GLOBAL WATER FUTURES
SOLUTIONS TO WATER THREATS IN AN ERA OF GLOBAL CHANGE

Pursuing reliable HOURLY nutrient predictions in cold regions

The coupling of CRHM to an extended version of WINTRA

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Research Team

GWF project: Agricultural Water Futures in Canada: Stressors and Solutions

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Modeling

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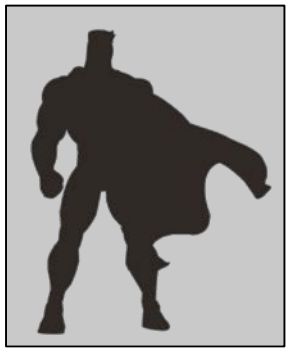

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Can we predict nutrient transport in cold climates?

1) *time step* (snowmelt period is short but may be critical),

2) *runoff-soil contact representation* (causing discontinuities in nutrient supply, e.g. frozen soils, tillage, fractional snowcover depletion),

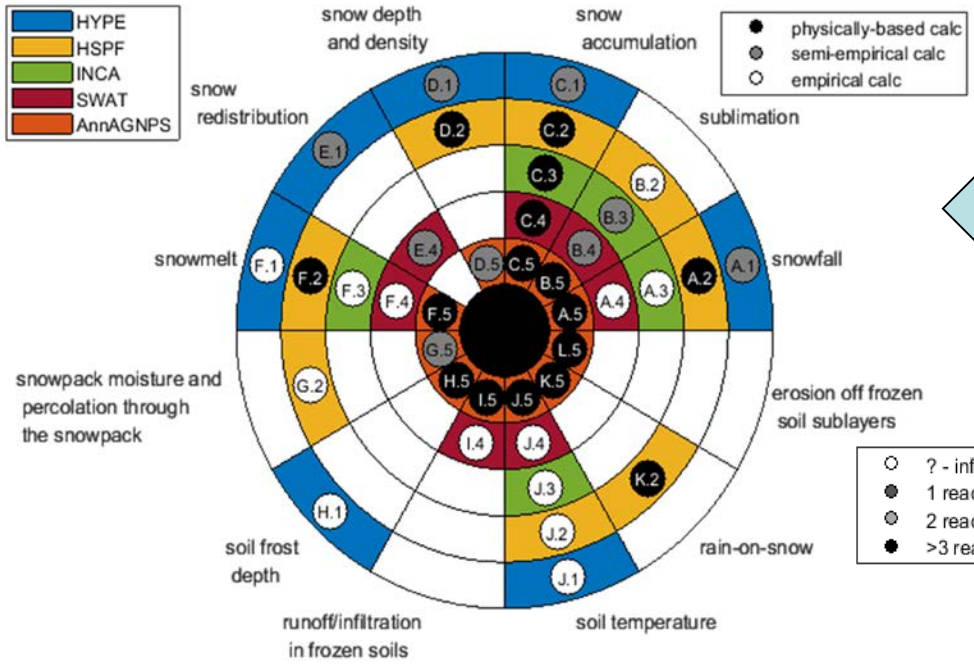
3) winter transformations (e.g. nutrient dynamics under lake ice)

4) over-parameterization, but still simplifications of reality, (equifinality phenomena)

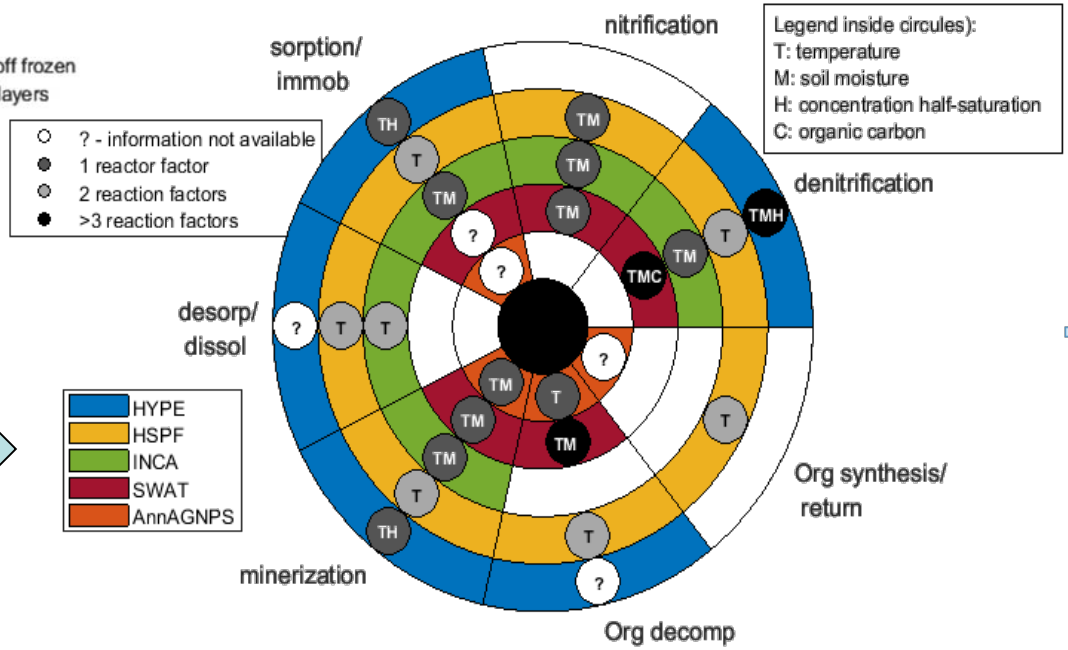
5) simulation of (hydrological) transport (e.g. blowing snow, infiltration/runoff during snowmelt, frozen soils, wetland drainage, variable contributing areas), and

6) applications (e.g. lack of critical evaluation of their performance in these cold/seasonally snowcovered agricultural environments)

Existing catchment nutrient models and where they might fail



Cold Region's Hydrology



Biogeochemistry

Costa, D., Pomeroy, J., Baulch, H., Elliot, J., and Wheater, H., (In Preparation) Prediction of nutrient export from cold agricultural regions: a review

Past/Current work at UofS

Snowpack:

1. PULSE (1D)
2. SMPP-PULSE (2D)

Snowpack + Soil (field):

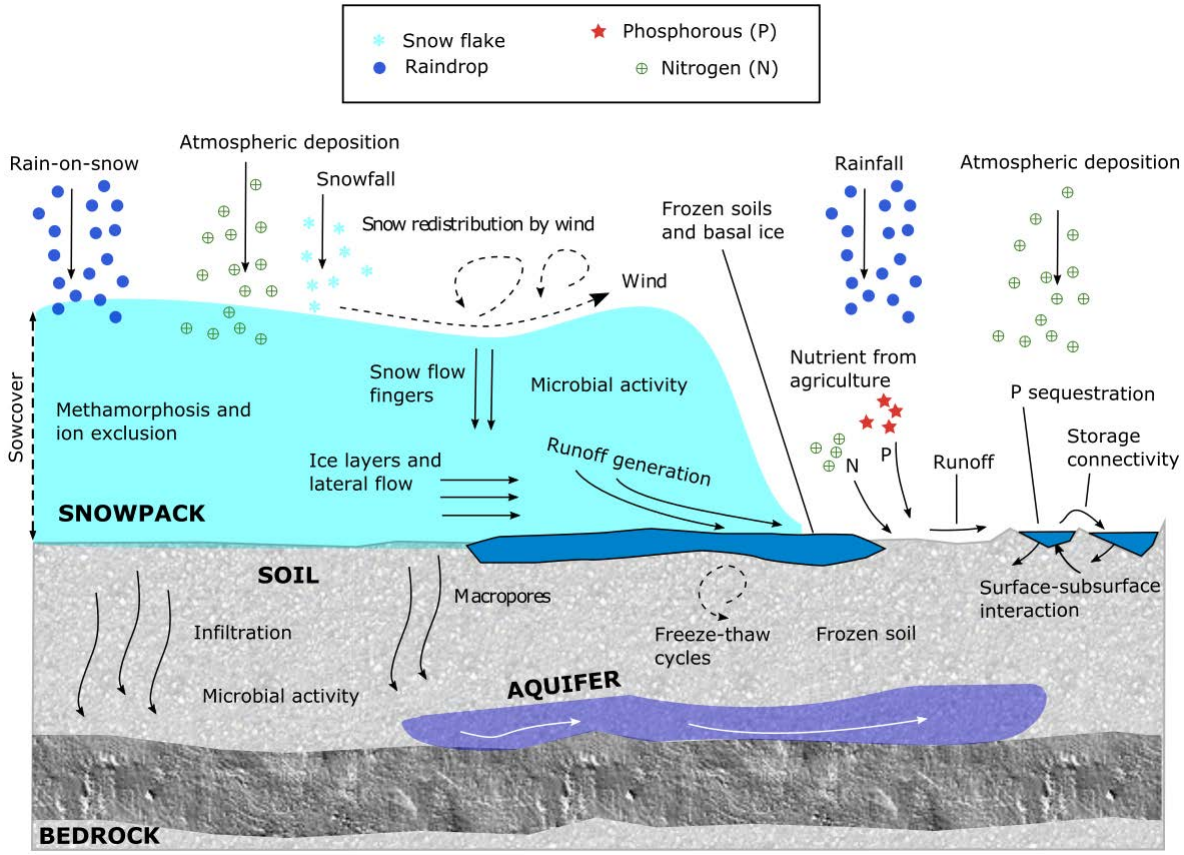
3. CRHM – WINTRA

Soil + Depress. St.:

4. CRHM – "Wetland MATLAB"

All (catchment scale)

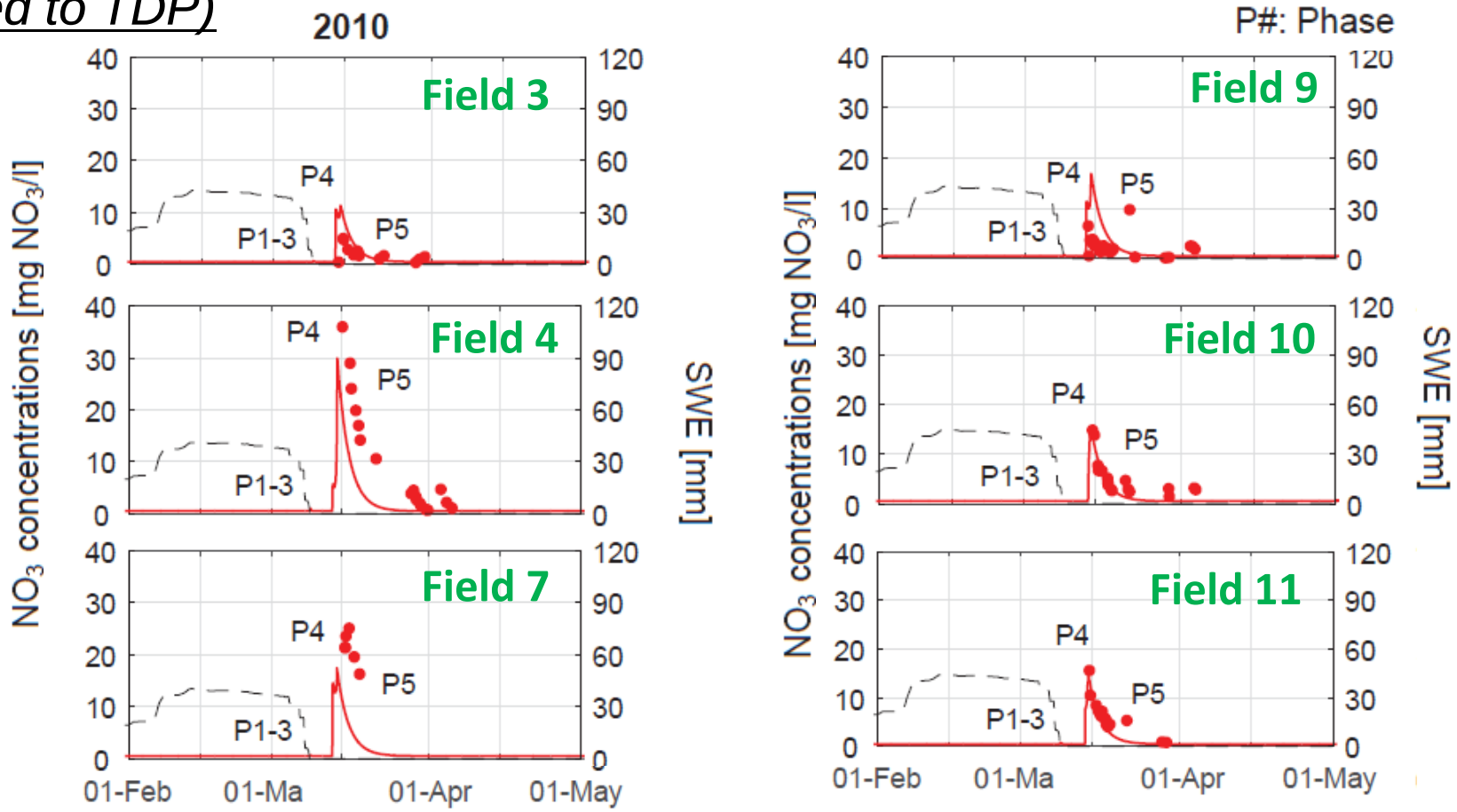
5. CRHM-WQ modules



Taking into consideration:
PULSE, WINTRA, and HYPE's water quality modules

WINTRA, PULSE, CRHM-WQ (hourly)

***EOF**: Application to South Tobacco Creek, Manitoba (NO3, but also extended to TDP)*



Costa, D., Roste, J., Pomeroy, J., Baulch, H., Elliot, J., Wheater, H., and Westbrook, C. J. (2017). A modeling framework to simulate field-scale nitrate response and transport during snowmelt: the WINTRA model. Hydrological Processes

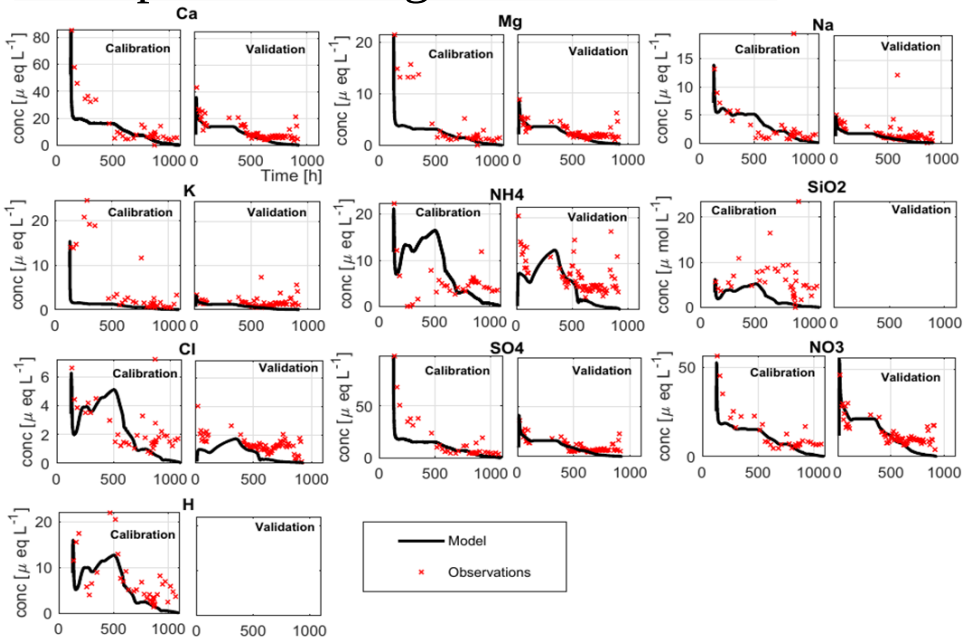
Costa, D., Pomeroy, J., Baulch, H., Elliot, J., and Wheater, H. (Submitted). Investigating the dominant climate, soil, and human controls of snowmelt nutrient export in agricultural regions: development and testing of an

WINTRA, PULSE, CRHM-WQ (hourly)

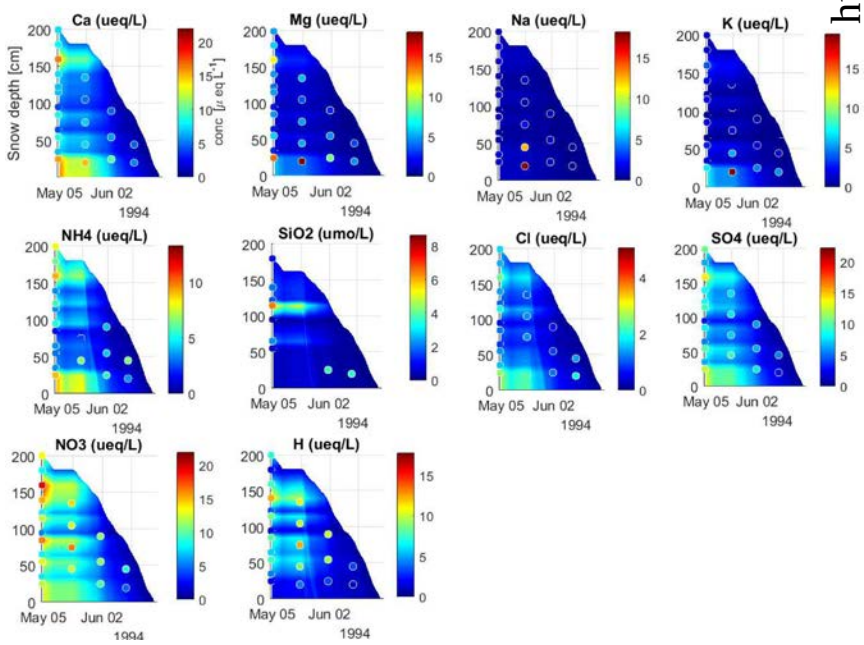
The Loch Vale Watershed is located in Rocky Mountain National Park, Colorado.

https://www.flickr.com

Snowpack discharge concentrations



In-Snow concentrations

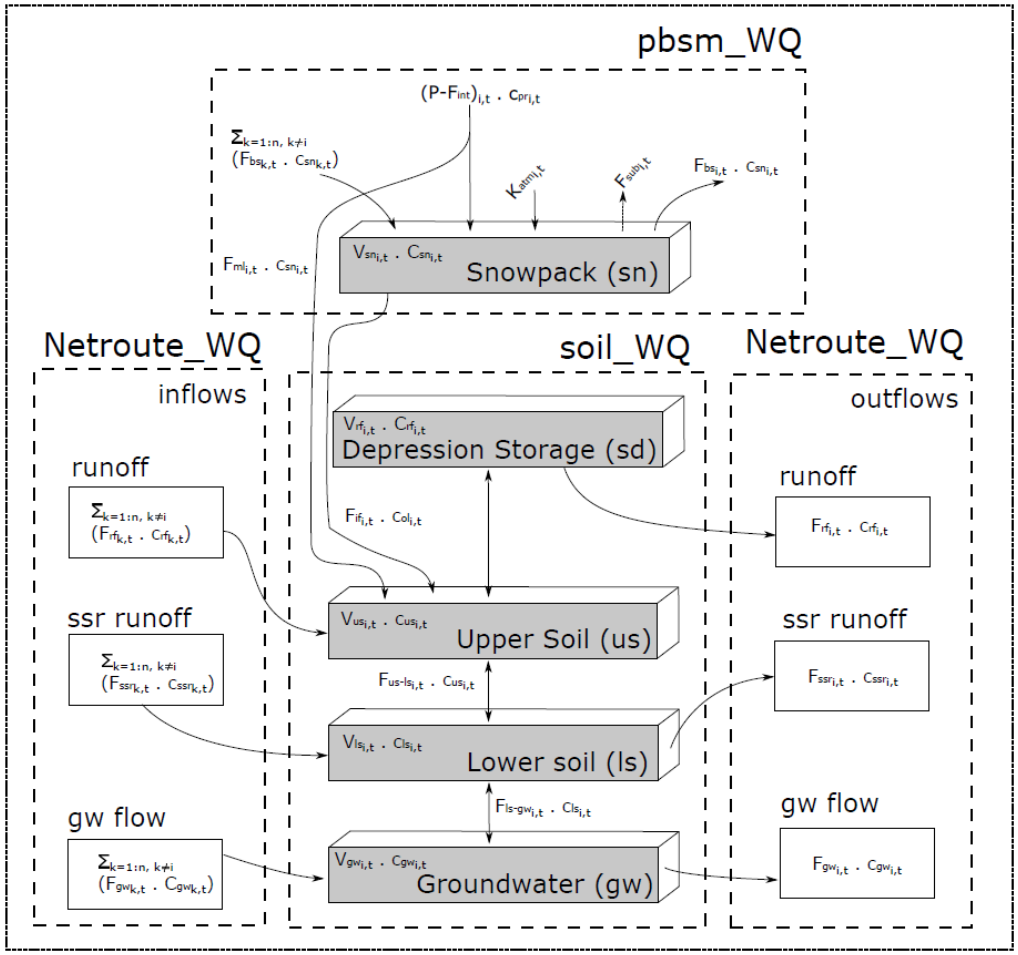


Costa, D., Pomeroy, J. W., and Wheater, H. S. (Under Review). A numerical model for the simulation of snowpack solute dynamics to capture runoff ionic pulses during snowmelt (Advances in Water Resources)

WINTRA, PULSE, CRHM-WQ (hourly)

Solute mass balance and Transport:

HRU i



Subscripts:

Discretization

i	space (HRU)
t	time

Domain

sn	snow
ol	overland
ssr	sub-surface reservoir
us	upper soil
ls	lower soil
gw	groundwater

Processes

pr	precipitation
rf	rainfall
sf	snowfall
bs	blowing snow
int	interception
inf	infiltration
evp	evaporation
$evpt$	evapotranspiration
ml	melt

Variables:

V	volume $[L^3]$
F	flux $[L^3T^{-1}]$
c	concentrations $[ML^{-3}]$

Input-Variables:

P	precipitation $[L^3T^{-1}]$
K_{atm}	atmospheric deposition $[MT^{-3}]$
c_{sf}	snowfall concentration $[ML^{-3}]$

MODULES:

SNOW:
Module: pbsm_WQ

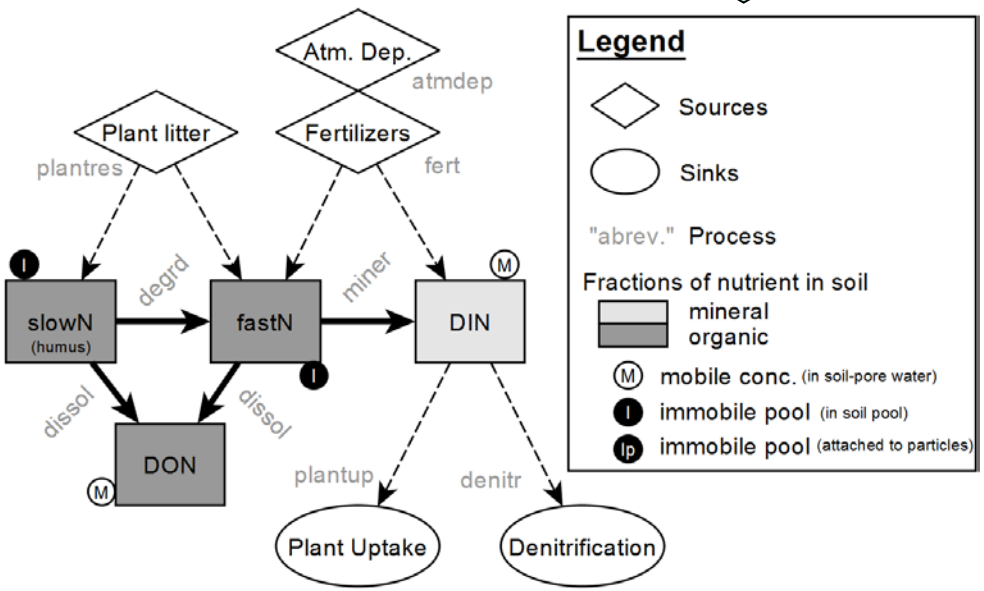
SOIL:
Module: soil_WQ

STREAM ROUTING:
Netroute_M_D_WQ

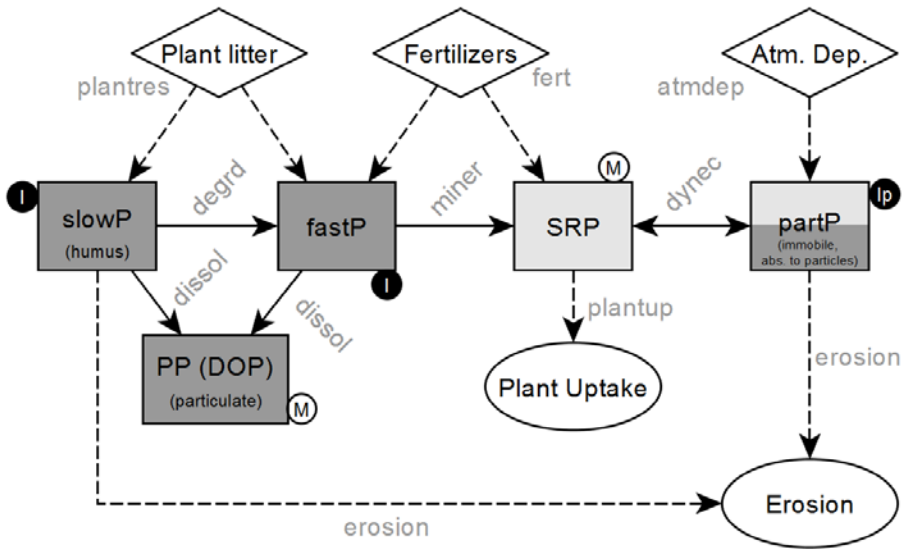
WINTRA, PULSE, CRHM-WQ (hourly)

Soil Processes

Nitrogen (N)



Phosphorous (N)

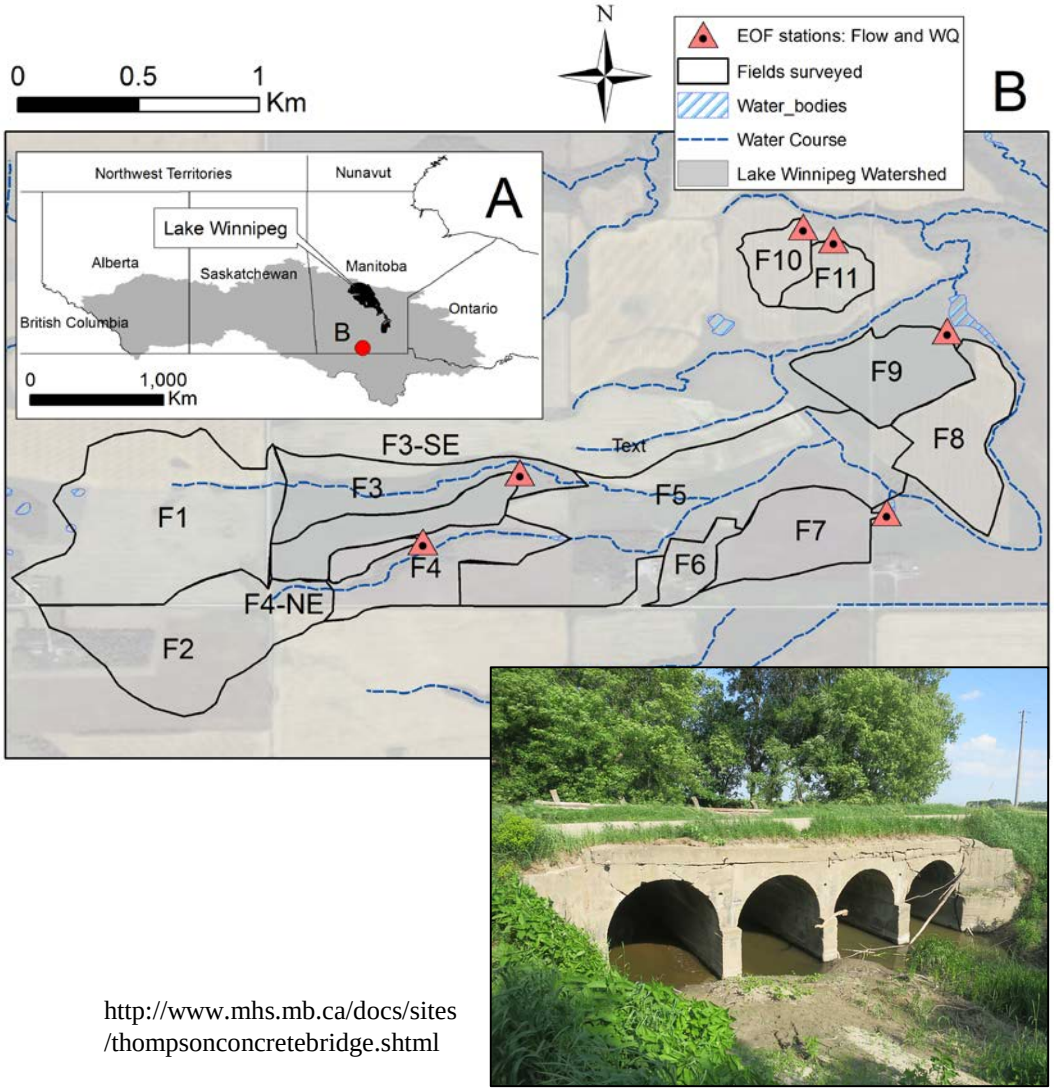


Rivers and lakes

a) Fast flowing (upper) layer

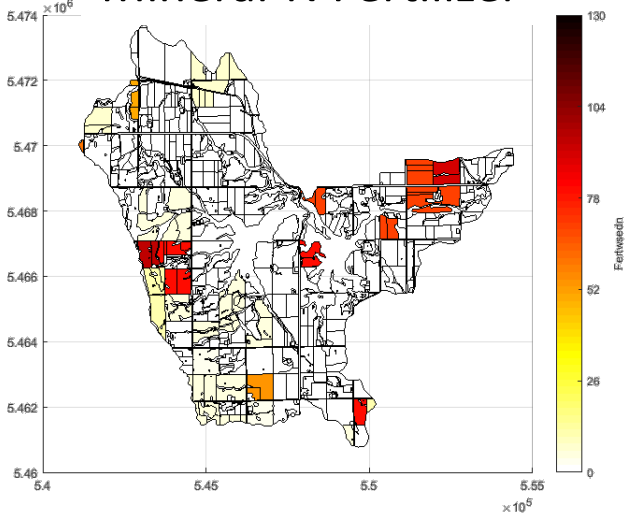
b) Slow-flowing (lower) layer

Model testing/application: South Tobacco Creek (STC) watershed, Manitoba

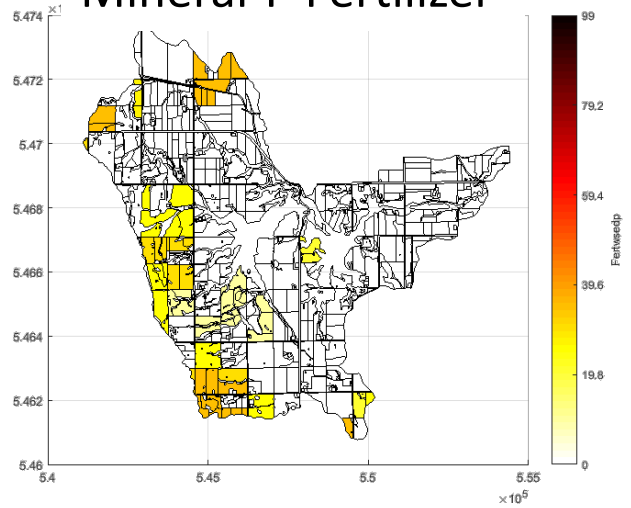


http://www.mhs.mb.ca/docs/sites/thompsonconcretebridge.shtml

Mineral-N Fertilizer

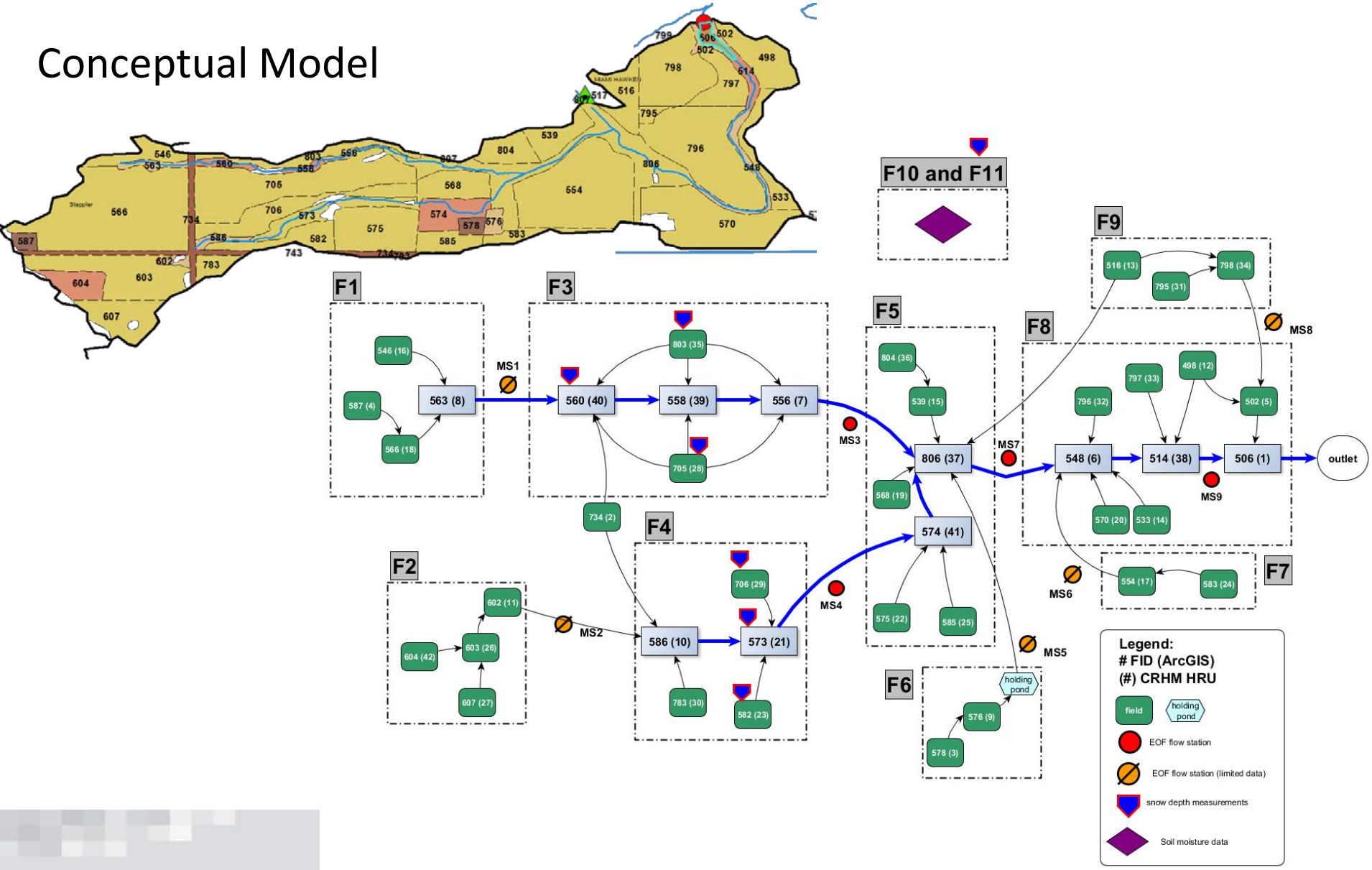


Mineral-P Fertilizer



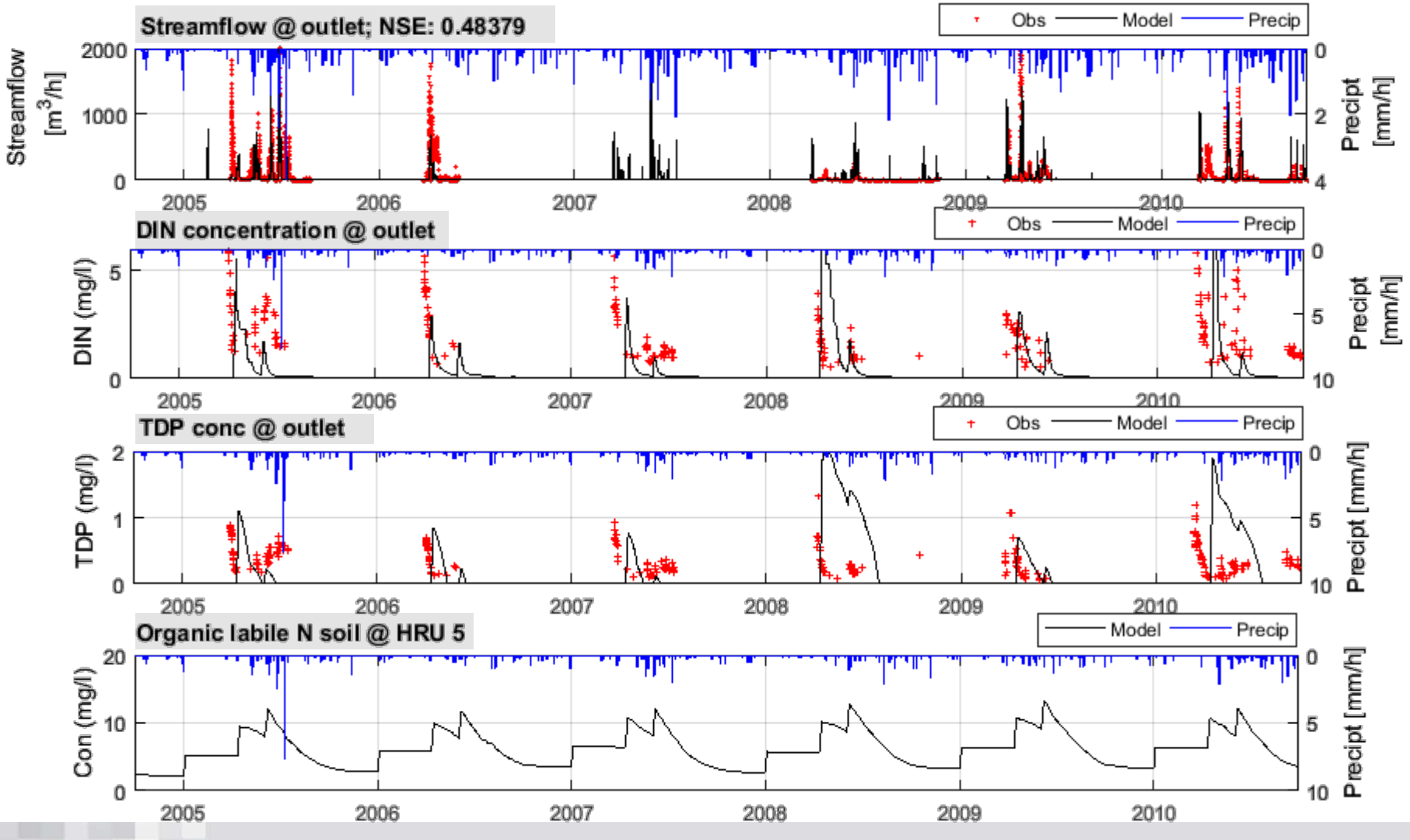
Model testing/application: South Tobacco Creek (STC) watershed, Manitoba

Conceptual Model



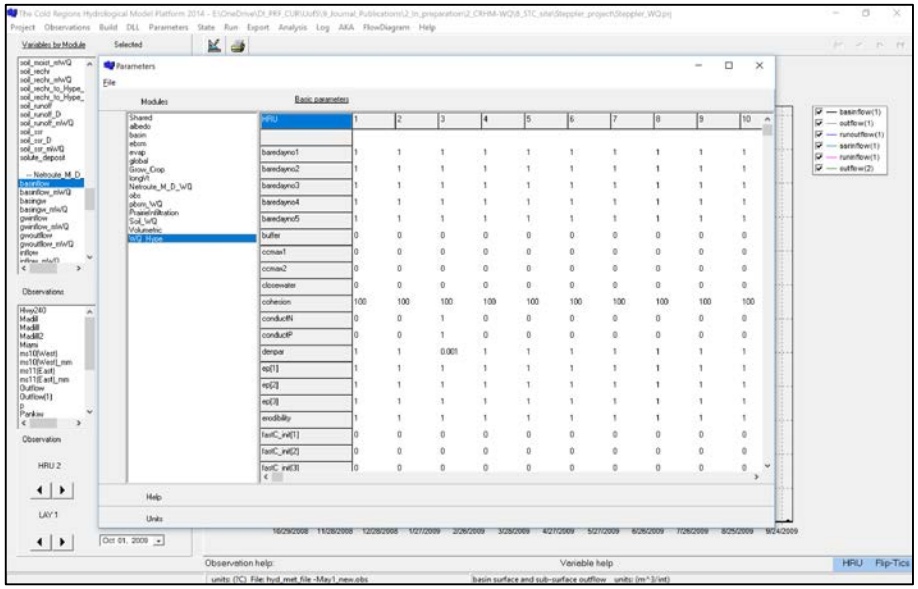
Model testing/application: South Tobacco Creek (STC) watershed, Manitoba

Demonstration of the model (using random parameter values)

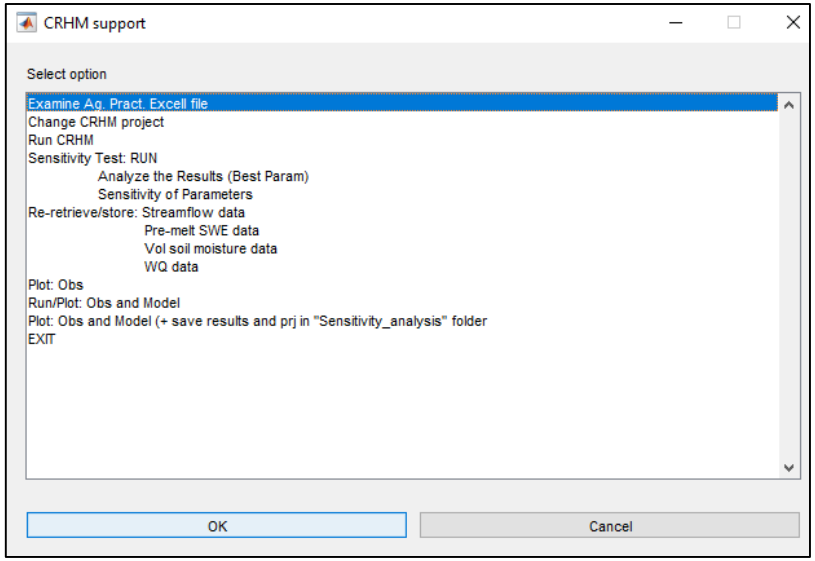


CRHM's WQ modules & Supporting tool

The CRHM platform with WQ modules



Supporting tool



https://www.cartoonstock.com/directory/l/low-cost.asp

1. Setup project
2. Run CRHM (from Command Line)
3. Sensitivity Tests
4. Analyze data for model setup
5. Plot observations against model results

Some Research Questions

- *Nutrient legacies*
- Agricultural practices
- *Climate change & climate sensitivity (temperature, ice)*
- Inter-basin exchange & internal nutrient loading

ACKNOWLEDGEMENTS

- Global Water Futures (GWF)
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- Agriculture and Agri-Food Canada (AAFC)
- Environment and Climate Change Canada (ECCC)

Thank you.

Q&A