.

The purpose is to use WRF simulated precipitation to derive **different precipitation species,** such as **rain, snow, hail, freezing rain, fog,** etc. And compare the results against surface METAR station observation.

Reference: *Thompson, G., M. K. Politovich, and R. M. Rasmussen, 2017: A numerical weather model's ability to predict characteristics of aircraft icing environments. Weather and Forecasting,* ***32****, 207-221, doi:10.1175/WAF-D-16-0125.1*

Bias Correction for WRF output

PRECIPITATION (PR) – SV

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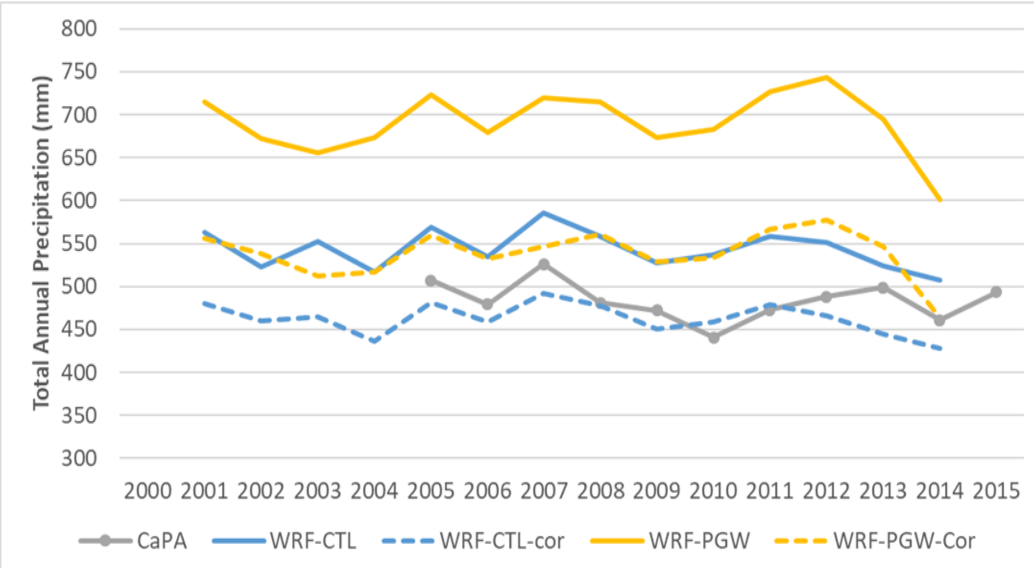
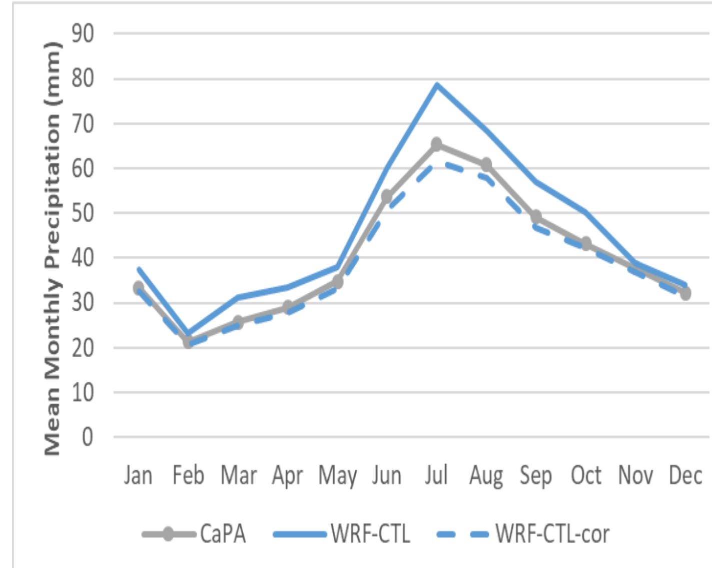
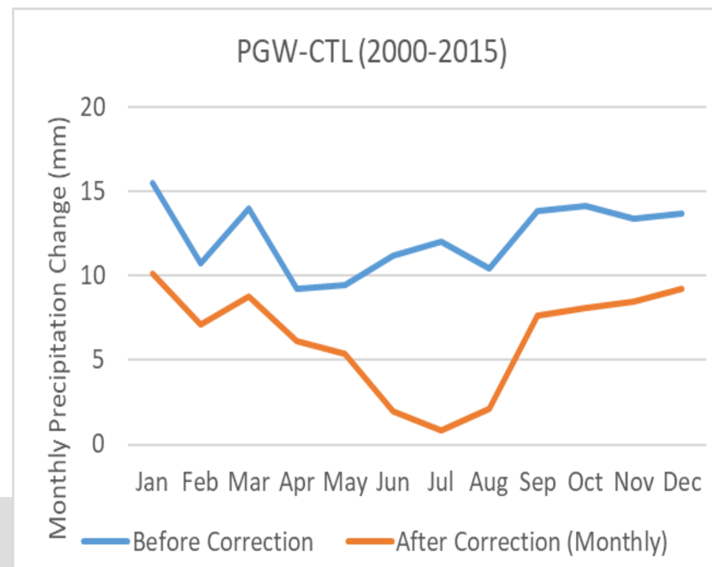




- The annual series show that the bias is corrected (WRF-CTL-Cor matches CaPA) and inter-annual variability is preserved for WRF-CTL and WRF-PGW
- Average Annual 2004-2015
  - CaPA: 486 mm
  - WRF-CTL (Before, After Correction): 550, 467 mm
  - WRF-PGW (Before, After Correction: 702, 546 mm
- The monthly distributions show that bias was corrected giving close seasonal distribution to CaPA over the correction period except for summer months
- The climate change signal is not preserved (PGW – CTL) after correction
- Seems we are extrapolating too much in summer beyond the fitting range (note that WRF summer rainfall is higher then CaPA to because it captures convection better)



Bias Correction for WRF output

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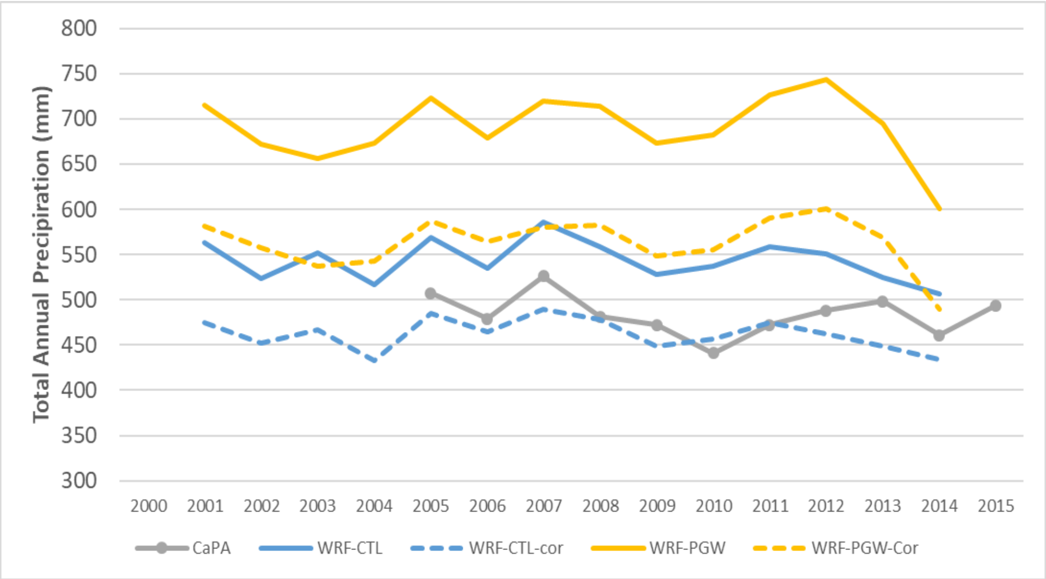
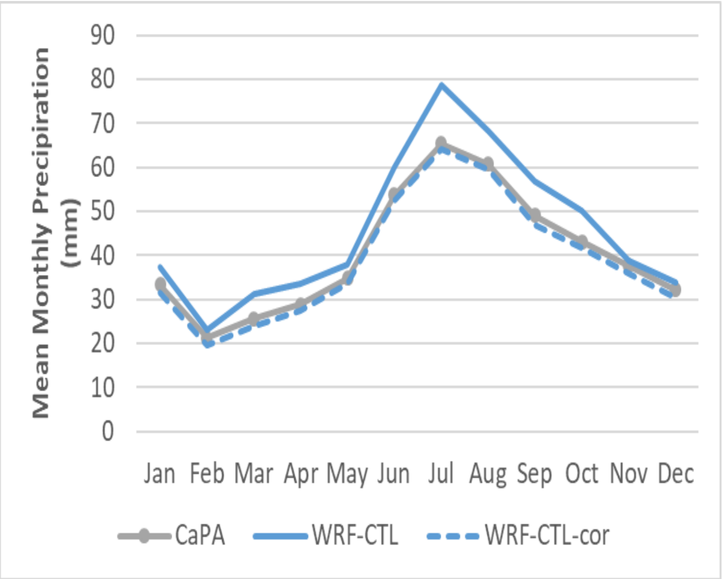
PRECIPITATION (PR) – MV





- The annual series show that the bias is corrected (WRF-CTL-Cor matches CaPA) and inter-annual variability is preserved for WRF-CTL and WRF-PGW
- Average Annual 2004-2015
  - CaPA: 486 mm
  - WRF-CTL (Before, After Correction): 550, 467 mm
  - WRF-PGW (Before, After Correction: 702, 571 mm
- The monthly distributions show that bias was corrected giving close seasonal distribution to CaPA over the correction period except for summer months
- The climate change signal is not preserved (PGW – CTL) after correction but better than the SV case except for summer months … may be patterns are shifting in space