Analysis of NARCCAP Multi-RCM Hydro-Climate Scenarios in the Lake Winnipeg Watershed

Yonas Dibike,
Terry Prowse and Roxanne Ahmed

Presented by Trevor Murdock, PCIC
Research Project: The Lake Winnipeg Basin Initiative (LWBI)

LWBI Science Objective supported:

- Assess the impact of climate variability and change on non-point source nutrients contribution in the Lake Winnipeg watershed

- Lake Winnipeg is Canada’s sixth-largest freshwater lake

- The catchment area is about 953,000 km²

- Drainage Systems: Red, Assiniboine, Saskatchewan and Winnipeg rivers
Observed Temperature and Precipitation Data for the Lake Winnipeg Watershed

• Comparison is based on the daily 10km Gridded Climate Dataset for Canada (1961-2003) (Hutchinson, et. al. 2009) - AGCAN

• Based on EC daily observations, and has been interpolated to a high-resolution 10km grid using the thin-plate spline surface fitting method

• Contains 43-year daily precipitation, maximum temperature and minimum temperature
NCEP/RCMs vs Gridded Observed Precipitation

NCEP-driven RCMs Vs AgCan Annual Total Precipitation (% Difference), 1981-2000

CRCM/NCEP vs AGCAN

HRM3/NCEP vs AGCAN

RCM3/NCEP vs AGCAN

Environment Canada

Canada
NCEP/RCMs vs Observed Precipitation Bias (%)
Q-Q plot of NCEP/RCMs vs Observed Precipitation

Precipitation Seasonal Quantiles, 1981-2000

Winter

Spring

Summer

Autumn

Legend: Observed, CRCM/NCEP, HRM3/NCEP, RCM3/NCEP
GCM/RCMs vs Gridded Observed Precipitation

GCM-driven RCMs Vs AgCan Annual Total Precipitation (% Difference), 1981-2000

CRCM/CGCM3 vs AGCAN

HRM3/HADCM3 vs AGCAN

RCM3/GFDL vs AGCAN

TimeSlices/GFDL vs AGCAN

Environment Canada

Environment Canada
GCM/RCMs vs Observed Precipitation Bias (%)

GCM-driven RCMs v AGCAN Precipitation Seasonal Bias, 1981-2000

- Winter
- Spring
- Summer
- Fall

Bias (%)

CRCM/CGCM3
HRM3/HADCM3
RCM3/GFDL
TimeSlices/GFDL
Comparison of RCM Projections of Change in Mean Annual Total Precipitation (%), 2041-2070 vs 1971-2000

RCM Projections of Change in Mean Annual Total Precipitation (%), 2041-2070 vs 1971-2000

CRCM/CGCM3

HRM3/HADCM3

RCM3/GFDL

TimeSlices/GFDL
Comparison of RCM Projections of Change in Mean Seasonal Precipitation (%) 2041-2070 vs 1971-2000

GCM/RCMs Change in Seasonal Precipitation, 2041-2070 vs 1971-2000

- Winter
- Spring
- Summer
- Fall

Change in Precipitation (%)

CRCM/CGCM3  HRM3/HADCM3  RCM3/GFDL  TimeSlices/GFDL
RCM Ensemble
Change in Seasonal Precipitation (%) (2041-2070 vs 1971-2000)

Seasonal Total Precipitation Difference [%], Ensemble, (2041-2070) vs (1971-2000)

Winter

Spring

Summer

Fall

[Map images showing seasonal precipitation differences with color coding for temperature changes]
RCMs Precipitation Scenarios

• Compared to 1981-2000 observed precipitation data over the Lake Winnipeg watershed:
  – NCEP driven CRCM and RCM3 has wet biases while HRM3 has a dry bias
  – While GCM driven RCM3 has a wet annual bias, the remaining three GCM/RCMs has a relatively small annual biases
  – CRCM/CGCM3 has less seasonal biases compared to the other three RCM/GCM

• Based on the A2 emission scenario of future climate:
  – All RCM/GCMs except TimeSlice/GFDL projected an increase in total annual precipitation by 5 - 7 % for the 2041-2070 compared to 1971-2000 while the later projected a decrease and the highest increase projected by RCM3/GFDL
  – Seasonally, all RCM/GCMs except RCM3/GFDL has projected increase in winter and spring and a decrease in summer precipitation while the later shows an increase in summer precipitation too.
Climate Impacts on Snow Depths and Discharges In the LWW

- Analyses of CRCM4 future projections of maximum snow depth, snow cover duration and snowmelt runoff

- Five river (and lakes) basins are identified in the LWW and snow and runoff analysis are performed and presented for each of these.
CRCM/CGCM3 Change in Seasonal Precipitation (%) (2041-2070 vs 1971-2000)

Seasonal Total Precipitation Difference [%], CRCM/CGCM3 (2041-2070) vs (1971-2000)

Winter

Spring

Summer

Fall
Comparison of RCM Projections of Change in Mean Seasonal Precipitation (%) 2041-2070 vs 1971-2000

Assiniboine River Basin

Red River Basin

Saskatchewan River Basin

Winnipeg River Basin

Change in Precipitation (%)
CRCM/CGCM3 Change in Seasonal Mean Tmin (2041-2070 vs 1971-2000)

Change in Seasonal Mean Tmin [°C], CRCM/CGCM3 (2041-2070) vs (1971-2000)

Winter

Spring

Summer

Fall
Projected Climate Change Impact on SWE

Saskatchewan River Basin

Winnipeg River Basin

Assiniboine River Basin

Red River Basin
Impact on Annual Maximum SWE

Average Annual Maximum SWE
CRCM/CGCM3
1970-2000 vs 2040-2070

Saskatchewan River Basin

Assiniboine River Basin

Red River Basin

Lakes Basin

Winnipeg River Basin
Impact on Mean Annual SCD
Projected Change in Mean Monthly Runoff

**Saskatchewan River Basin**

**Winnipeg River Basin**

**Assiniboine River Basin**

**Red River Basin**
Summary: Projected Changes in Snow and Runoff:

- There is an overall reduction in the mean SWE values for the 2041-2070 period compared to the 1971-2000 period.
- The mean annual maximum SWE is expected to decrease in the range of 2.6 to 5.7 mm over most river basins.
- The timing of the maximum SWE is projected to be earlier by about a month (from March to February).
- The mean annual SCD is projected to be reduced in all river basins by 14 to 21 days.
- There will be a shift in spring runoff to earlier periods with increasing runoff in February and March and a corresponding decrease in April for most river basins.
- The mean annual runoff is projected to increase in the range of 2.2 to 10.4 mm for most river basins except the Winnipeg River basin which shows a decrease of about 6.9 mm.
- The projected climate also show a slight increase in annual peak monthly flow for most river basins except the Winnipeg River basin.
We wish to thank the North American Regional Climate Change Assessment Program (NARCCAP) for providing the data used in this Presentation.

NARCCAP is funded by the National Science Foundation (NSF), the U.S. Department of Energy (DoE), the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Environmental Protection Agency Office of Research and Development (EPA).