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

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The Changing Cold Regions Network (CCRN)

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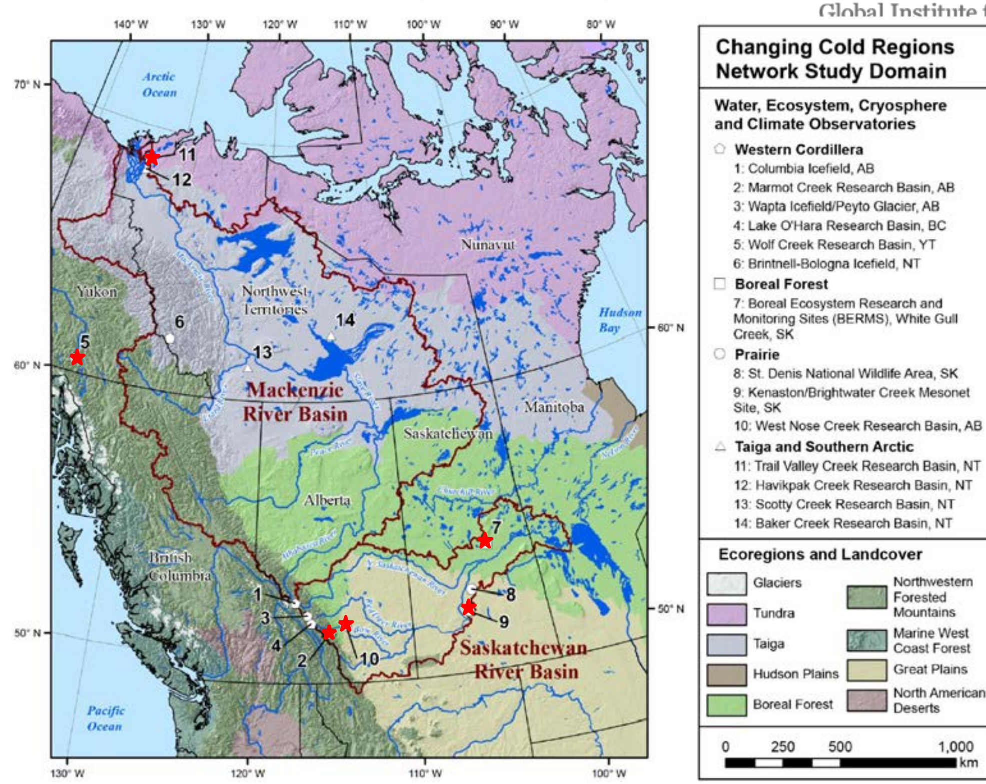
CCRN: to integrate existing and new sources of data with improved predictive modeling and observational tools to understand, diagnose and predict interactions amongst the cryospheric, ecological, hydrological, and climatic components of the changing Earth system at multiple scales, with a geographic focus on Western Canada's rapidly changing cold interior.



My completed projects:

- June 2013 Alberta Flooding (Li et al. 2017; Liu et al, 2017; Kochtubajda et al. 2017)
- MJO-ENSO and Prairies Growing Season Drought in 2015(Li et al, 2018)
- Precipitation measurement calibration (Scaff et al, 2016; Pan et al. 2017)
- Diurnal cycle of summer precipitation east of the Rocky Mountain (Scaff et al., 2018)
- The remote moisture sources for precipitation over Saskatchewan River Basin
- Land-atmosphere interaction at Boreal forest site using Noah-MP LSM (Chen et al. 2016)
- **Continental Scale Regional Climate Simulation using 4-KM WRF**

Available RCM output for CCRN region

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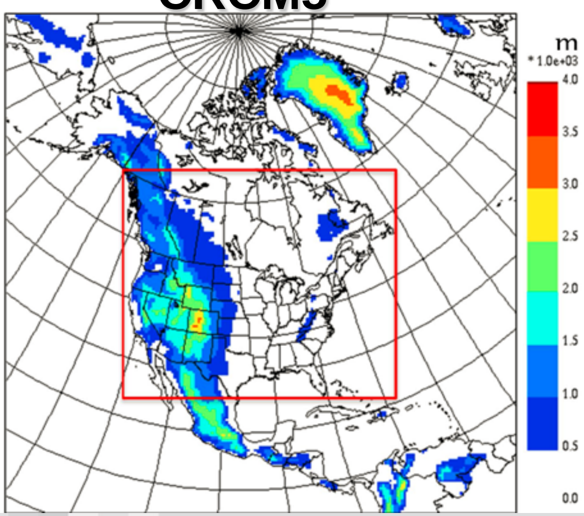
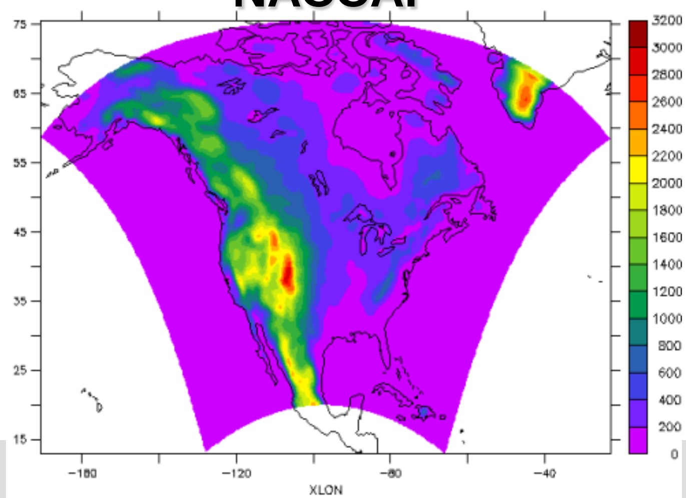
	CRCM5	CanRCM4	NACCAP	CCRN-WRF
Spatial Resolution	**50 km**	NAM-22 (**25 km**) NAM-44 (50 km)	**50 km**	**4 km**
Vertical levels	29	4	26	51
Temporal resolution	**daily**	NAM-22(**daily**) NAM-44(daily, hourly for Pr)	**3-hourly**	**hourly**
Downscale from	CanESM2	CCCma-CanESM2	11 members	CMIP5 models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

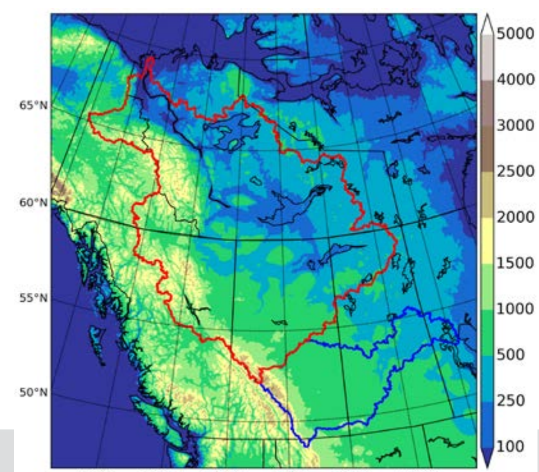
CRCM5



NACCAP



CCRN-WRF



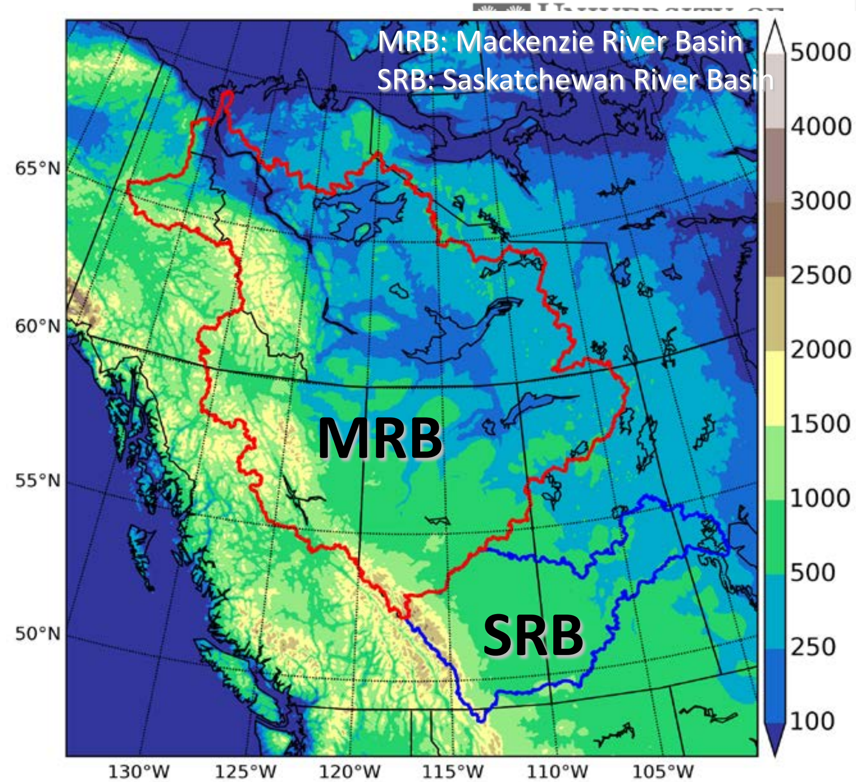
Continental Scale Regional Climate Simulation using 4-KM WRF

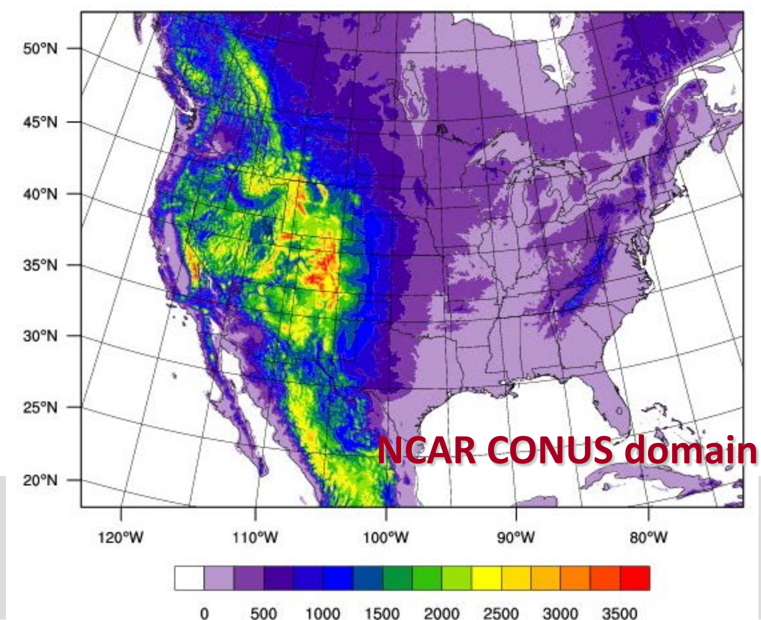
WRF Model Setup and Design

- 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, $0.703^0 \times 0.703^0$ 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	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

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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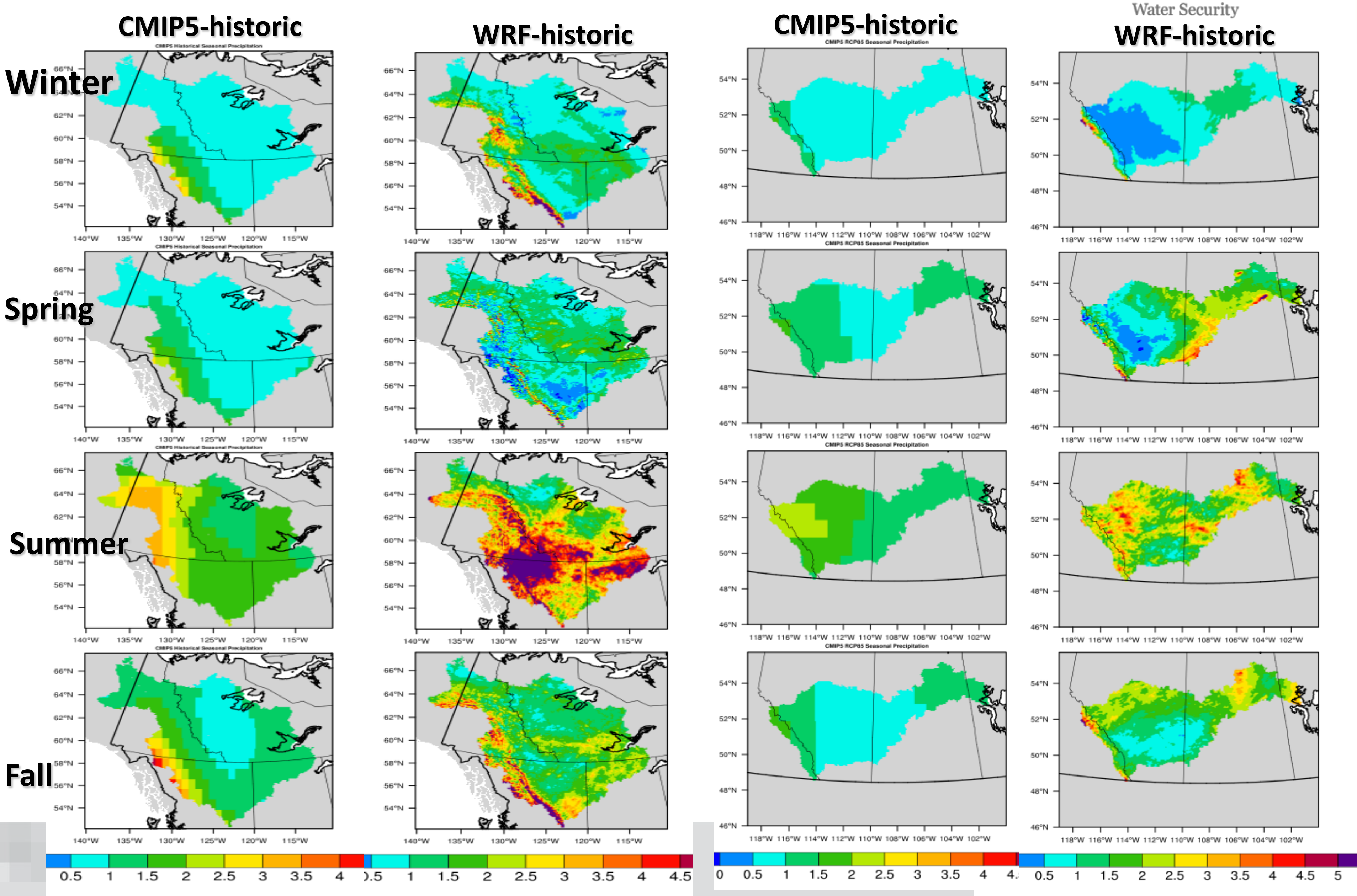

WRF dynamical downscaling of CMIP5

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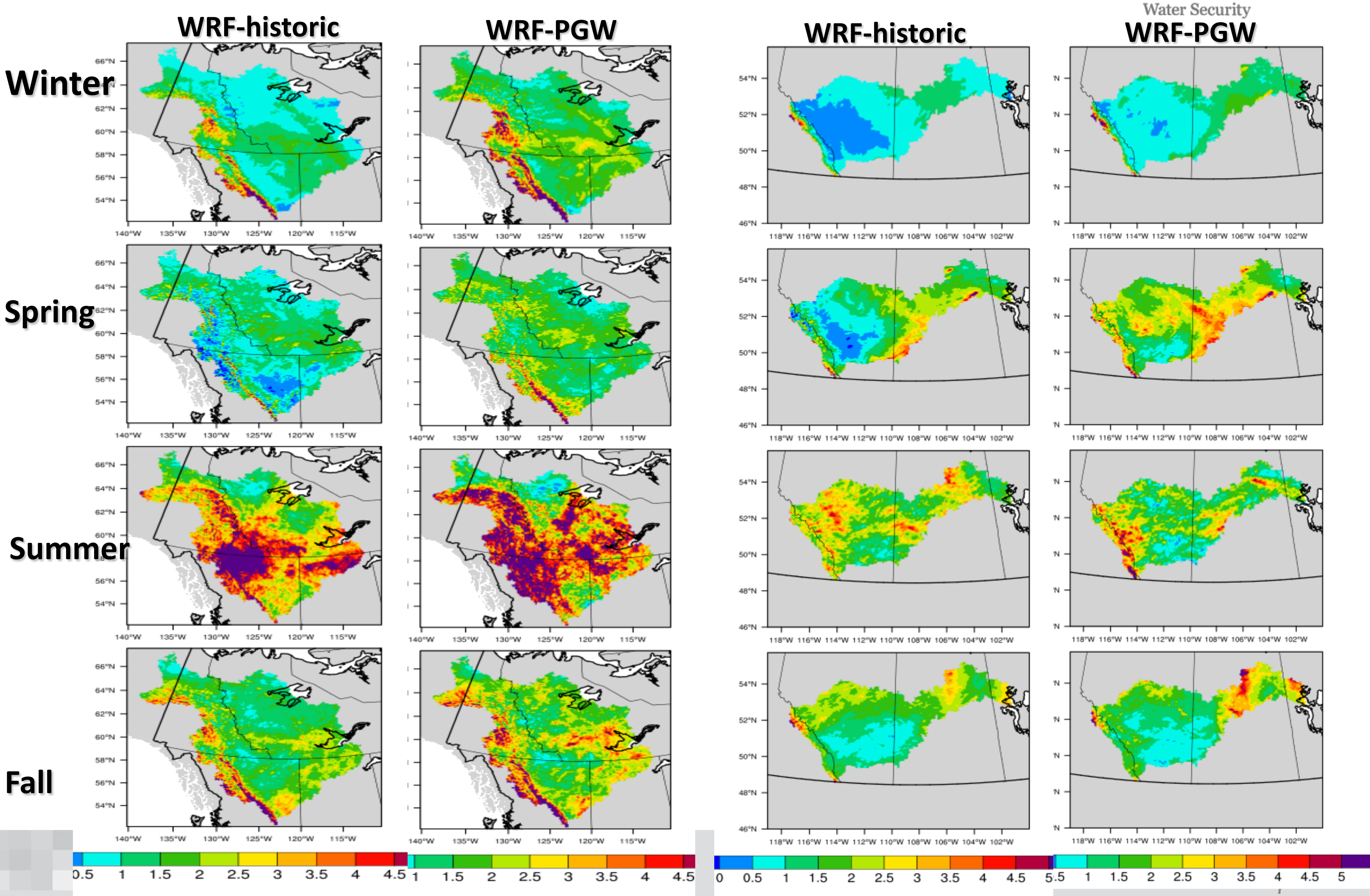

Annual precipitation/Temperature

CMIP5 vs WRF

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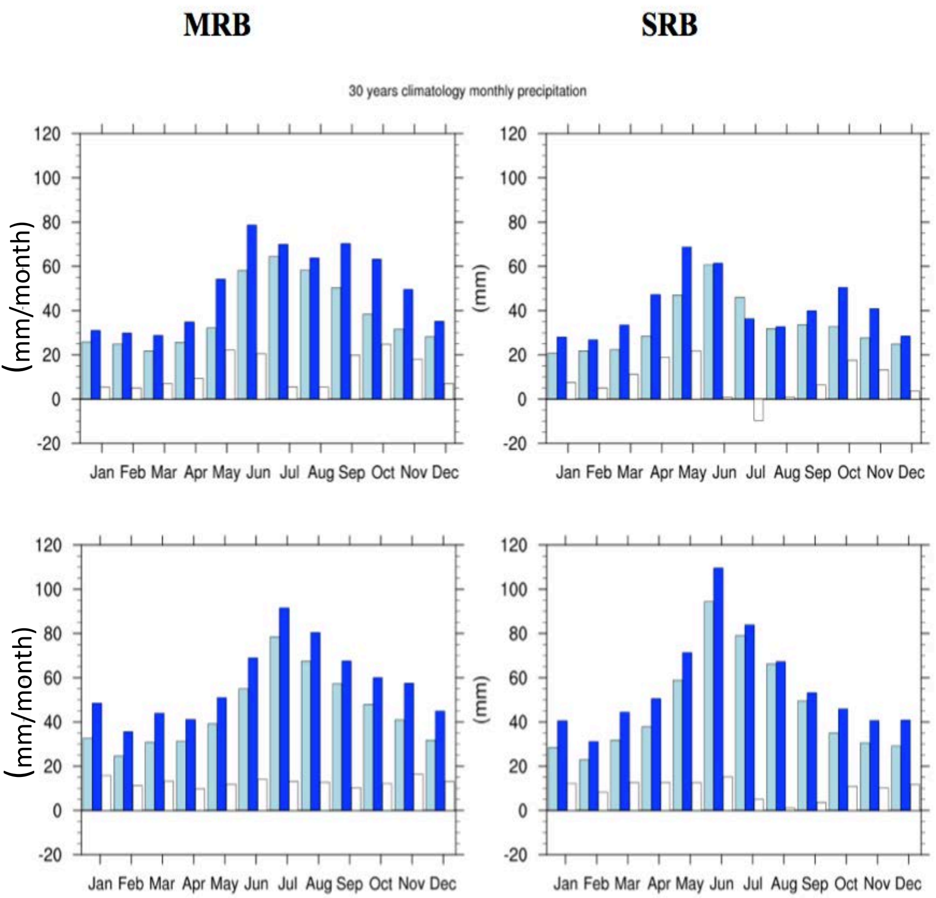
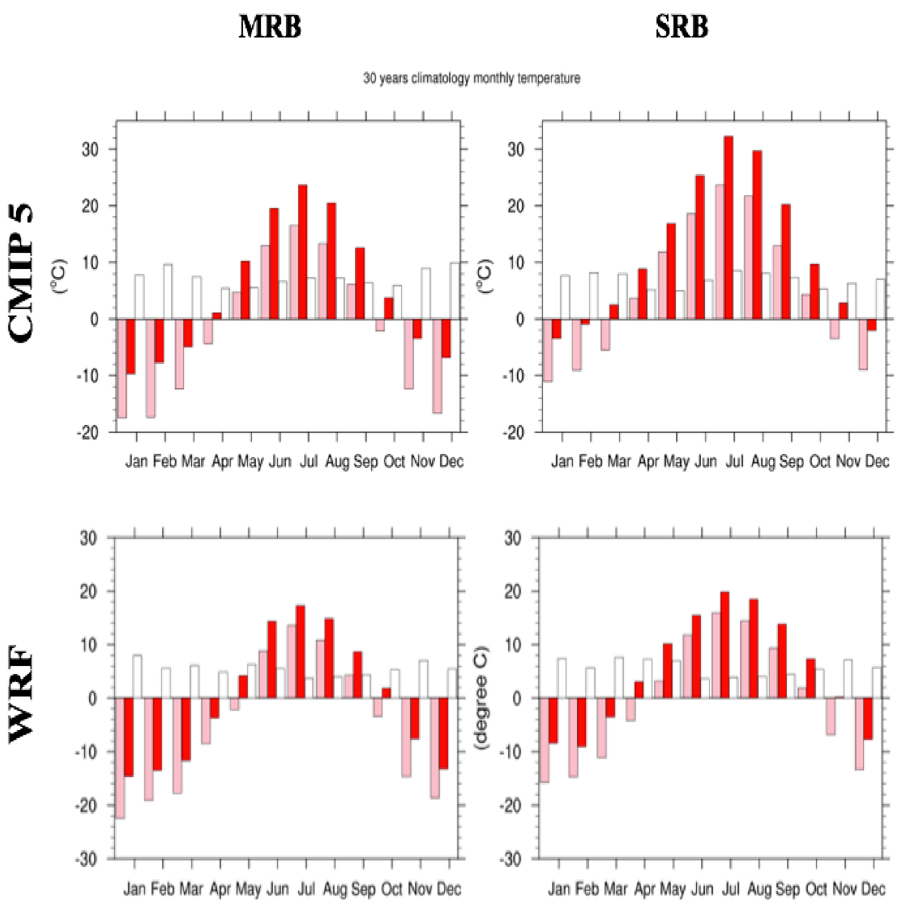
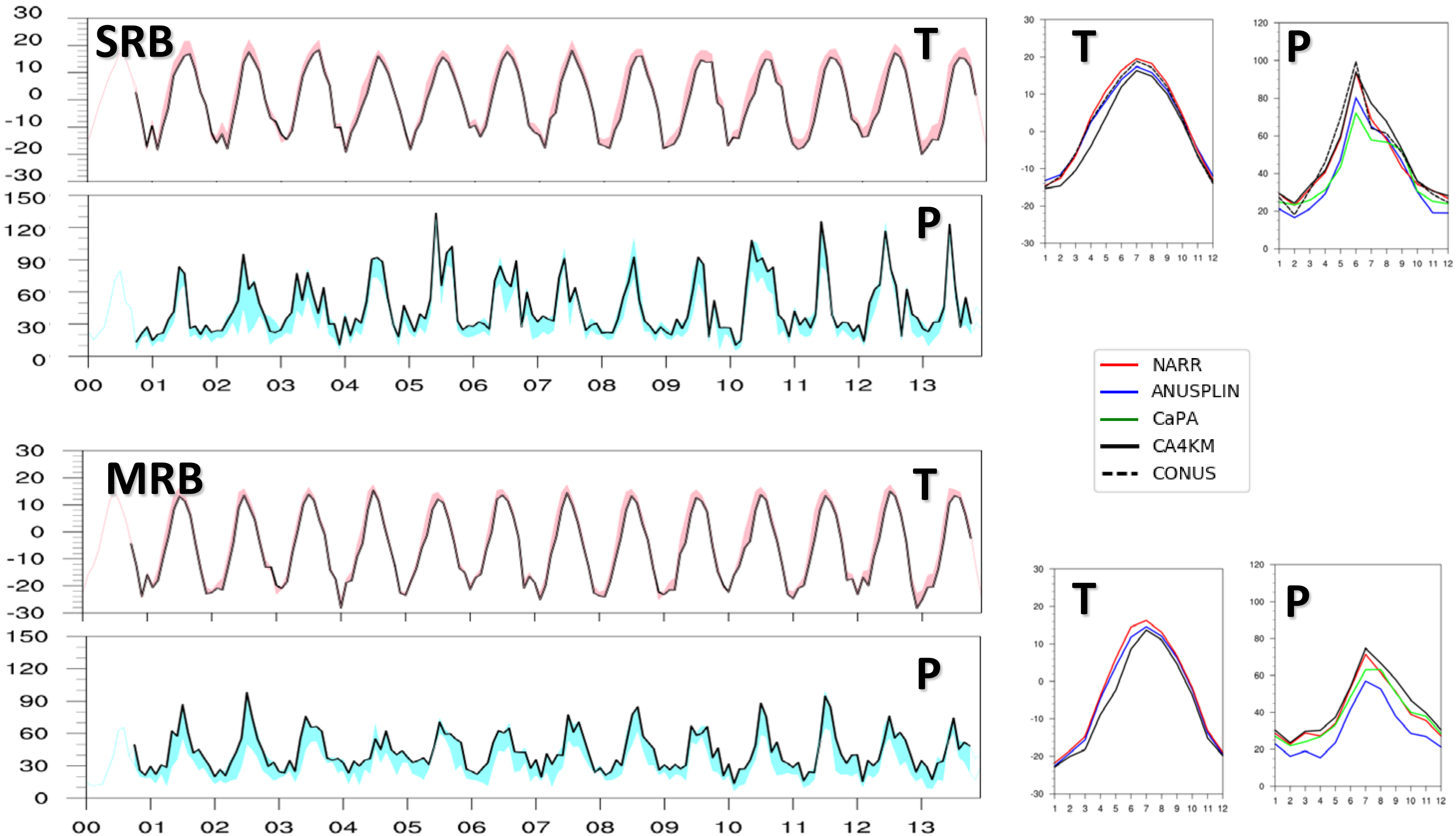




CCRN-WRF Performance Evaluation (Annual cycle)



Extreme Temperature change

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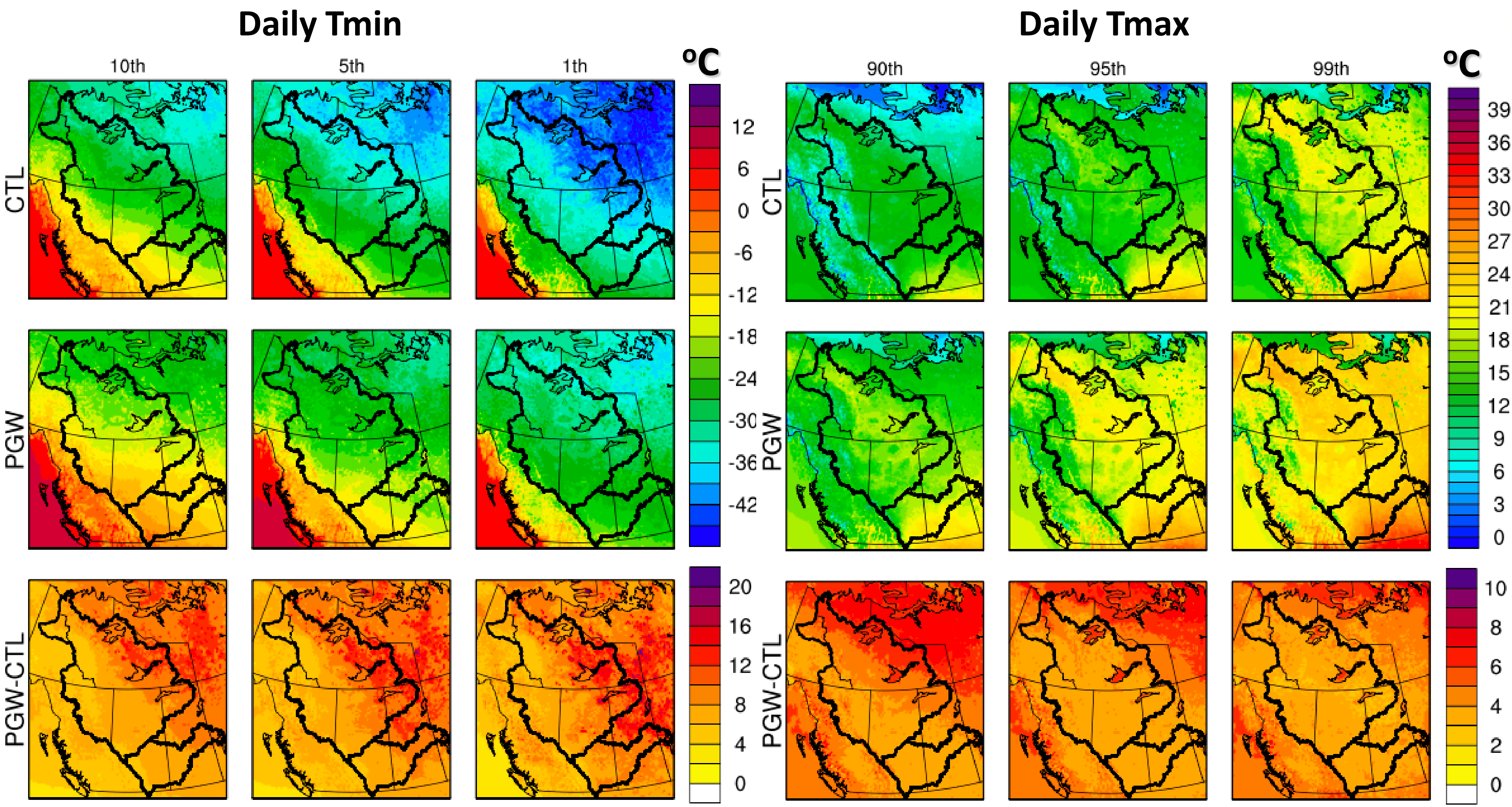

Extreme Daily Precipitation change

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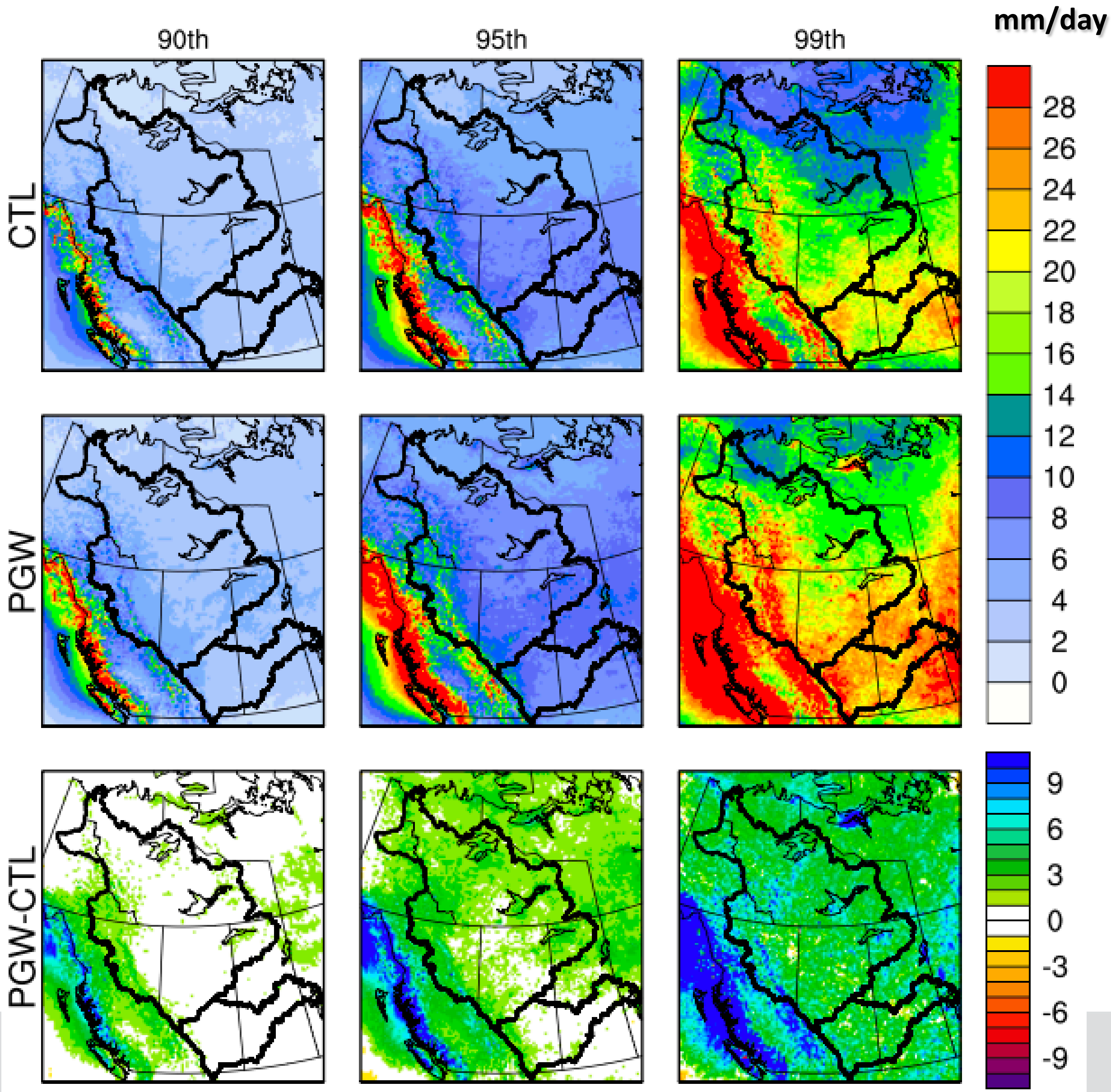
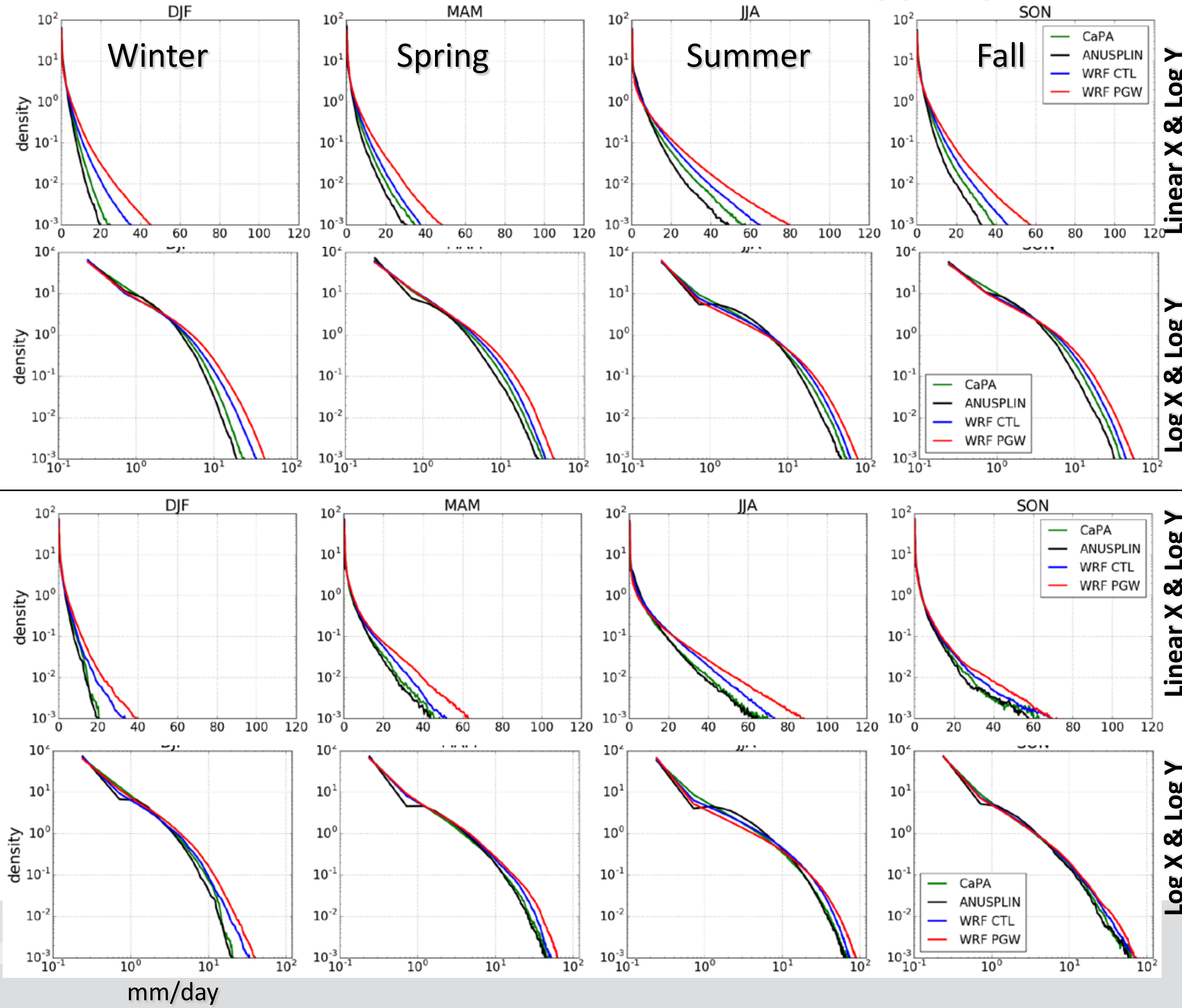


CA4KM-WRF Performance Evaluation -PDF for daily precipitation intensity

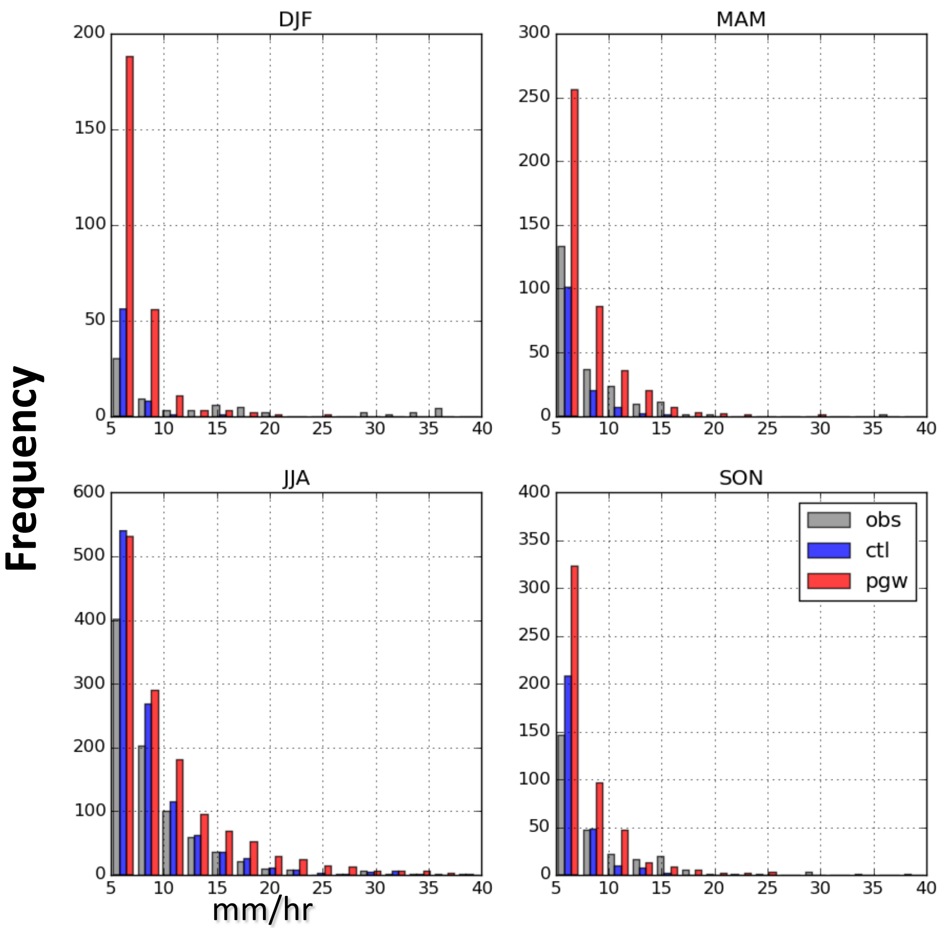
MRB

SRB

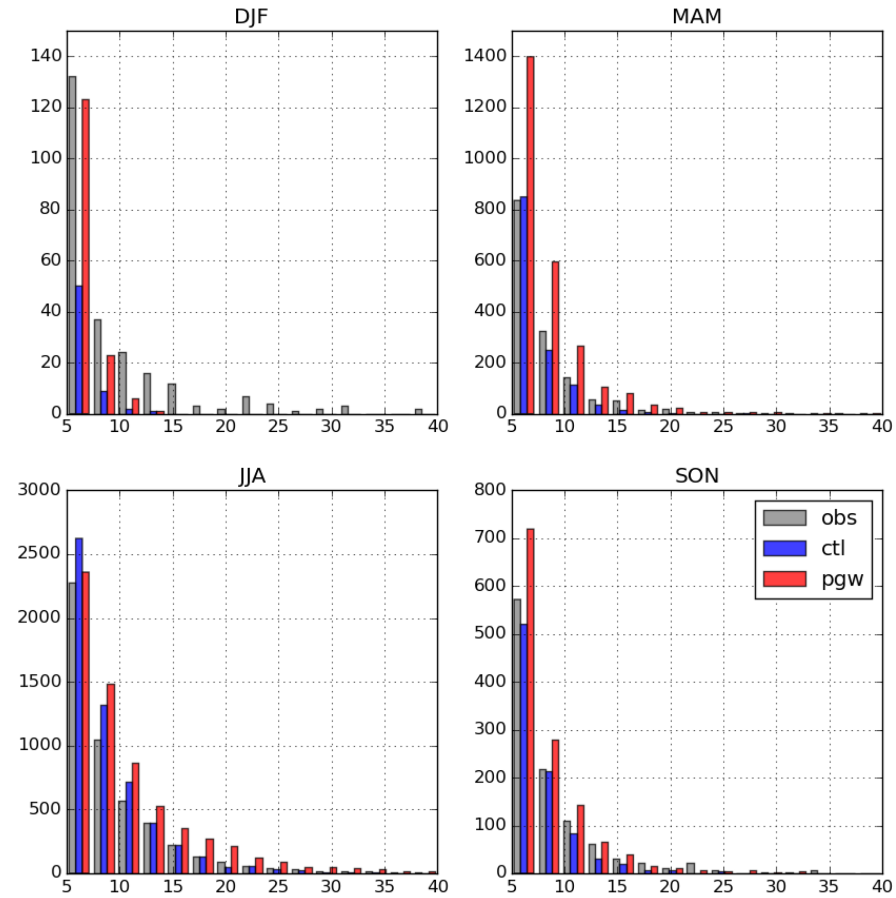


CA4KM-WRF Performance Evaluation -PDF for hourly precipitation intensity

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

WRF data output for Observation (Metar, PIREP) comparison

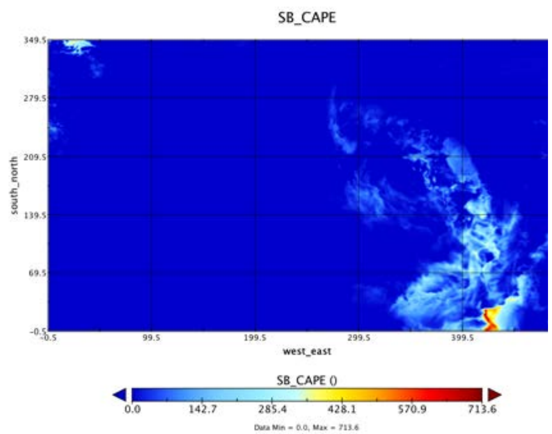
1. We adapted the code compare2meter[Thompson et al. 2017] to extract WRF 2d precipitation data according to METAR station location (over 1400+ in Canada), a small patch of near-surface (as in METAR comparison) or full vertical columns (as in PIREP comparison) then derive icing accretion or cloud ceiling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

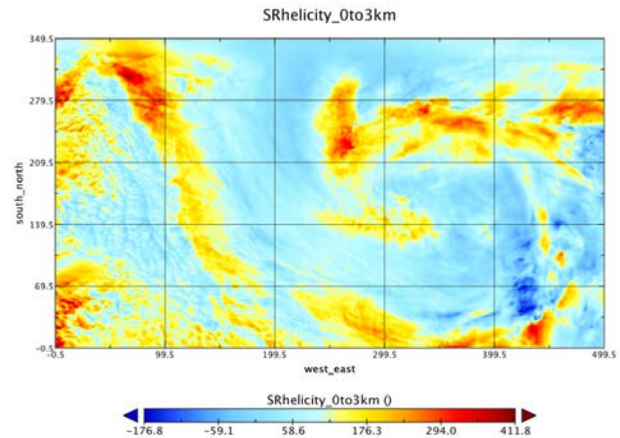
2. The purpose is to extract WRF simulated precipitation, derived them into different species, rain, snow, hail, freezing rain, fog, etc. And compare the results against surface METAR station observation.

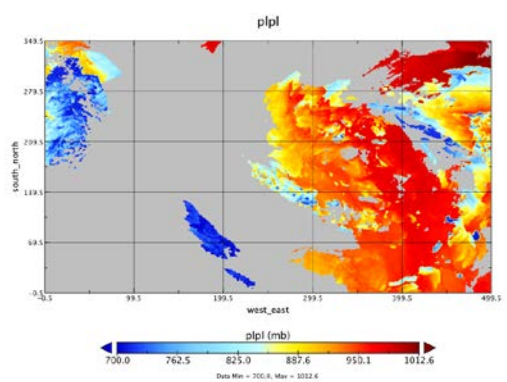
`Reference:` *Thompson, G., M. K. Politovich, and R. M. Rasmussen, 2017: A numerical weather model's ability to predict characteristics of aircraft icing environments. Weather and Forecasting,* ***32****, 207-221, doi:10.1175/WAF-D-16-0125.1.*

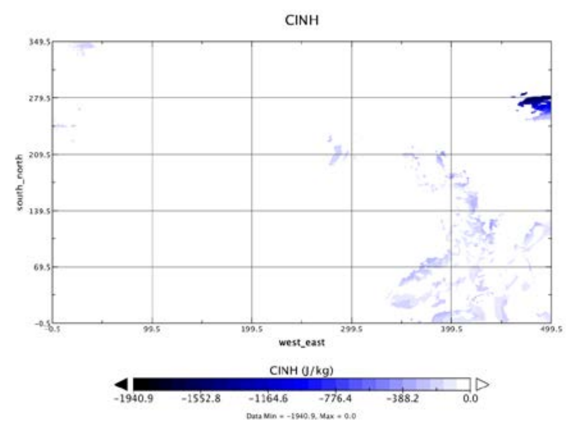
Hailcast and severe weather parameter

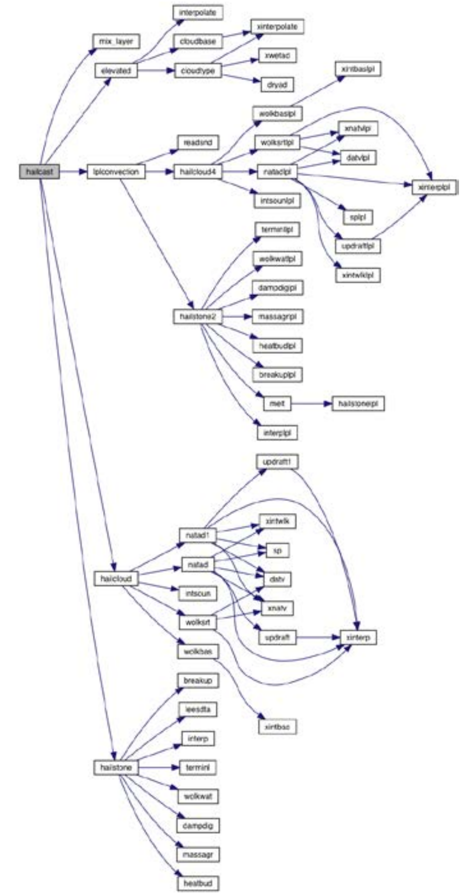
We integrated the 1-d cloud model provided by John's Group from U of Manitoba in the processing of WRF 3d output to generate hail and severe weather related parameters for our colleagues in U of Manitoba.











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