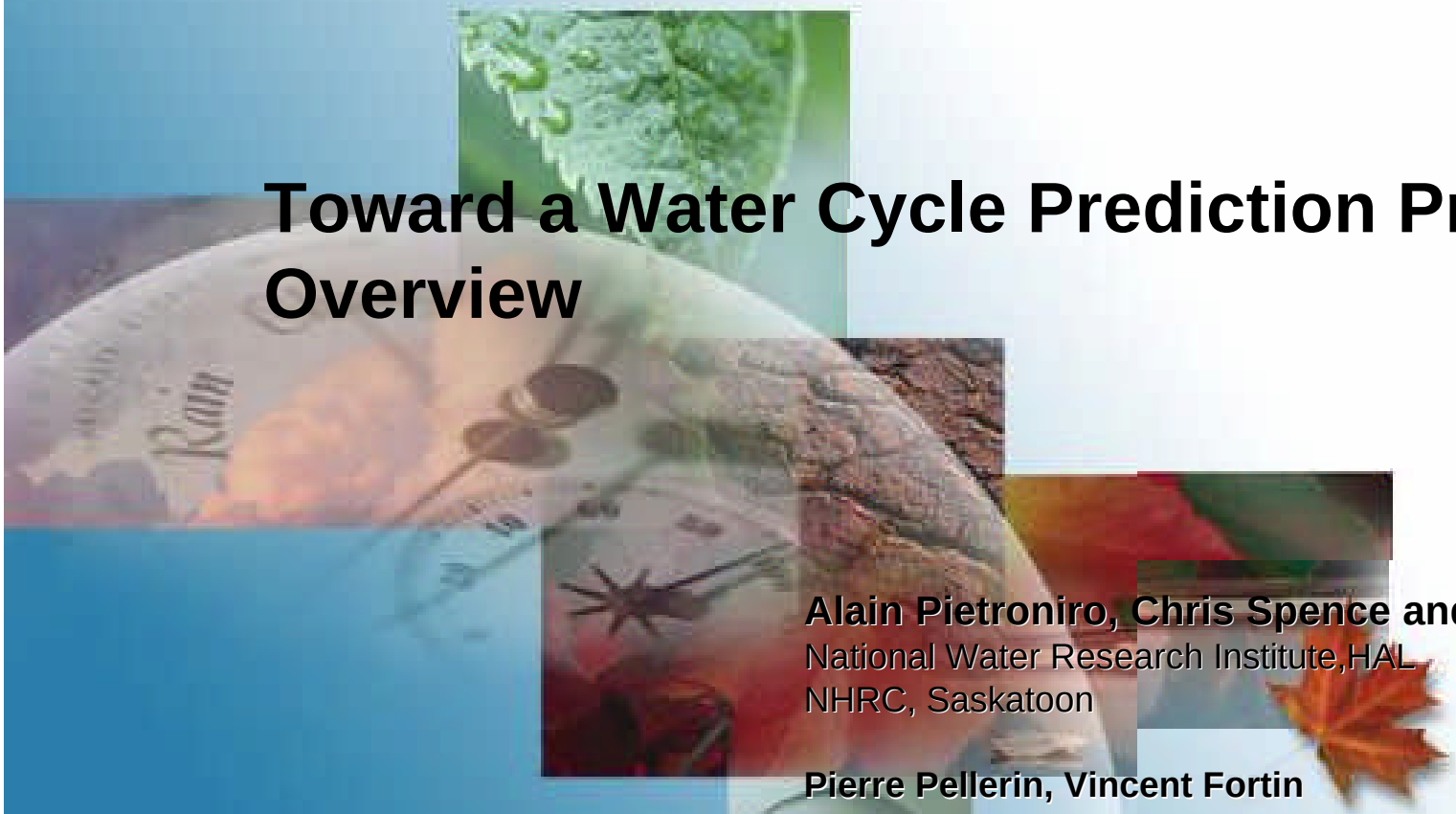
Toward a Water Cycle Prediction Program: Overview



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Meteorological Service of Canada (MSC).

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Water Cycle Prediction - Our plan

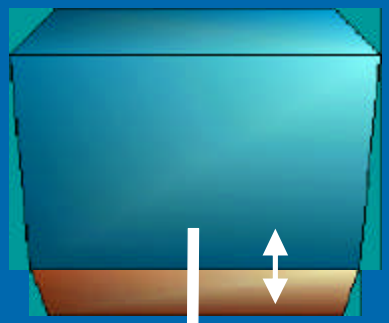
An integrated system that uses existing gauge networks, hydrometerological information, NWP technology (including land data assimilation) and hydrological models to attempt at closing the water balance

Largely influenced by 10 years of MAGS research

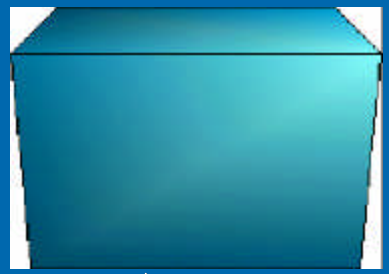
- NWRI will provide process and hydrological science
- RPN will provide and support a community environmental modelling system:
  - MEC-*Modélisation Environnementale Communautaire*
  - *NWP expertise (land data assimilation)*
- HAL will provide and support a community hydrologic prediction system within MEC:
  - MESH: MEC – Surface and Hydrology
- CRB will provide and support a community land-surface model
  - CLASS
- WSC/MSC data and applications expertise
  - Closing the water balance in Canada

Close collaborations with University and Private sector and OGD's

MEC: make the surface scheme an independent component



Atmospheric model (3D) with its own surface scheme (1D)



Atmospheric model (3D)

Adaptation of atmospheric model forcings

"On-line" mode

"Off-line" mode

Surface scheme (1D)

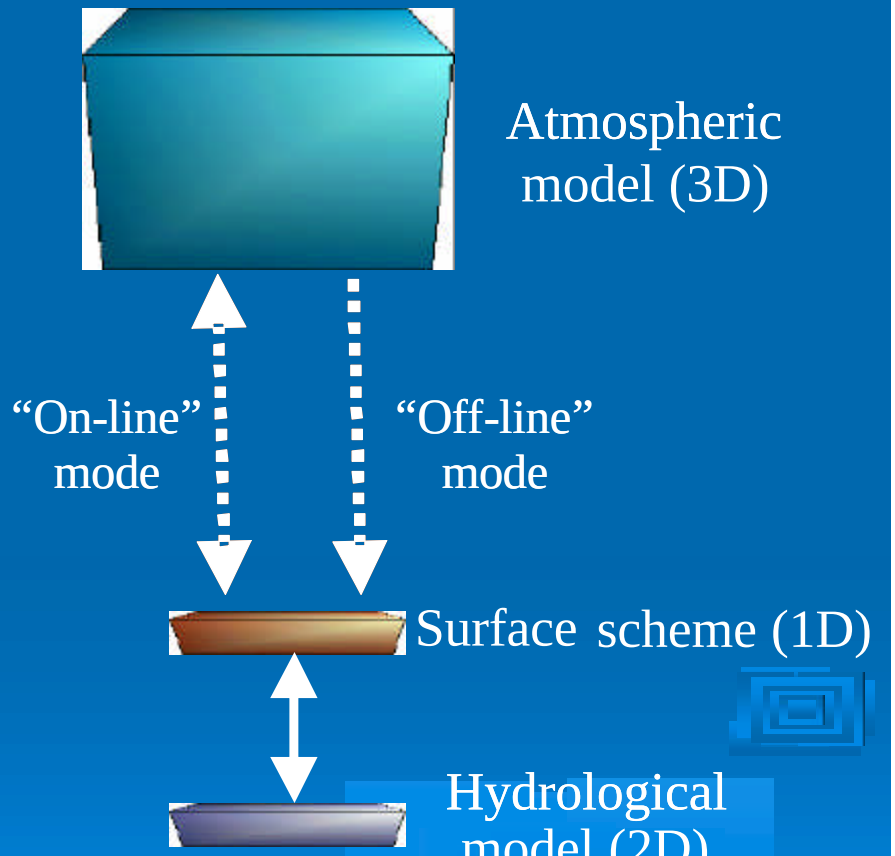
Hydrological model (lumped or 2D) with its own LSS

Hydrological model (2D)

- Built from the GEM atmospheric model driver
  - Benefits from all of the I/O pre- and post-processing software, including a powerful GUI for visualizing model outputs

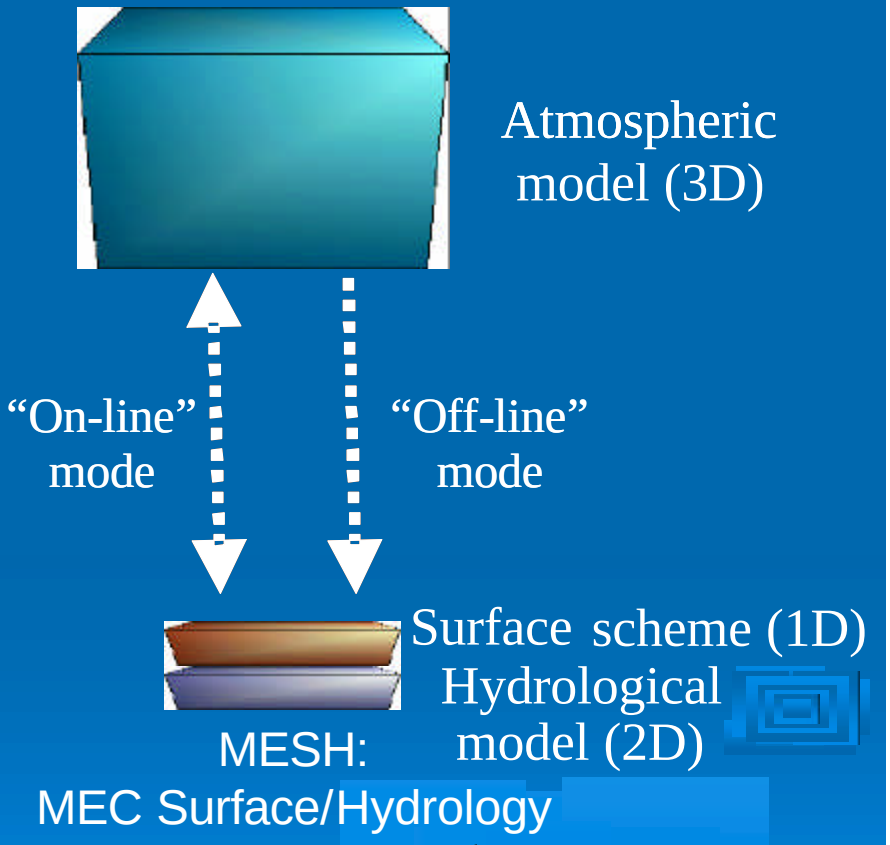
MEC: a hydrometeorologic model driver

- Models available within MEC:
  - Atmosphere: GEM
  - Surface: force-restore, ISBA, CLASS, WATFLOOD,Hydrotel, HBV(?)….
  - Hydrology: GRU approach based on WATFLOOD
- Uses MPI for parrallel processing
- It is quite simple to make surface/hydrological simulations offline at high resolution and over a large domain
  - e.g. with reanalyses or archived forecasts



MEC/MESH mode

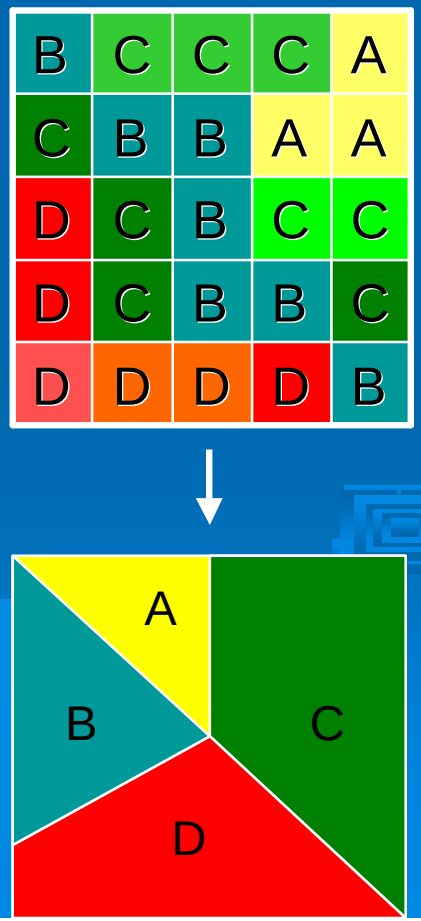
- The surface model is less costly to run than the atmospheric model, and can benefit from a higher resolution
  - It can be run at the resolution of the hydrologic model
  - The LSS and the hydrologic model can then be closely linked to better parameterize subgrid-scale processes
  - The atmospheric and hydrological models still share the LSS



MESH: A MEC surface/hydrology configuration designed for regional hydrological modeling

- Designed for a regular grid at a 1-15 km resolution
- Each grid divided into grouped response units (GRU or tiles) to deal with subgrid hetereogeneity
  - based on WATFLOOD

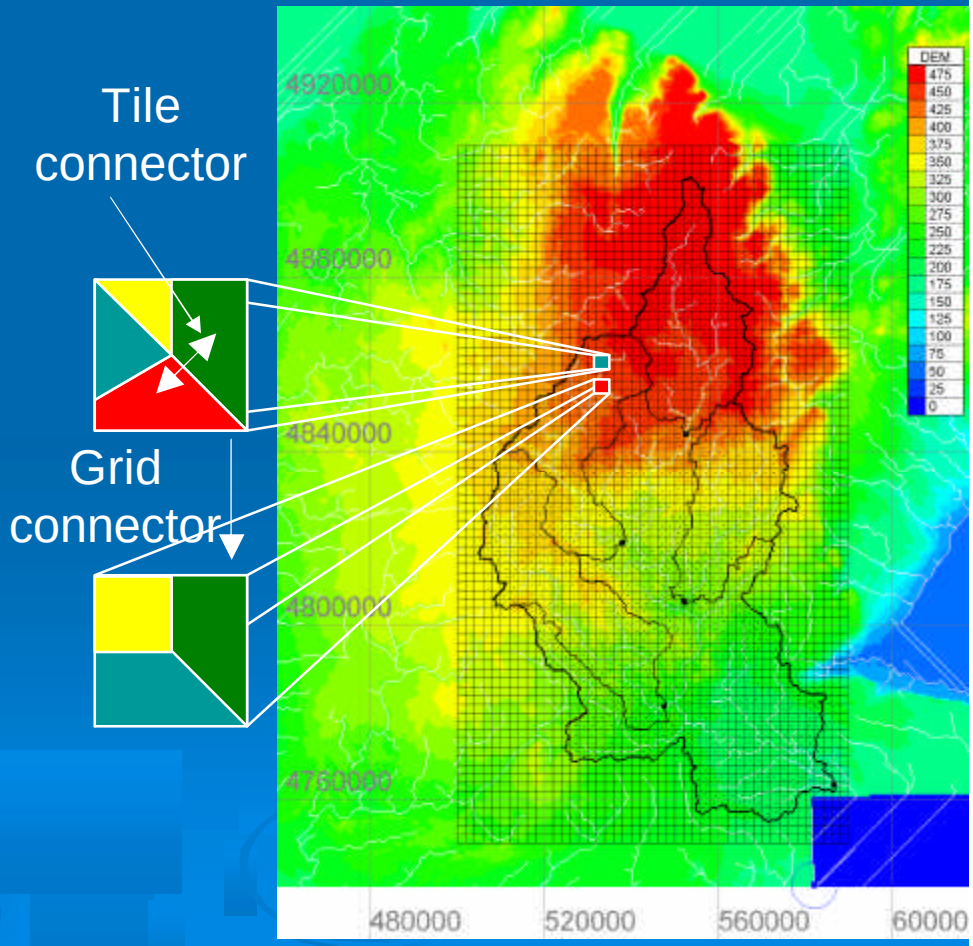
Sub-grid Hetereogeneity (land cover, soil type, slope, aspect, altitude)



A relatively small number of classes are kept, only the % of coverage for each class is kept

MESH: A MEC surface/hydrology configuration designed for regional hydrological modeling

- The tile connector (1D, scalable) redistributes mass and energy between tiles in a grid cell
  - e.g. snow drift
- The grid connector (2D) is responsible for routing runoff
  - can still be parallelized by grouping grid cells by subwatershed



Community Model

- MEC is available for download:
  - As the current version of MEC is a subset of the GEM atmospheric model driver, go to: http://collaboration.cmc.ec.gc.ca/science/rpn.com/
  - Then Click on « GEM »
  - Complete documentation for installing and running MEC available online

Canadian Land Surface Data Assimilation System (CaLDAS)

- Biases in energy and water stores can develop in coupled modeling systems due to forcing errors, and errors in model physics and parameters, and continue to grow in such self contained systems
- Uncoupled Land Data Assimilation Systems (LDAS) driven by observations and constrained by data assimilation have potential to more accurately depict land surface conditions
- Output benefits flood prediction, determination of observation needs and error criteria, improvement of land data assimilation and land surface models
- Numerical weather prediction (NWP) models should benefit from initialization with LDAS land surface states

Canadian Land Surface Data Assimilation System (CaLDAS)

ATMOSPHERIC FORCING

Meteorological Analyses
- low-level winds, temps, and humidity

Precipitation analyses
- meteorological forecasts
- precipitation from 4DVAR assimilation cycles or key analysis runs
- precipitation analyses from radar mosaics (at least US) and surface gauges

Radiation analyses
From 4DVAR assimilation analyses AND/OR
- Cloud analyses from satellite observations and met assimilation cycles
- 1D stand-alone radiation package to estimate downward solar and IR at the surface

ANCILLARY DATA

Ancillary data
- Vegetation types (USGS, ECOCLIMAP I (II), GLC2000)
- Soil texture (STATSGO, FAO)
- Water bodies
- Cities (NLCD, CMC)

Downscaling

OFF-LINE SURFACE MODELING SYSTEM

Land schemes ISBA, CLASS, MICA
Regional - North America (1-2 km)
Global (5-10 km)
Integrated on CMC's supercomputer

Transfer models (emission, backscatter, surface layer…)

OBSERVATIONS

Surface temperature
From remote sensing:
GOES, … (IR)

Vegetation
From remote sensing:
MODIS, AVHRR (NDVI)

Snow
(on land, sea-ice, and glaciers)
From remote-sensing:
SSM/I, MODIS (visible, MW)

Freeze/thaw
From remote-sensing:
QuikScat (Ku-band)
Hydros (L-band)
SSM/I (Microwave)

Soil Moisture
- low-level air characteristics
- IR heating rates
- C-band radiances
- L-band T_b and ?^{o} (Hydros)

The HEPEX Canada EPS

Multi-model ensemble (SEF + GEM)

- T149 for SEF, 1.2º for GEM
- A different parameterization is used for each member

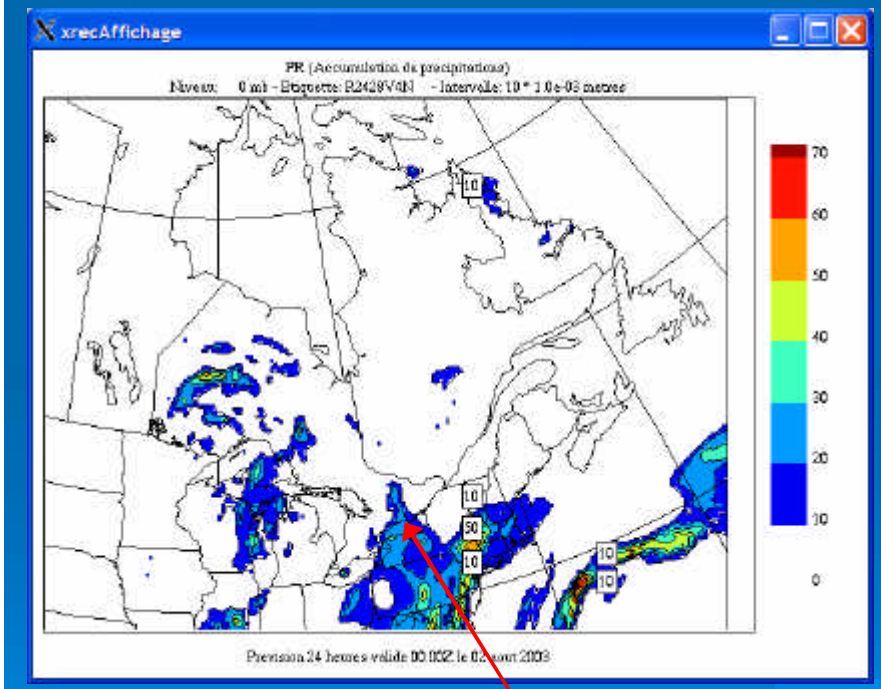
Since June 2001:

- 10 day runs once a day
- 8 perturbed runs from each model
- Surface scheme:
  - force-restore

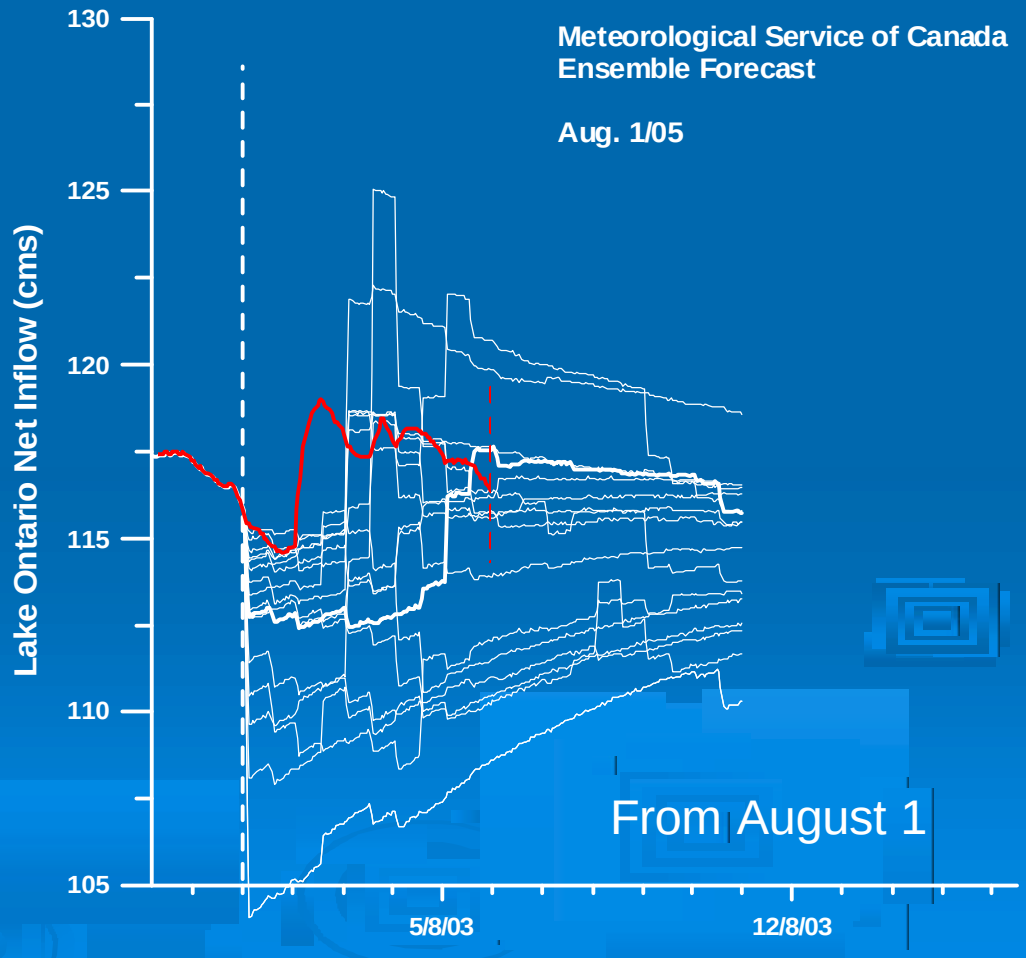
Starting January 2006:

- 15 day runs twice per day
- 10 perturbed runs from each model
- Surface scheme:
  - 10 members with F-R
  - 10 members with ISBA

Ensemble forecast of inflows into Lake Ontario, August 2003



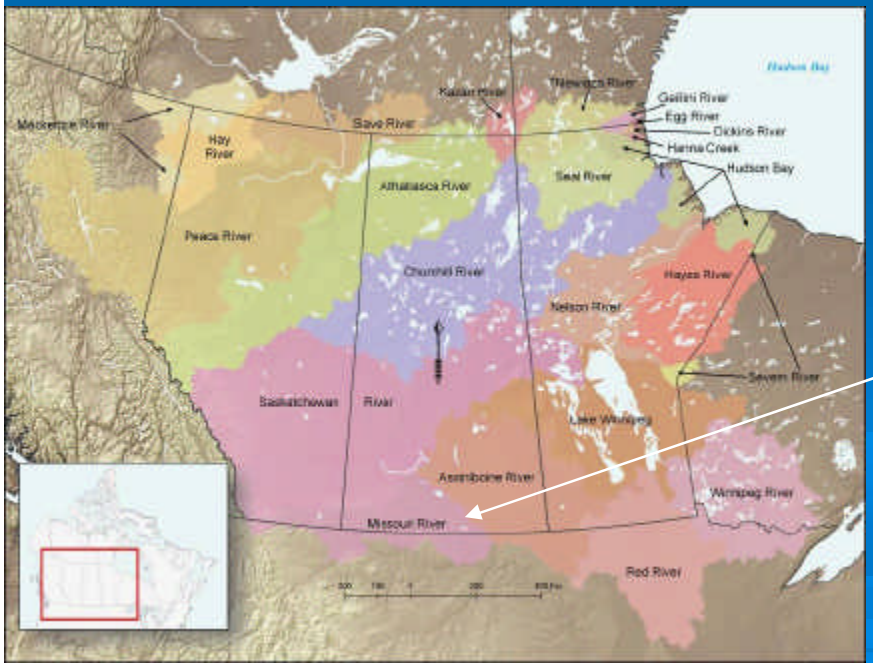
Lake Ontario



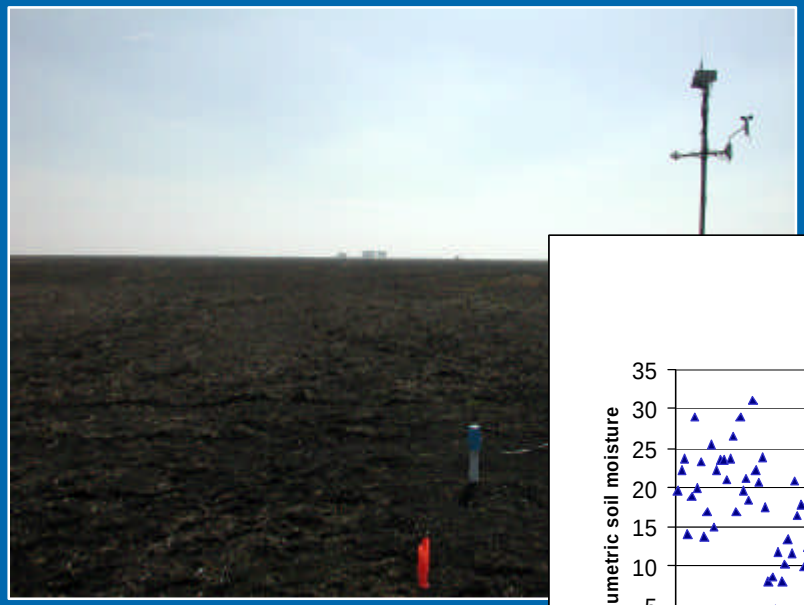
DRI STRATEGY

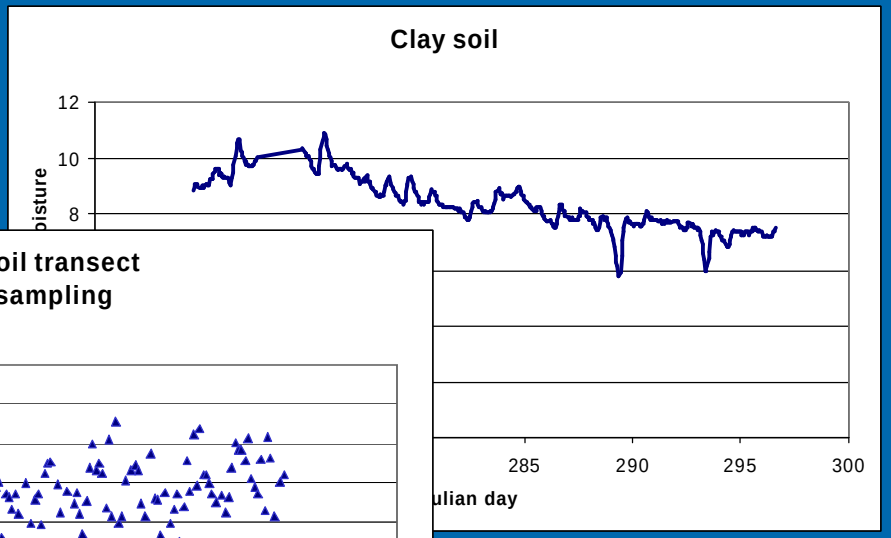
Physical-Dynamic Approach

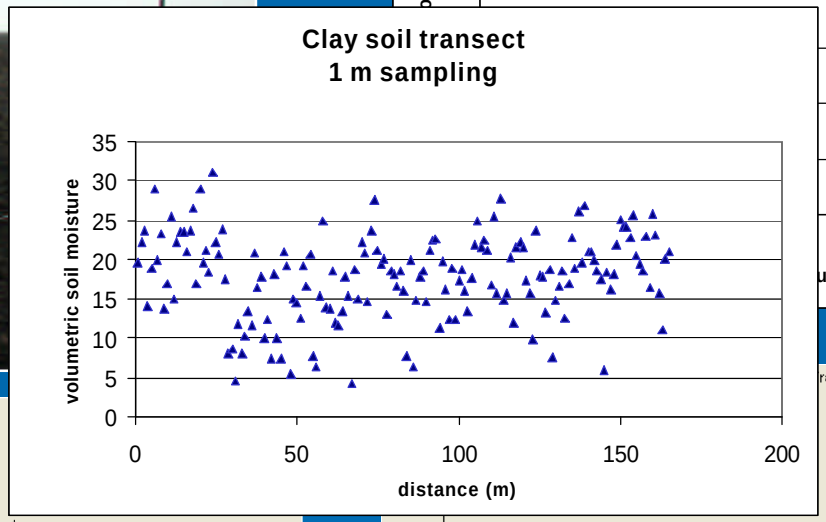
- **Improve understanding and model representation of processes**
- **Improve understanding and simulation of the whole system**
- **Contribute to better prediction**

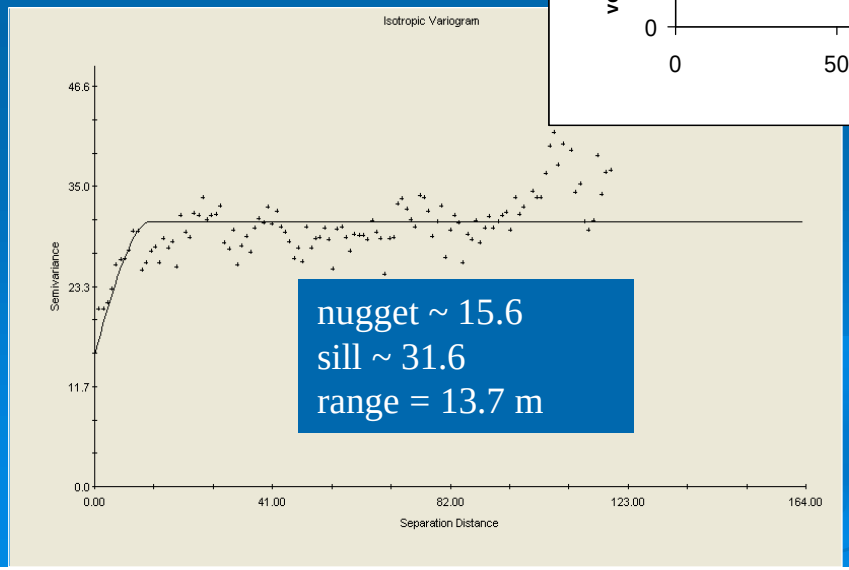


Southern Manitoba
(truly orographically challenged region)
clay soil

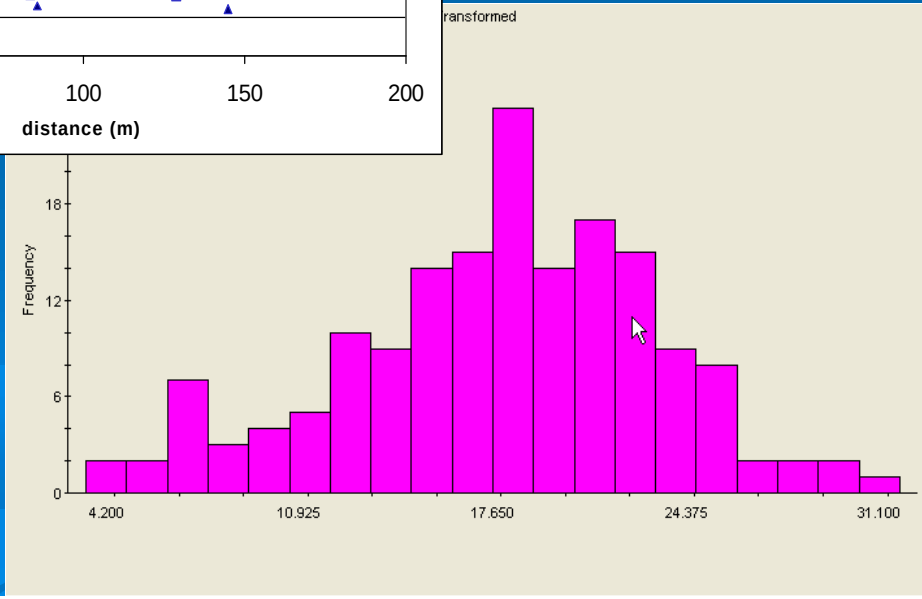




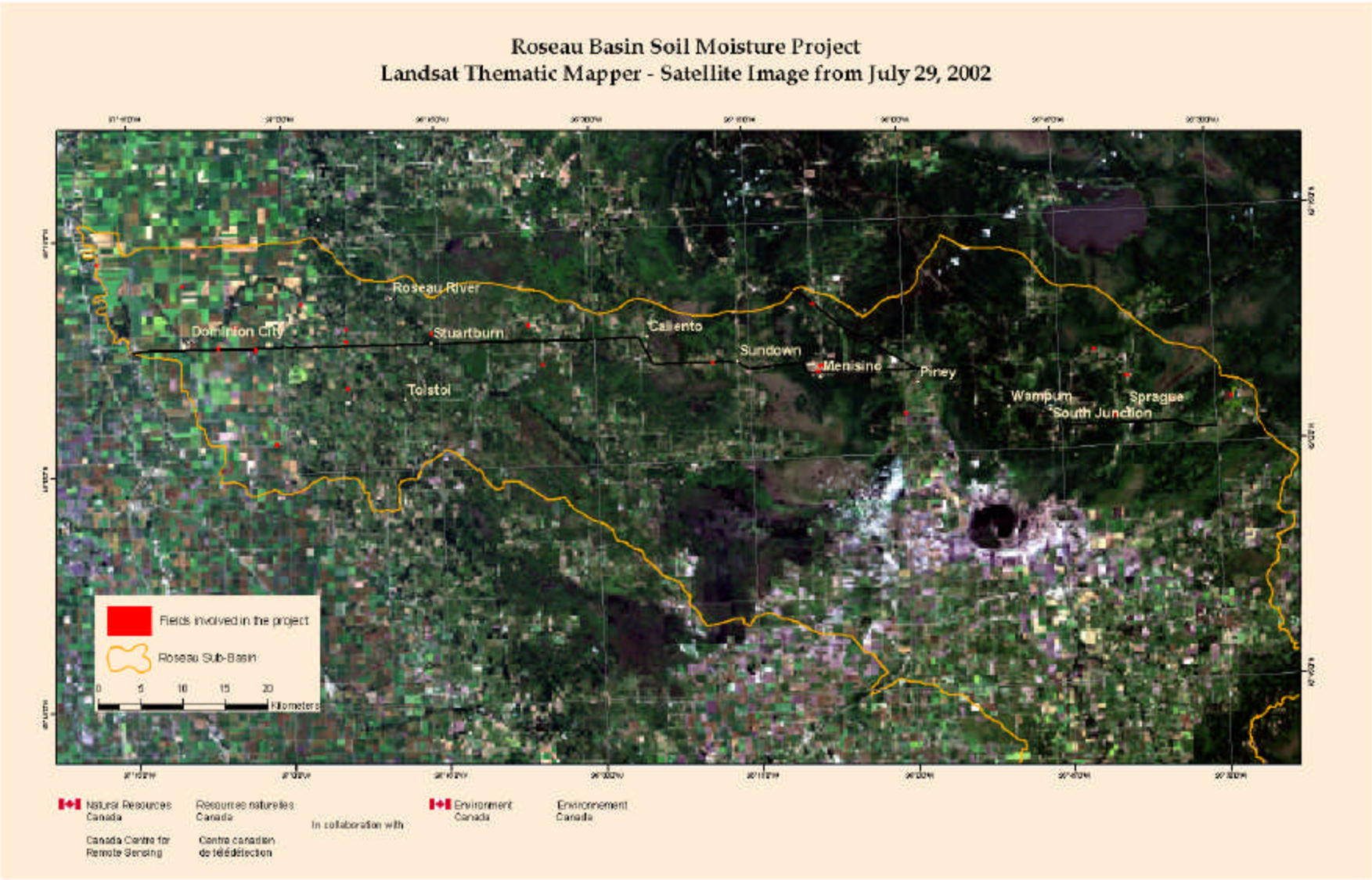




nugget ~ 15.6
sill ~ 31.6
range = 13.7 m



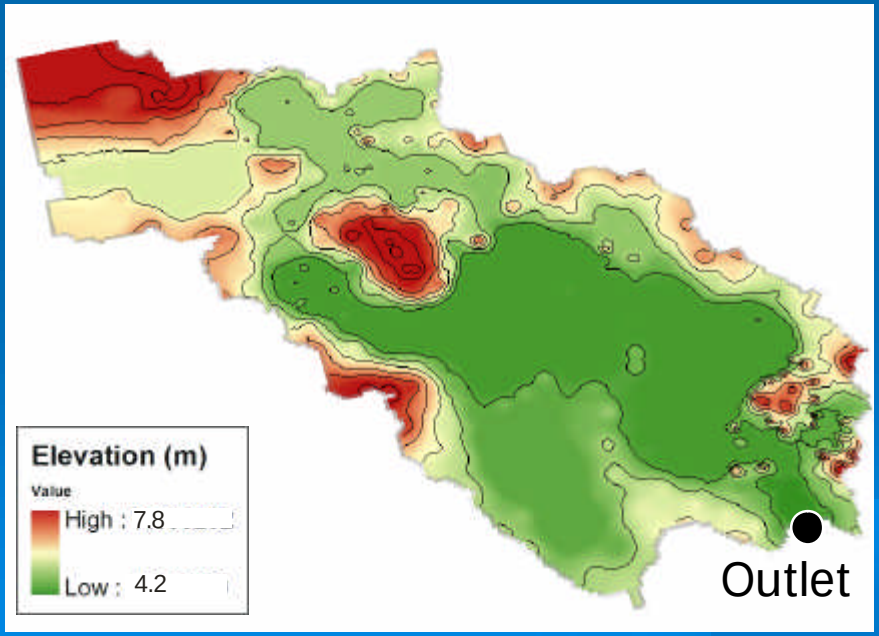
Now what ?


Roseau Basin Soil Moisture Project
Landsat Thematic Mapper - Satellite Image from July 29, 2002
Roseau River
Dominion City
Stuartburn
Tolstoi
Caliento
Sundown
Menisino
Piney
Wampum
Sprague
South Junction
Fields involved in the project
Roseau Sub-Basin
0 5 10 15 20
Kilometers
Natural Resources Canada
Canada Centre for Remote Sensing
Ressources naturelles Canada
Centre canadien de télédétection
In collaboration with
Environment Canada
Environnement Canada

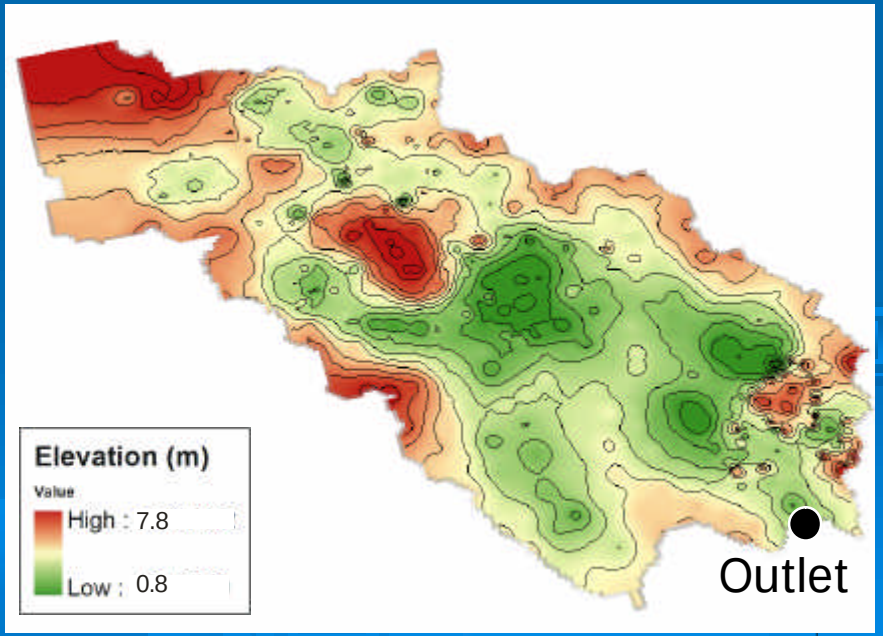
Contributing area

- The portion of a drainage basin which might be expected to entirely contribute runoff to the outlet.
- Varies in relation to the size of the runoff event.

Basin with 100% contributing area

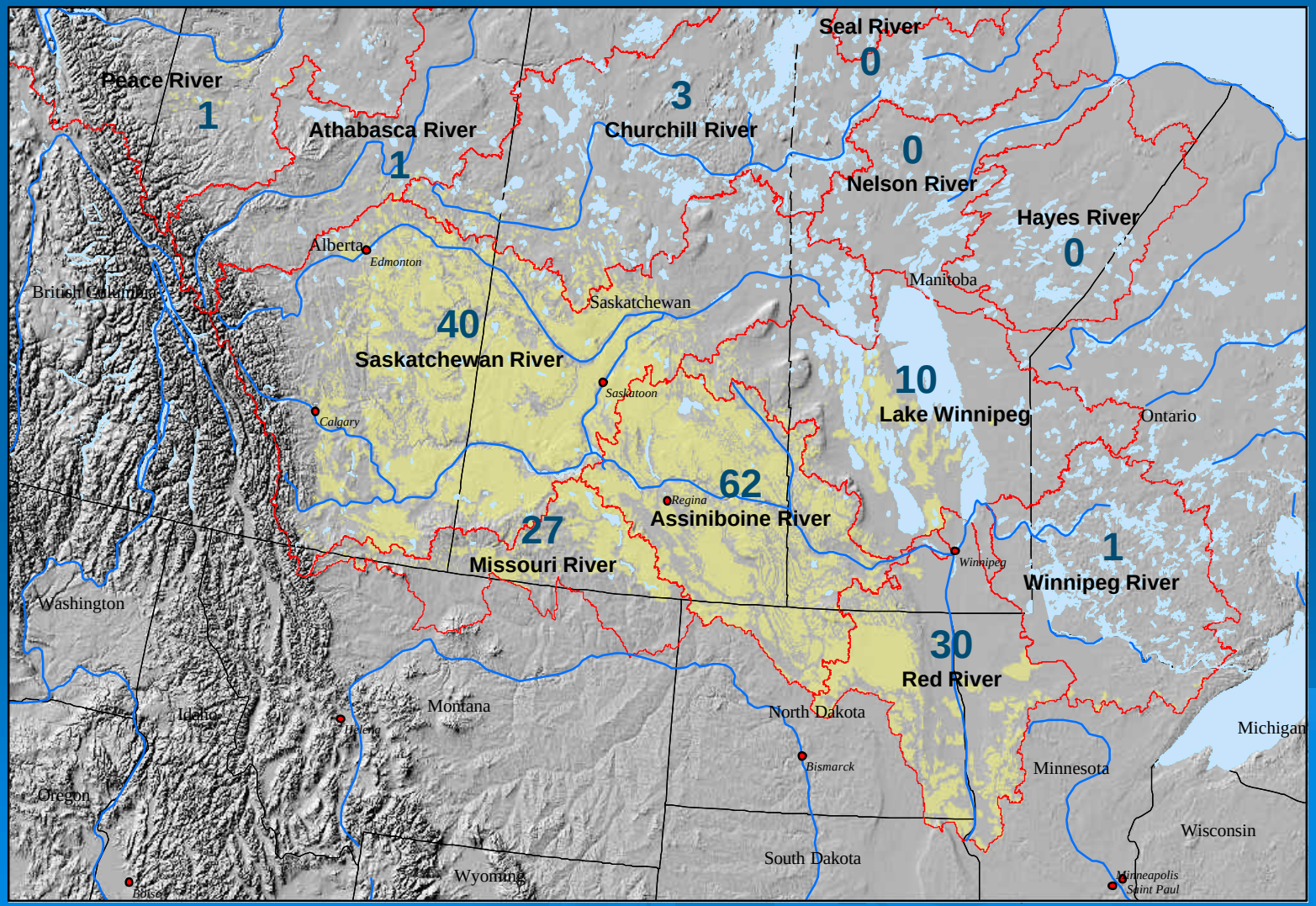


Basin with 0% contributing area



Non-contributing areas

- mean annual runoff -



Source: Non-contributing area - Agriculture and Agri-Food Canada, P.F.R.A.
Elevation data - Environmental Systems Research Institute

HAL/RPN lab Involvement (what we want to achieve)

- Hydromet Aspects
  - Taylor, Davison, Goodson, Spence, Belair,Fortin, Pellerin, Verseghy
    - Establish GEM-LAM domain
    - Field verification for CaLDAS and NWP
      - Latent and sensible heat flux
      - Soil moisture
      - SWE
  - CLASS model parametrization for prairie environment
  - phenology
  - Improved NWP forecast
- Product development under CalDAS/NWP and MESH for use by operational agencies

HAL/RPN lab Involvement (what we want to achieve)

- Hydrological Aspects
  - Davison, Goodson, Spence,Fortin, Pellerin, Verseghy
    - MESH domain (same as GEM-LAM)
  - MESH/CLASS model parametrization for prairie environment
  - Improved hydrological prediction and representation
  - Scaling of non-contributing areas
  - Groundwater (coupling)
- Product development under CalDAS, NWP and MESH for use by operational agencies

HAL/RPN lab Involvement (what we want to do)

- Hydromet Aspects (with partners)
  - Establish additional field site for validation of NWP (soil moisture and ET)
  - Phenology into CLASS
  - Off line testing of MESH in prairie domain
    - Land-surface variables.
- Hydrological Aspects (with partners)
  - Parameterize MESH for prairie runoff
  - Incorporate dynamics of non contributing areas.
  - scaling

HAL/RPN lab Involvement (How it will fit)

- How will it fit
  - Community based models for MESH can be used by all DRI partners
  - Saskatoon Cluster can be made available to individual PI for testing GEM-LAM runs
  - We expect that findings in DRI will be vetted through EC and operationalized.
  - ISO9001 standardization for MESH
  - Access to selected and archived data.
  - Training for DRI partners in running GEM-LAM and MESH.
  - Benefits to the HAL Agromet product development.