Convection-permitting WRF regional climate simulations over Western Canada

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## Available RCM output for CCRN region

<table>
<thead>
<tr>
<th></th>
<th>CRCM5</th>
<th>CanRCM4</th>
<th>NACCAP</th>
<th>CCRN-WRF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spatial Resolution</strong></td>
<td>50 km</td>
<td>NAM-22 (25 km)</td>
<td>50 km</td>
<td>4 km</td>
</tr>
<tr>
<td><strong>Vertical levels</strong></td>
<td>29</td>
<td>4</td>
<td>26</td>
<td>51</td>
</tr>
<tr>
<td><strong>Temporal resolution</strong></td>
<td>daily</td>
<td>NAM-22(daily)</td>
<td>3-hourly</td>
<td>hourly</td>
</tr>
<tr>
<td><strong>Downscale from</strong></td>
<td>CanESM2</td>
<td>CCCma-CanESM2</td>
<td>11 members</td>
<td>CMIP5 models 20 ensemble</td>
</tr>
<tr>
<td><strong>Scenario</strong></td>
<td>RCP4.5, RCP8.5</td>
<td>RCP4.5, RCP8.5</td>
<td>SRES A2</td>
<td>RCP8.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2006-2010 (future)</td>
<td>2041-2070 (near future)</td>
<td>2086-2099 (PGW equivalent)</td>
</tr>
</tbody>
</table>

### Maps

- **CRCM5**
- **NACCAP**
- **CCRN-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

**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

**HIGH-RESOLUTION (4-km) REGIONAL CLIMATE MODEL**

Weather Research Forecast V3.6

**DYNAMICAL DOWNSCALING HINDCAST**

**DYNAMICAL DOWNSCALING FUTURE PGW**

**PSEUDO GLOBAL WARMING**

ERA-I + ΔCIMP5

Global monthly multi-model average increments:

ΔCIMP5 = projection ensemble – historical ensemble

(2070 to 2099) – (1976 to 2005)
WRF dynamical downscaling for 2000-2013

Winter

CMIP5-historic

WRF-historic

CMIP5-historic

WRF-historic

Spring

CMIP5-historic

WRF-historic

CMIP5-historic

WRF-historic

Summer

CMIP5-historic

WRF-historic

CMIP5-historic

WRF-historic

Fall

CMIP5-historic

WRF-historic

CMIP5-historic

WRF-historic
Annual precipitation – CMIP5 vs WRF
WRF dynamical downscaling of CMIP5

Winter

Spring

Summer

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

**Daily Tmin**

**Daily Tmax**
Monthly T2: CONUS-WRF

CCRN-WRF

Jan  Feb  Mar
Apr  May  Jun
Jul  Aug  Sep
Oct  Nov  Dec
CONUS-WRF precipitation validation

(a) Precipitation difference [mm d^{-1}]

(b) 2m temperature difference [°C]

- Obs. ensemble
- Newman ensemble
- WRF
CCRN-WRF Performance Evaluation (Annual cycle)
WRF Precipitation Annual cycle for SRB
WRF Temperature Annual cycle for SRB
Precipitation, Temperature Annual cycle for MRB, SRB

MRB

PR

SRB

T2

Legend:
- NARR
- ANUSPLIN
- CaPA
- CA4KM
- CONUS
CCRN-WRF Performance Evaluation - PDF for daily precipitation intensity

MRB

Log X & Log Y          Linear X & Log Y         Log X & Log Y          Linear X & Log Y

SRB

Log X & Log Y          Linear X & Log Y         Log X & Log Y          Linear X & Log Y
CCRN-WRF Performance Evaluation - PDF for hourly precipitation intensity

MRB

SRB

Frequency

DJF

MAM

DJF

MAM

JJA

SON

JJA

SON

obs
ctl
gw
CCRN-WRF Performance Evaluation (Diurnal cycle)

Temperature (°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
Precipitation measurements across Canada-US border

Bias Corrections of Precipitation measurements across different ecoclimate regions

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