Manitoba Hydro's Climate Change Impact Studies:

Tools and techniques used to study climate change impacts on runoff

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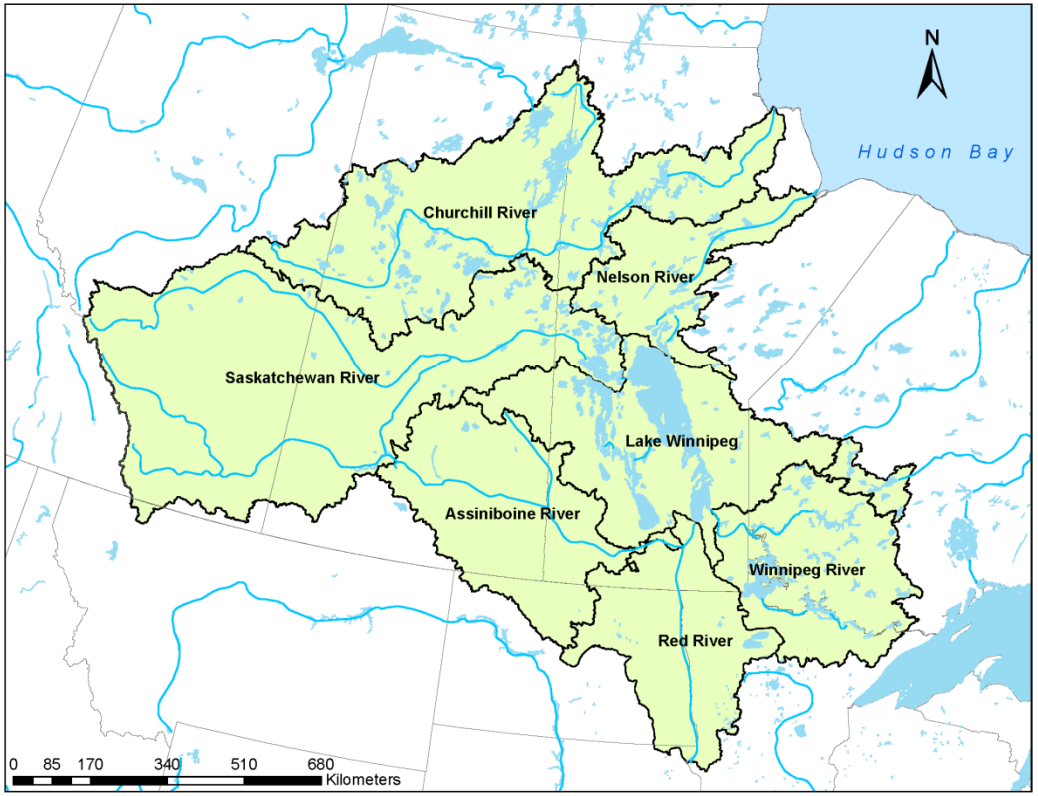
Collaboration

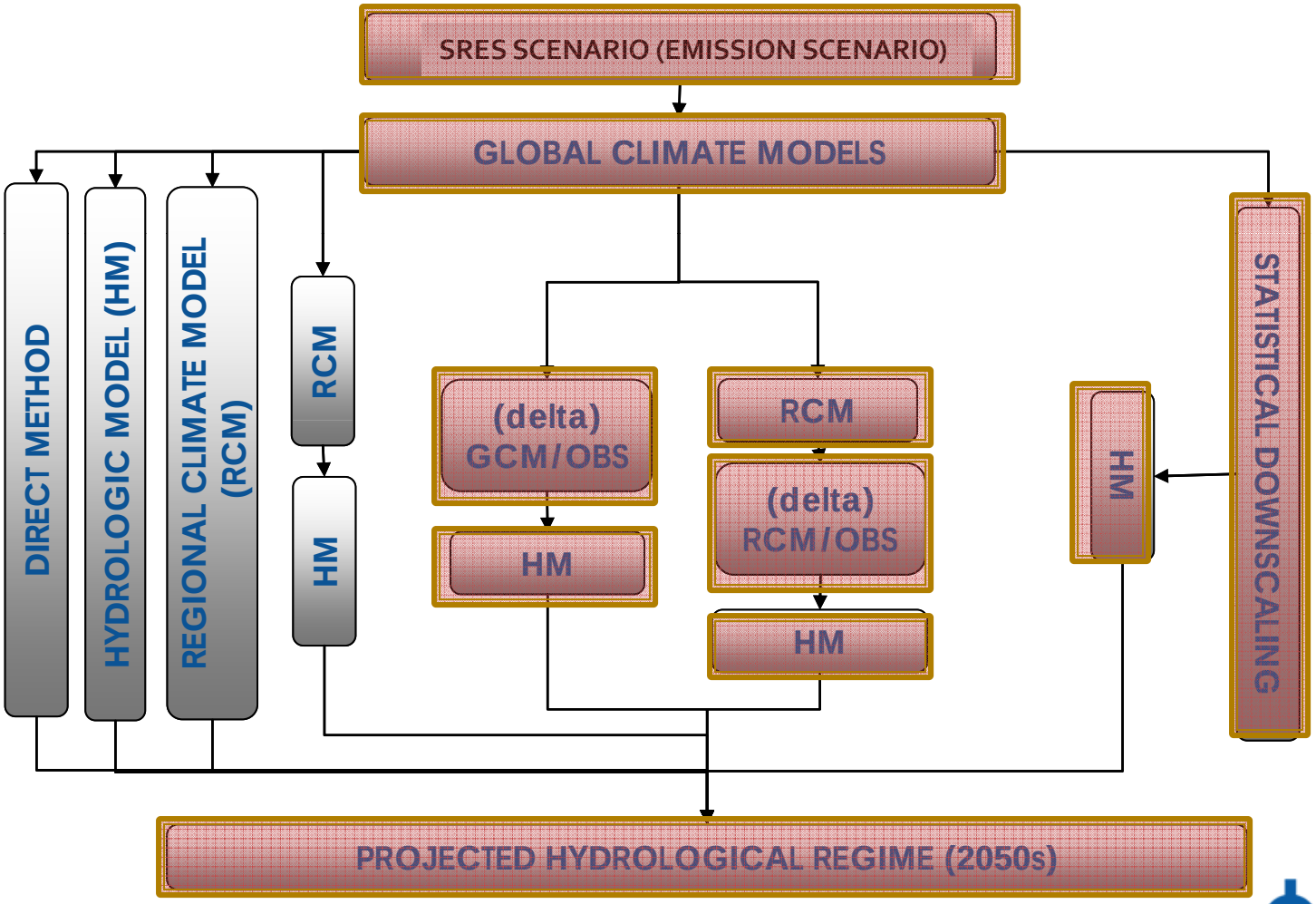
- University of Manitoba
- University of Waterloo
- Environment Canada
  - *National Hydrology Research Centre*
  - *Meteorological Research Division*
- Hydro-Quebec
- Lake of the Woods Control Board
- MB, Sask, Ont Forest Fire Program
- Ontario Ministry of Natural Resources
- Ouranos
- PCIC
- Canadian Hydraulics Centre
- Ecole de technolgie superieure
- IP3
- NSERC

Guidance Documents from the IPCC and other National Agencies.

Hydrological Modeling

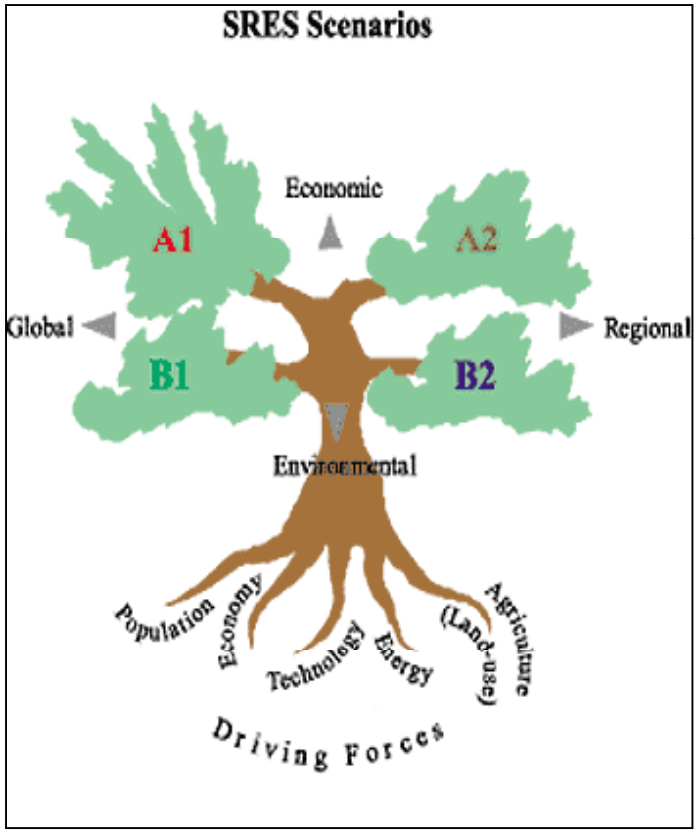


How to project future runoff?



SRES Scenarios (Emission Scenarios)

A1: Rapid economic growth, low population growth, and rapid introduction of new and more efficient technology.



A2: Emphasis on family values and local traditions, high population growth, and less concern for rapid economic development.

B1: Emphasis on local and regional solutions to economic, social, and environmental sustainability, and moderate population growth.

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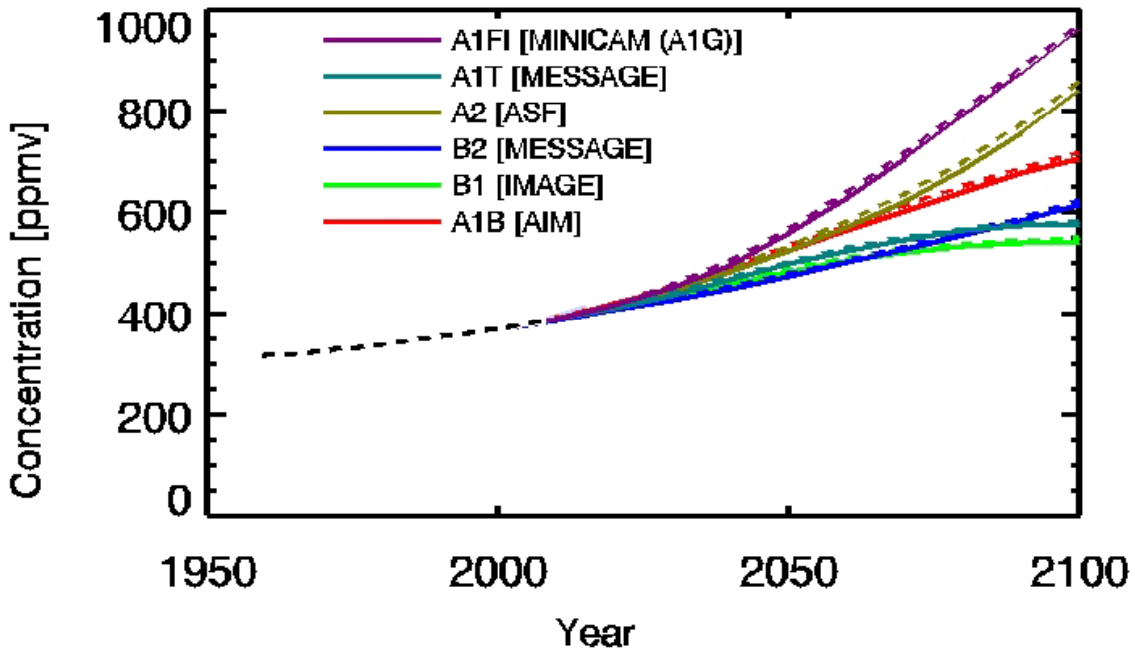
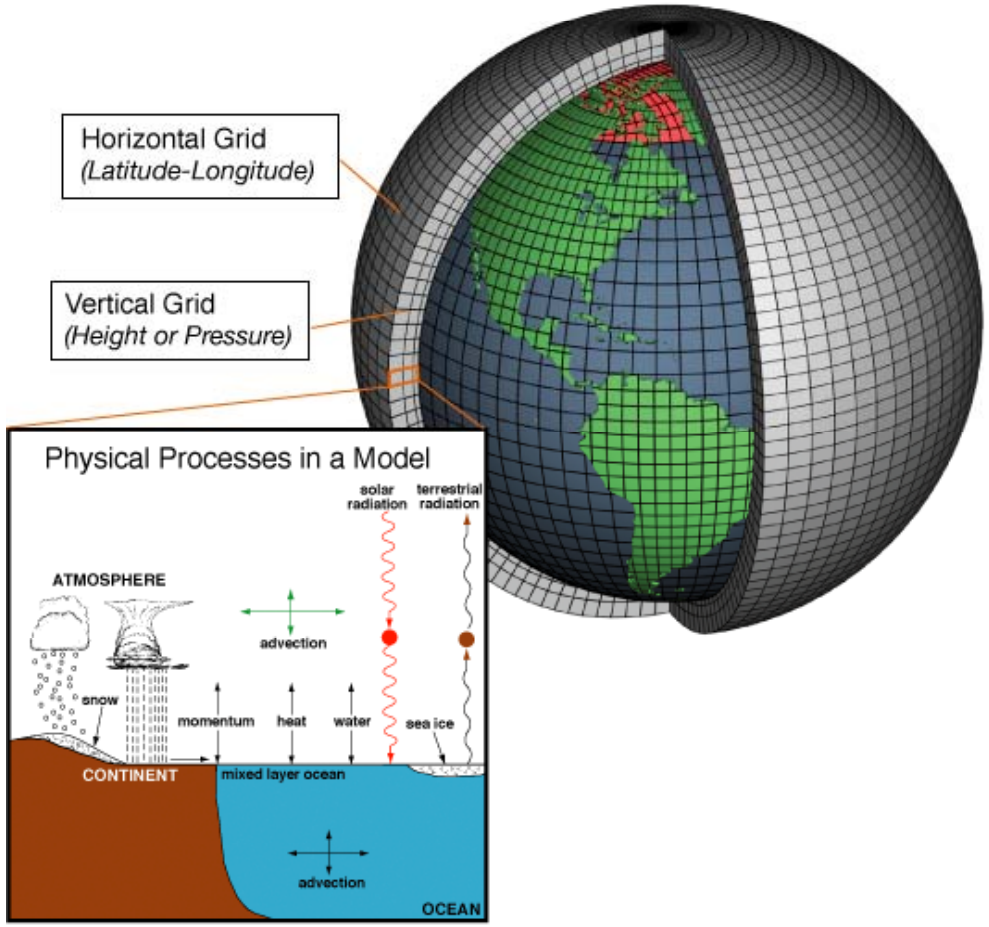
SRES Scenarios



Global Climate Models



-GCMs are the most sophisticated tools designed to simulate Earth's climate system

-Coarse resolution: limited ability in reproducing regional climate

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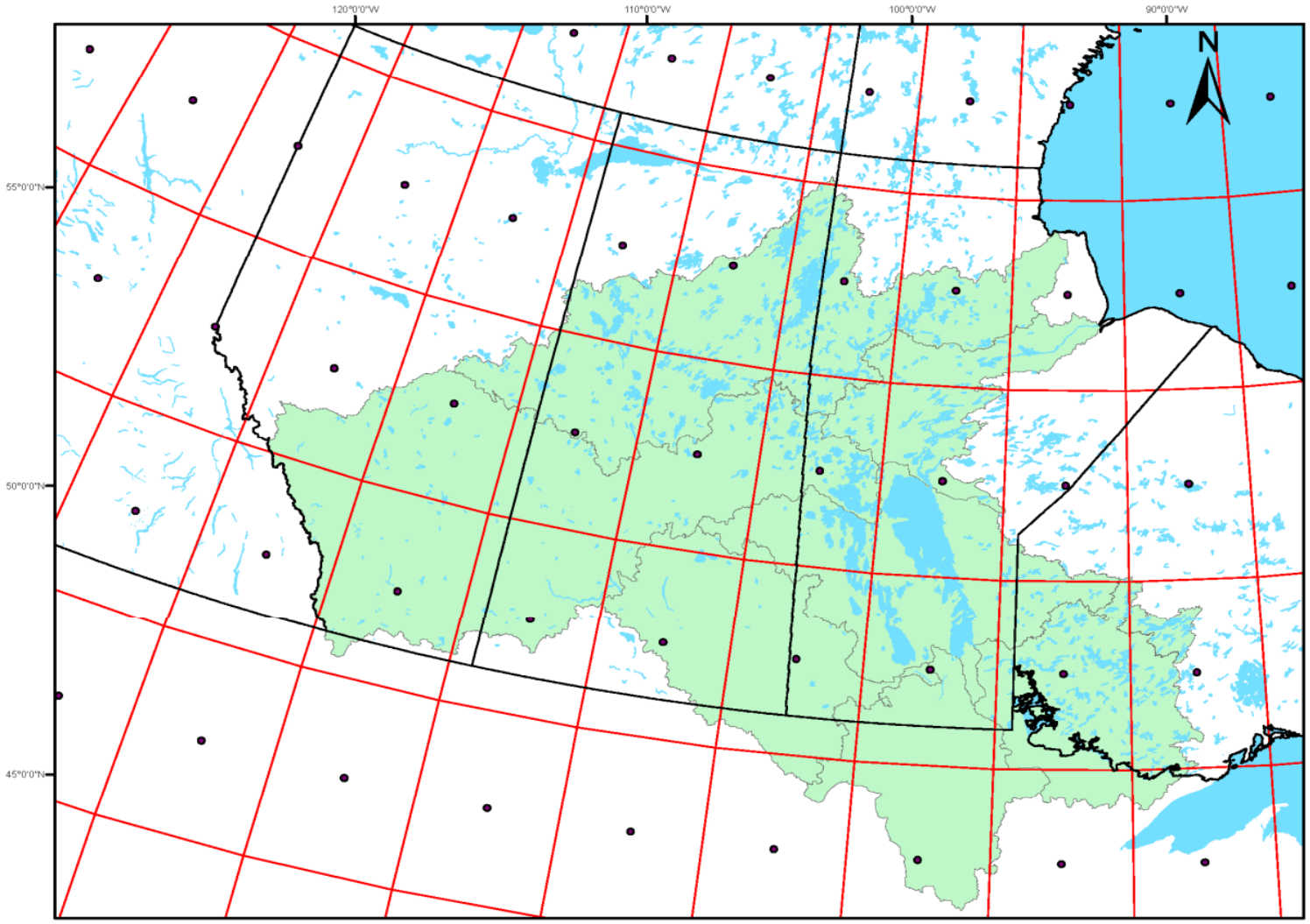
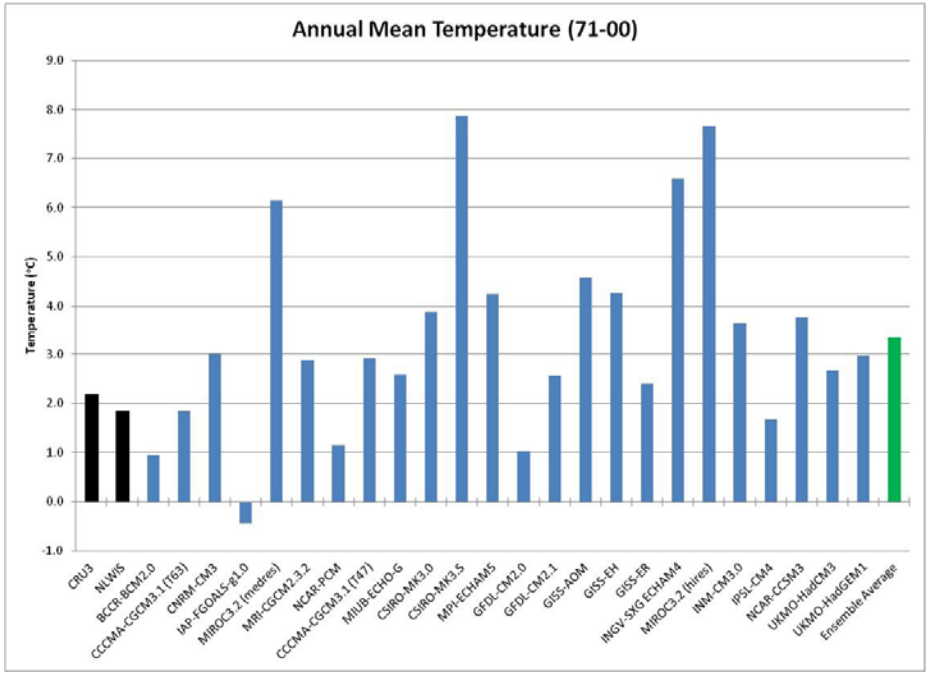
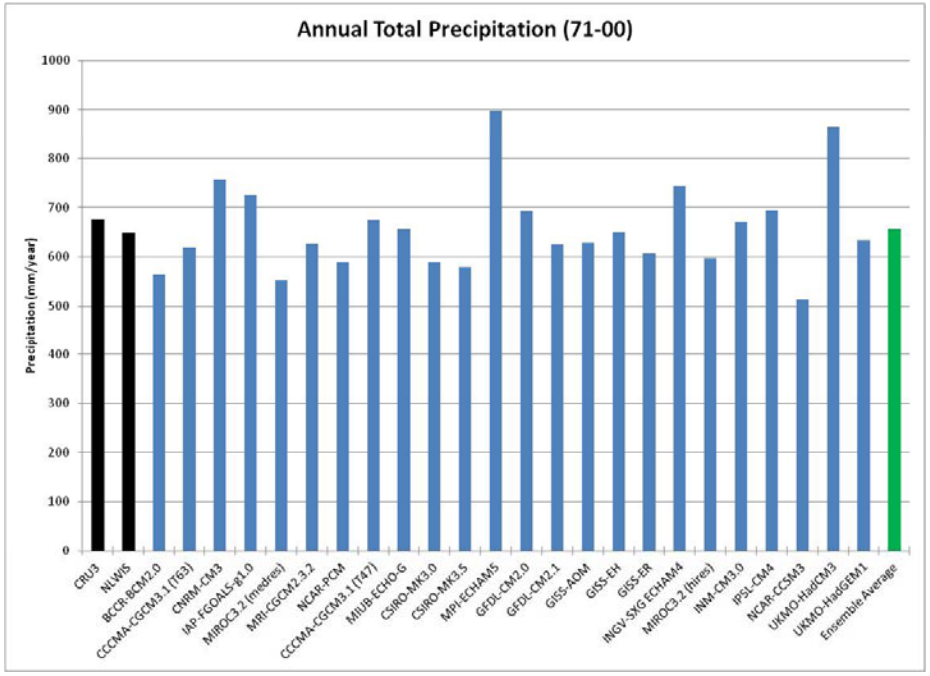
GCM Grid



GCM Bias





Historical:	2.0 °C
GCM Max:	7.9 °C
GCM Min:	-0.4 °C
Ensemble Avg:	3.4 °C

Historical:	663 mm/yr
GCM Max:	898 mm/yr
GCM Min:	514 mm/yr
Ensemble Avg:	657 mm/yr

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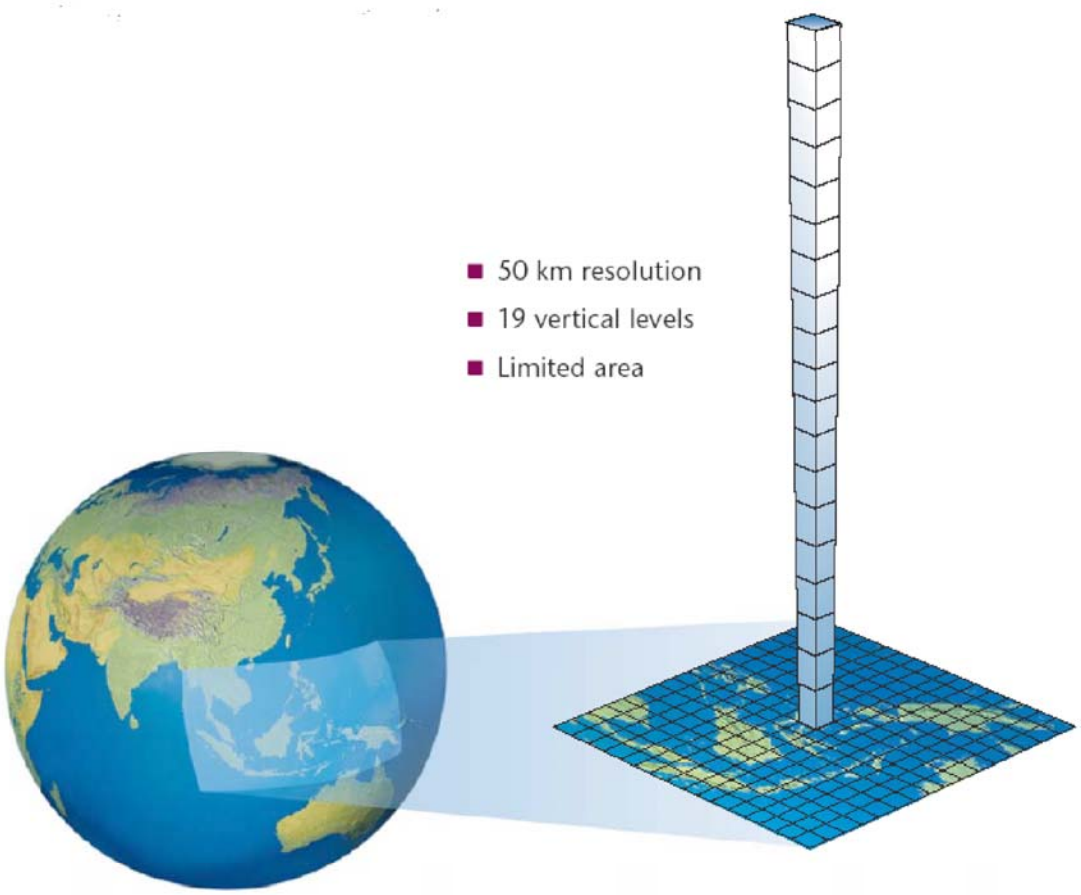
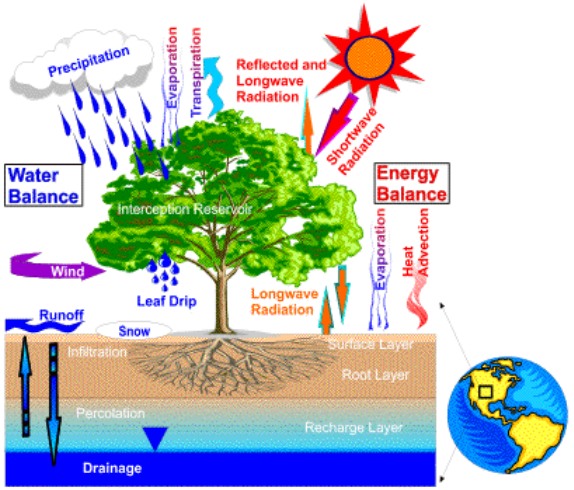
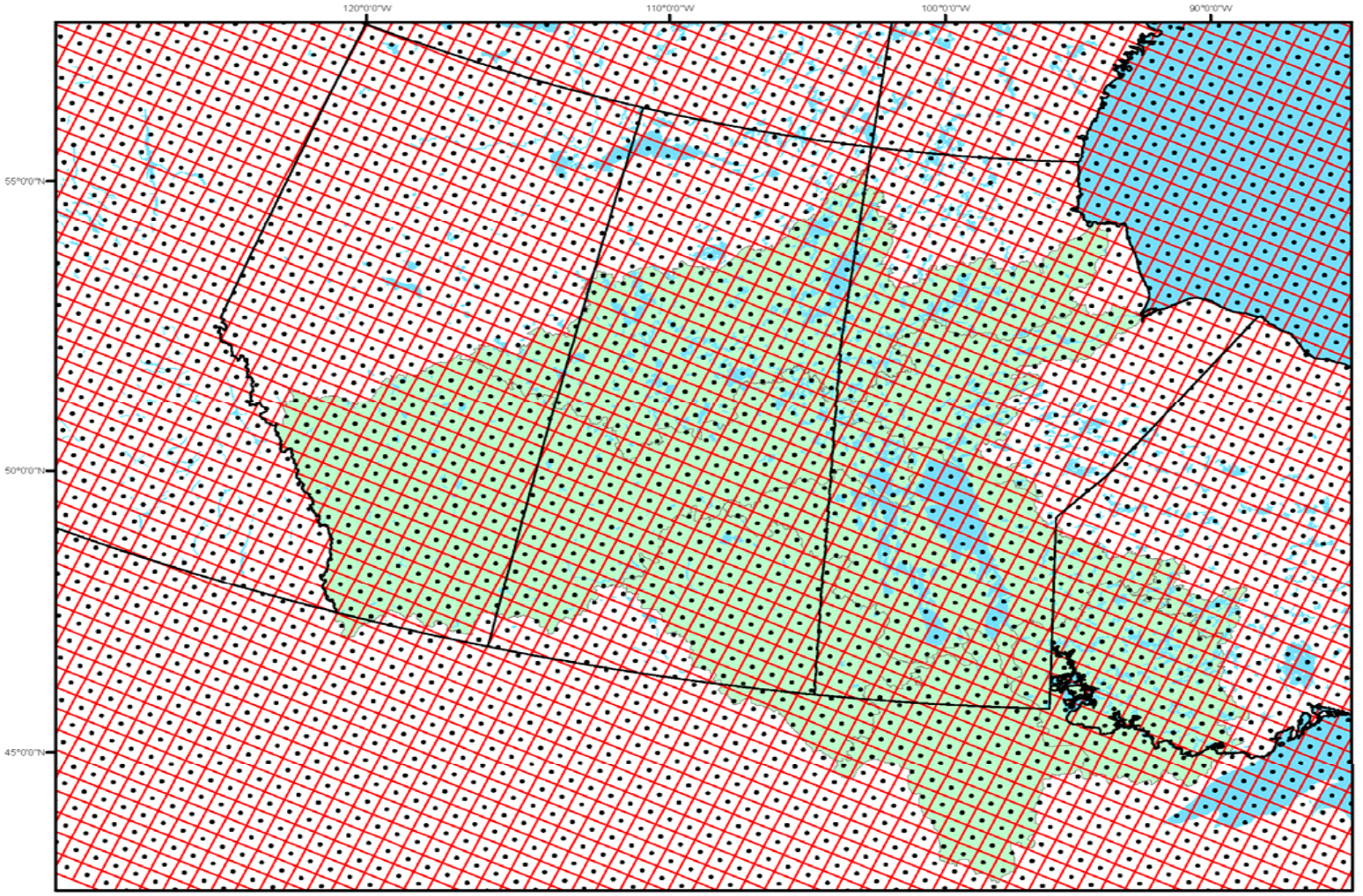
Regional Climate Models



Land Surface Modeling Concept

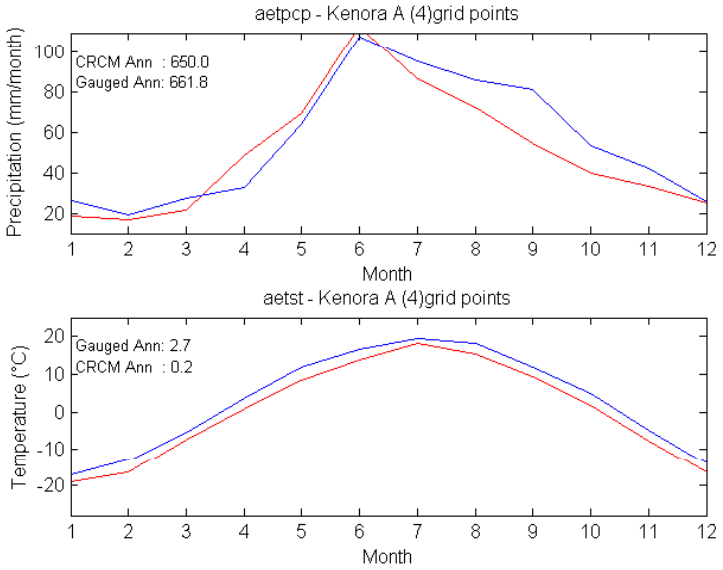


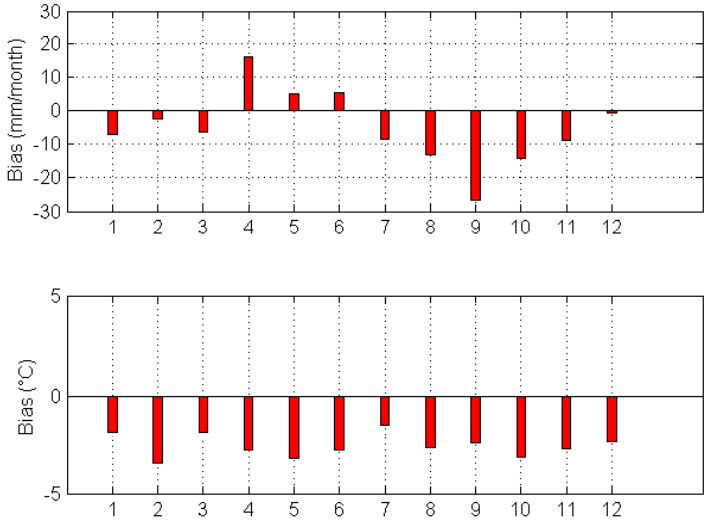
RCM Grid



RCM Bias

1971-2000 Normals
Kenora A and CRCM Comparison





Delta Method

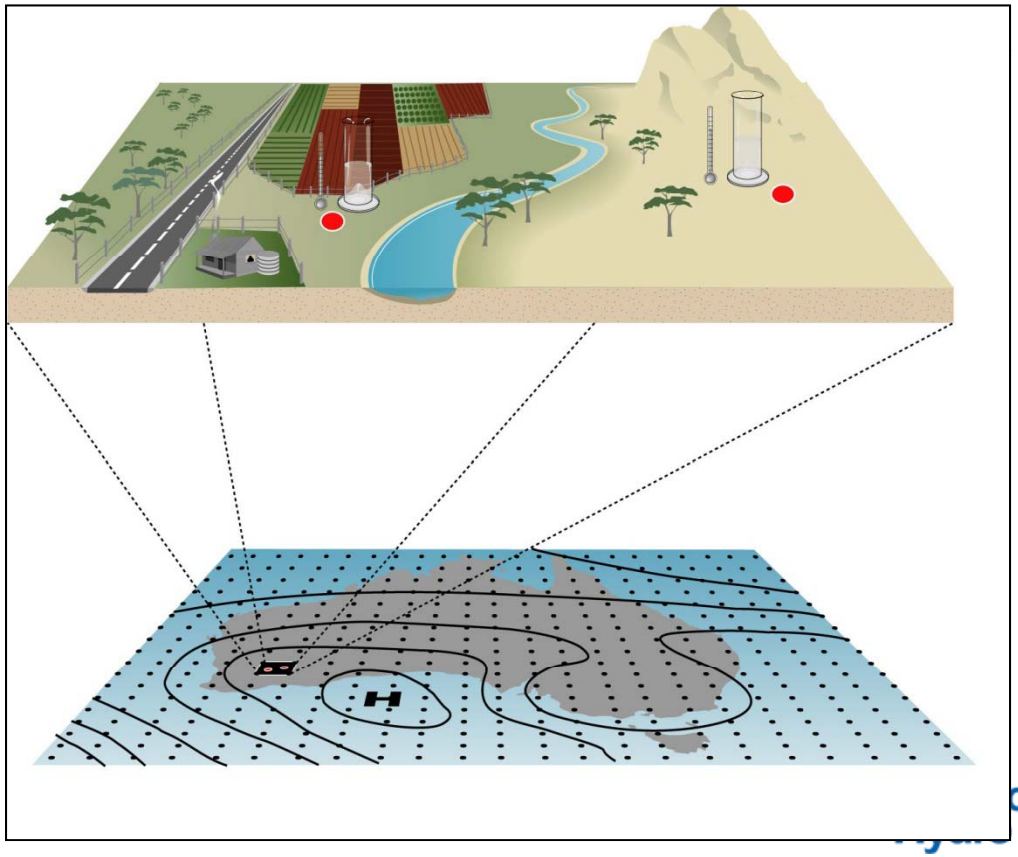
- Future climate is obtained by adjusting the baseline observations by the period-averaged results for the GCM or RCM and the corresponding averages for the GCM or RCM simulated baseline period (e.g. 1971-2000).
- Differences are usually applied for temperature changes
- Ratios are commonly used for precipitation change though differences may be preferred in some cases.

Statistical Downscaling

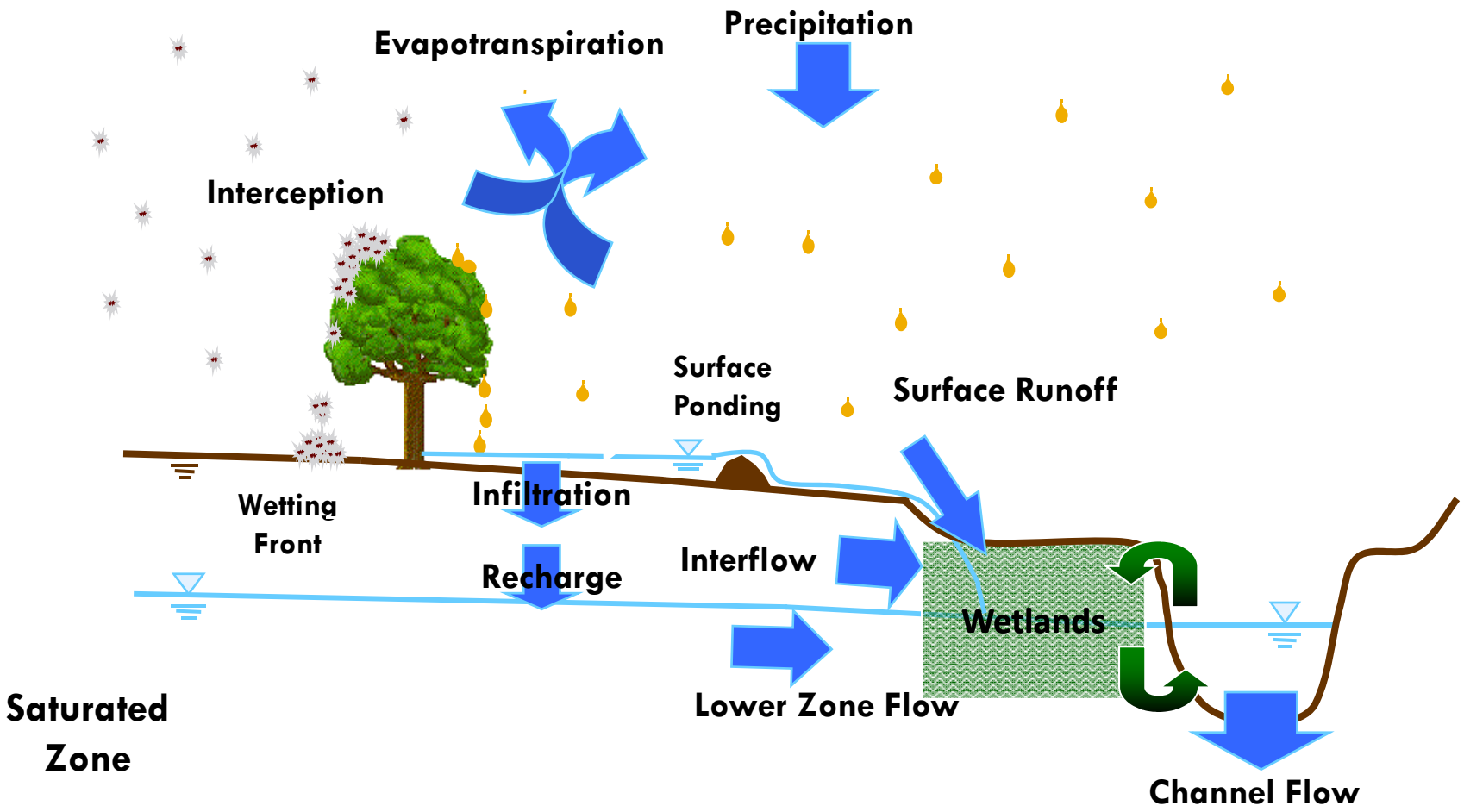
Empirical relationship between observed weather and large scale circulation variables

Three main types:

- Transfer Functions
- Weather Generators
- Weather Typing

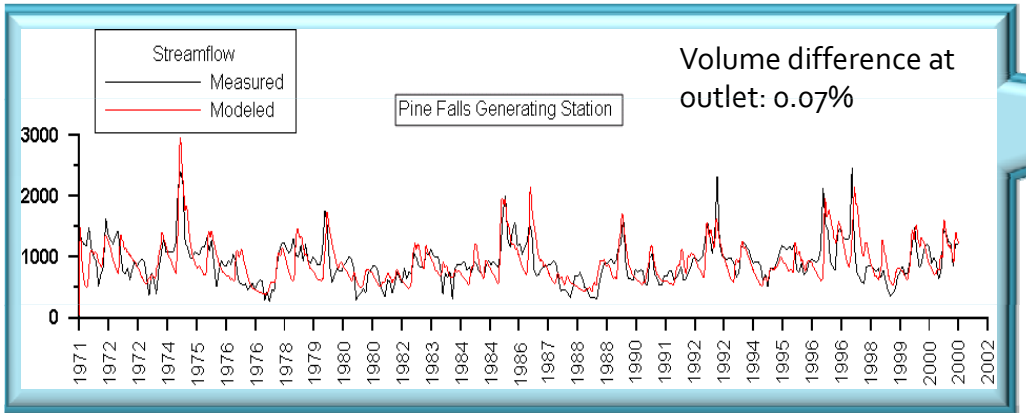


Hydrological Modeling- WATFLOOD

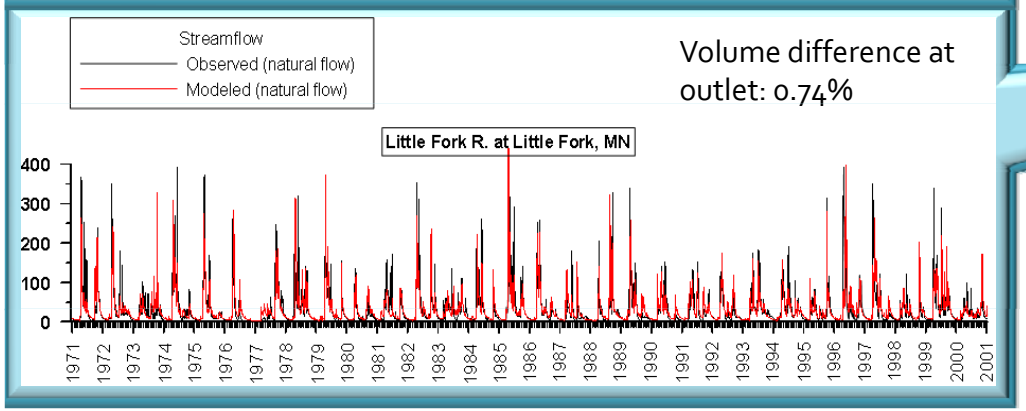


WATFLOOD User Manual. Kouwen, 2011

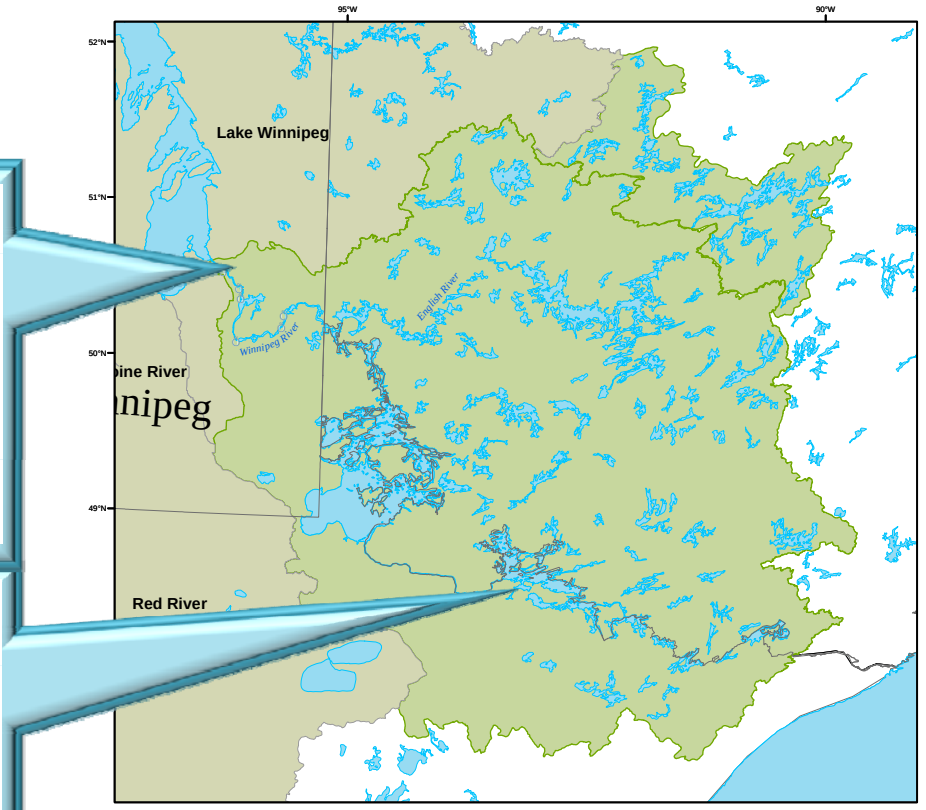
Hydrological Modeling



Volume difference at outlet: 0.07%

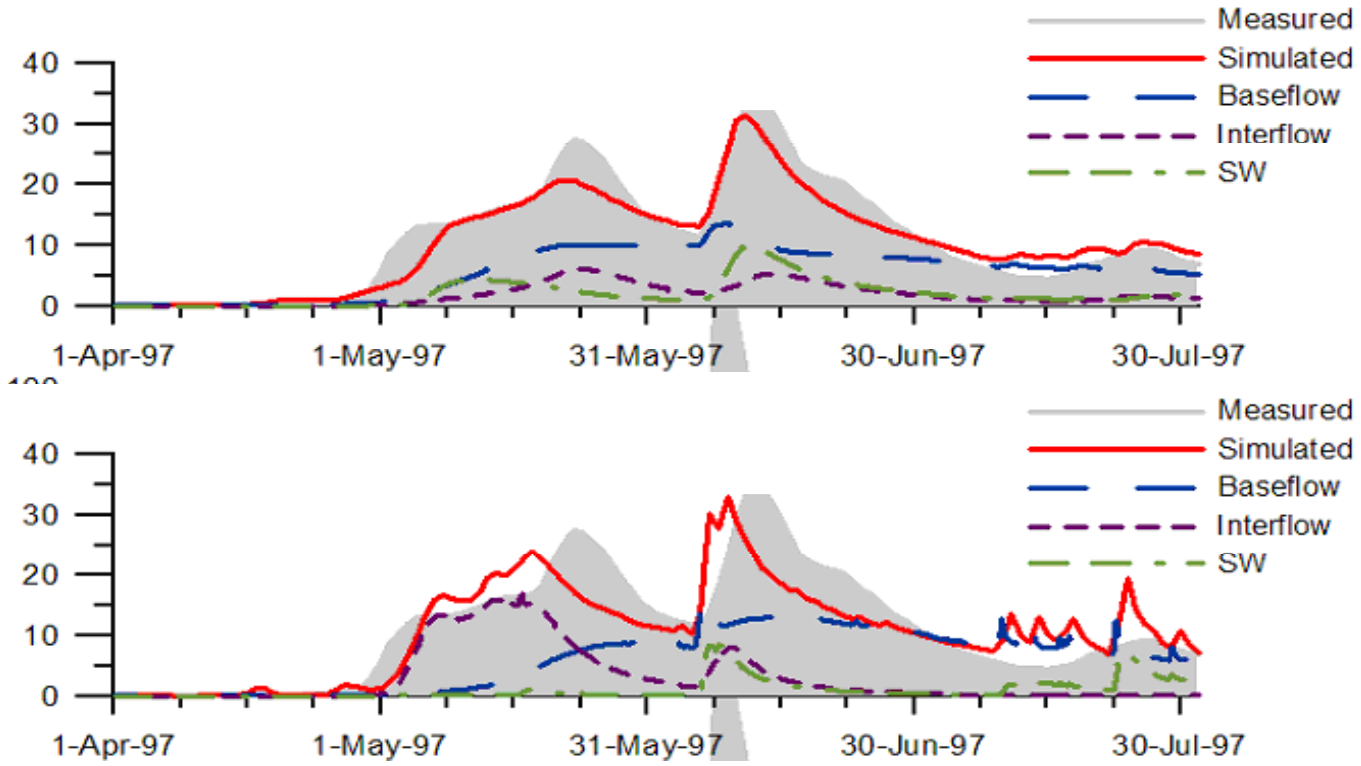


Volume difference at outlet: 0.74%



Model Uncertainty

- Two streamflow simulations performed
- Different calibrations (parameters)
  - Only one is possible…but which one?



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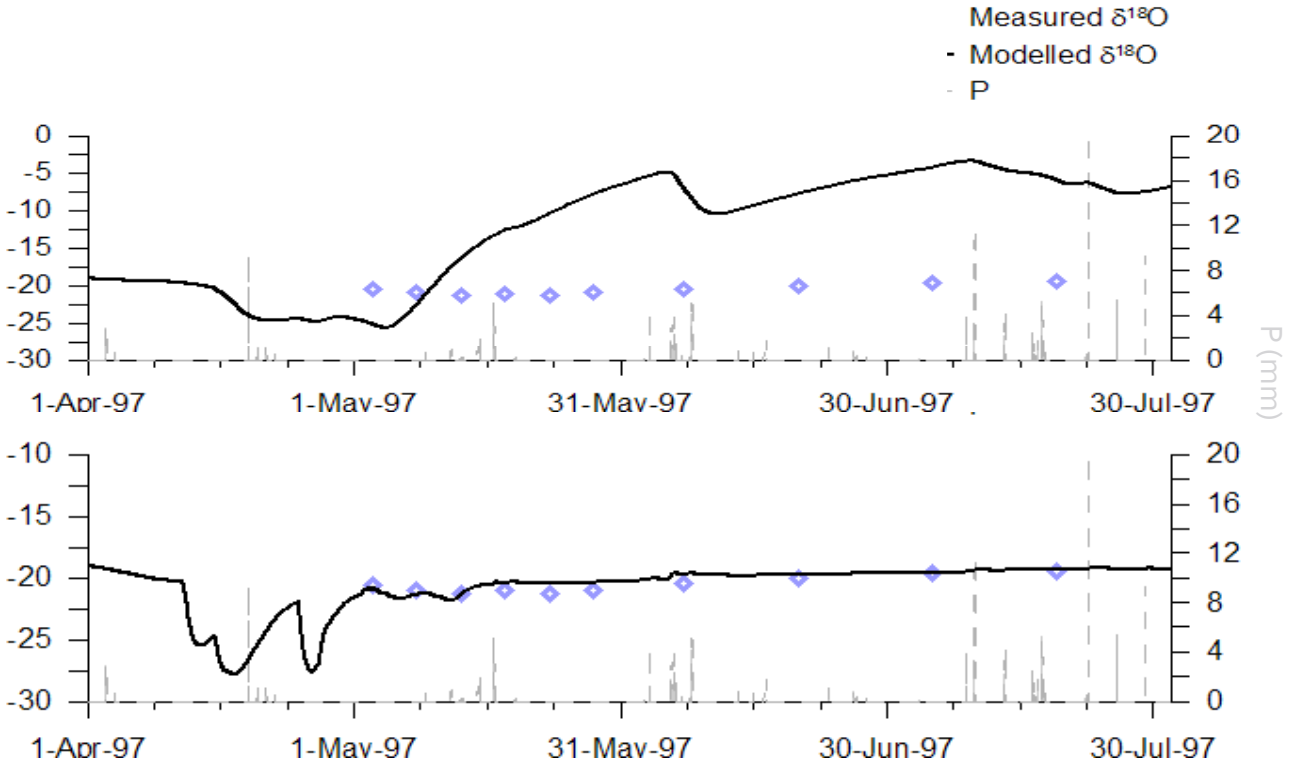
Model Uncertainty

It is very easy to set-up a hydrological model- but is it set-up correctly?

We use isotopes for more advanced validations



T. Stadnyk

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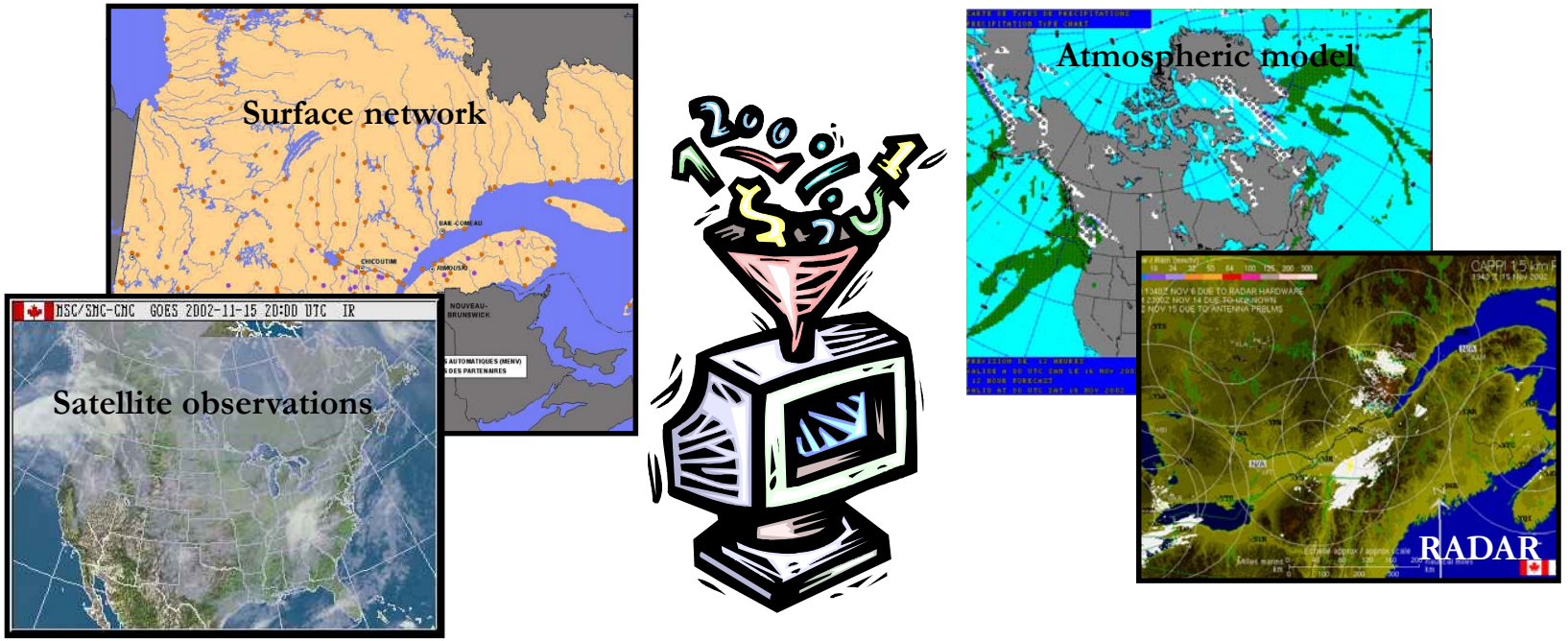
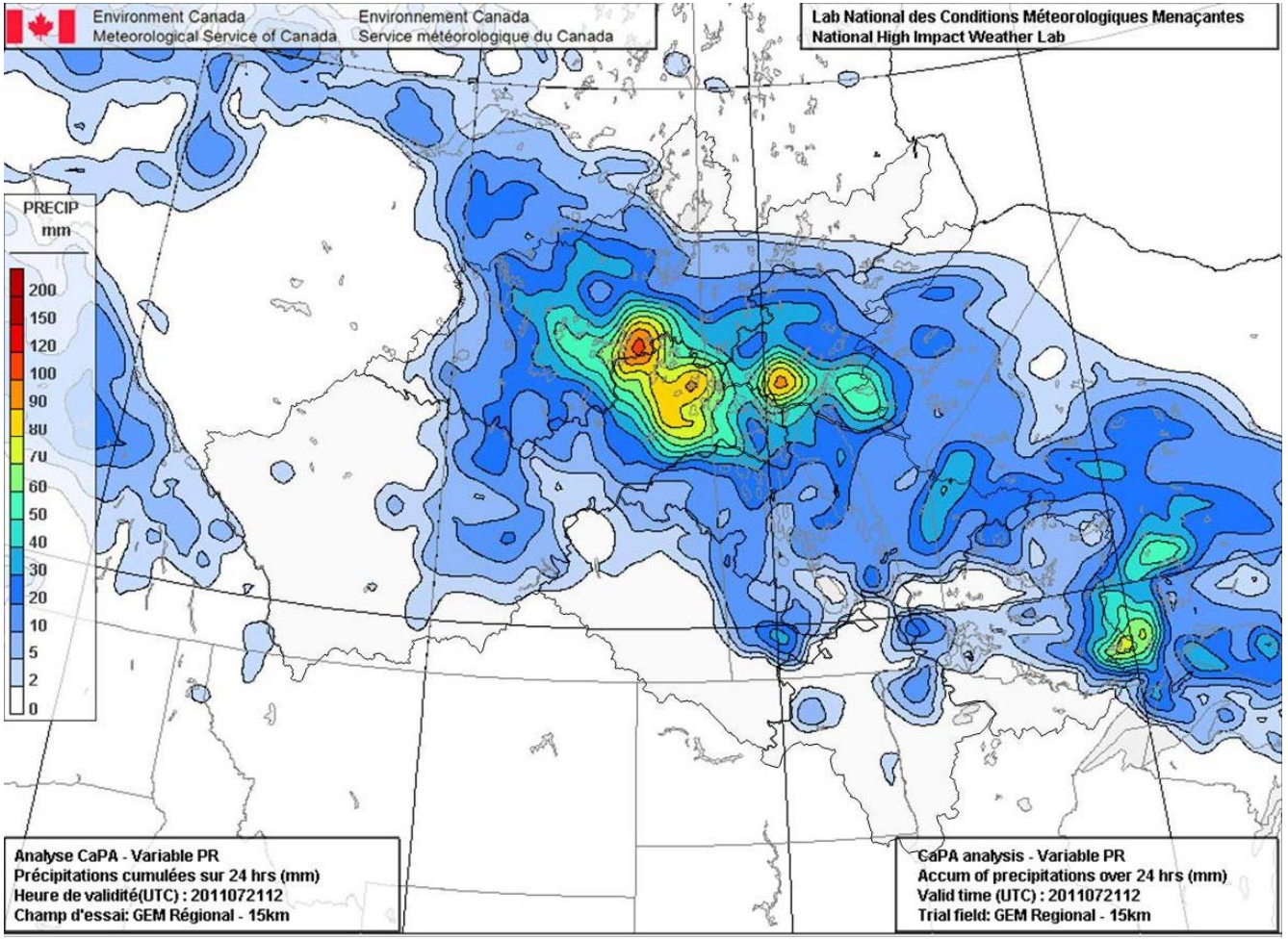
Canadian Precipitation Analysis

- Combination of different sources of precipitation information into a single, gridded near real-time analysis plus 15 day forecast and hindcast.



Canadian Precipitation Analysis



Uncertainity

- Emission Scenarios
  - Up to the 2050s are relatively indistinguishable
  - Range of differences attributable to differences in climate models
- Climate Models
  - Boundary conditions
  - Which processes are excluded
  - How small scale phenomena are parameterized
  - Spatial and temporal resolution
  - Type of grid
  - Parameter uncertainty
- Impact Model
  - Each impact model has its own inherent uncertainty
  - May consider multi-model approach.

Must use an ensemble approach!

Thank you

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