Pseudo-Global warming approach using 4KM WRF model

S. Kurkute\textsuperscript{1,2} \quad Y. Li\textsuperscript{1,2}

\textsuperscript{1}School of Environment and Sustainability
University of Saskatchewan

\textsuperscript{2}Global Institute of Water Security
University of Saskatchewan

CRHM Expert Workshop, 2016
Goals and Objective

- Perform *convection-permitting* regional climate simulation of western Canada using 4-km WRF-RCM.
- Study the convection initiation mechanism in Saskatchewan River Basin (SRB) by coupling WRF-RCM with land-surface model (Noah-MP).
- Assessment of extreme weather events, study synoptic and meso-scale features of future climate using *pseudo-global warming* (PGW) method.
- Implement and apply the physically-based, dynamical downscaling of CMIP5 using 4-km WRF for assessing global warming impacts on the water resources and regional climatology of Saskatchewan and McKenzie river basins (SRB and MRB resp.)
Various RCM’s over Western Canada

(a) 80KM CanRCM

(b) 25KM CanRCM

(c) 10KM WRF-ARW

(d) 4KM WRF-ARW

S. Kurkute, Y. Li (Universities of Saskatchewan) Pseudo-Global warming approach using 4KM WRF model

CRHM Expert Workshop, 2016
WRF Domain over Western Canada

Figure: WRF Domain Terrain Height
WRF model Set-Up (Control experiment for 2000-2013)

- WRF model (Version 3.4.1)
- Single domain: $2560 \times 2800 \text{ km}^2$, $\Delta x=4\text{ km}$, 37 vertical levels
- Microphysics Scheme: New Thompson et al.
- PBL Scheme: YSU
- RRTM long-wave and short-wave scheme
- No cumulus parameterization assumed explicit convection

**Forcing Data**

6 hourly, $0.703^\circ \times 0.703^\circ$ resolution

ERA-Interim reanalysis data provides initial and lateral boundary conditions

S. Kurkute, Y. Li (Universities of Saskatchewan)

Figure: Spatial Distribution of annual mean daily PRCP for 2007-2012 resp.

Figure: Annual mean daily error (mm/day) for WRF vs OBS and WRF vs ANUSPLINE resp.
Figure: Spatial pattern of correlation between WRF Vs OBS and WRF Vs ANUSPLINE resp.
WRF Performance

Inter-annual viability of seasonal monthly PRCP totals averaged over all sites in SRB and MRB

**Figure:** DJF, MAM, JJA and SON resp.
WRF Performance

QQ-plot for DJF, MAM, JJA and SON resp

Figure: WRF Vs OBS and WRF Vs ANUSPLINE, OBS (X-axis) and WRF (Y-axis)
Pseudo-Global Warming

Method

- Calculate 25-year monthly mean values of U, V, T, Qv, PSFC, and SST of current and future climate periods from multi CMIP5 model ensemble (1975-1999 historical and 2075-2099, RCP8.5)
- Subtract current from future to get monthly climate perturbations global warming signal
- Add time-interpolated perturbation to current reanalysis (ERA-Interim, 6-hourly) to give new WRF model initial and lateral boundary conditions
Pseudo-Global Warming

Method

CMIP5 models
- 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

Multi-model mean Historical Average 1976-2005

Global warming increments (monthly means)

Multi-model mean RCP85 Average 2070-2099
Pseudo-Global Warming

Method

CTRL Simulation

ERA-Interim reanalysis data

WRF- model V3.6

PGW Boundary conditions
6-hourly … considered as a new observed conditions (reanalysis data) for the future climate

Global warming increments (monthly climatic change components) (T,U,V,Z,SST,PS)

Assumption:
1. Linear Coupling
2. Unchanged inter-annual variability
The WRF CTRL and PGW post-process data has been stored on GIWS water server at /data2/NOBACKUP/sak298/Post_Processed/3D_2D_YYYY

The WRF CTRL and PGW post-process data have spatial ($\Delta X = 4$KM) and temporal ($\Delta T = 1$HR) resolution resp.

Surface winds, Humidity, Outgoing and Incoming Long-wave and short wave radiation flux, Pressure, Geo-potential height, Latent heat flux, Temperature, Upward and Downward heat flux, snow, accumulated PRCP etc
Control runs 2000-2013 has completed
PGW runs 2000-2009 has completed equivalent to 2075-2099
The data has been converted into MESH and CLASS r2c format.