Non-point source modelling (HYPE and future of MESH/CHM)

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

Problems with existing models

- Deficiencies in existing simulation tools for the prediction/forecast of nutrient exports in seasonally snowcovered areas are related to:

1) *time step* (snowmelt period is short but critical, particularly in the Prairies),

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 in ice-covered wetlands)

4) heavily simplified and over-parameterized, (associated with parameter nonidentifiability and equifinality phenomena)

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

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

There is need for…

multi-scale models of water quality suitable for agricultural cold regions where snowmelt and frozen ground as well as agricultural practices such as tillage and wetland drainage impact hydrochemistry

improved simulation of nutrient exports during the short but crucial snowmelt period

improved tools to evaluate beneficial management practices and support regional water quality modelling.

The HYPE model (developed by the Swedish SMHI)

- **Advantages**

1. Focus on cold regions
2. Focus on agricultural environments
3. Coupled hydrological and nutrient simulations (N, P, and C)
4. Has been successfully applied to cold climates (not in the Prairies)

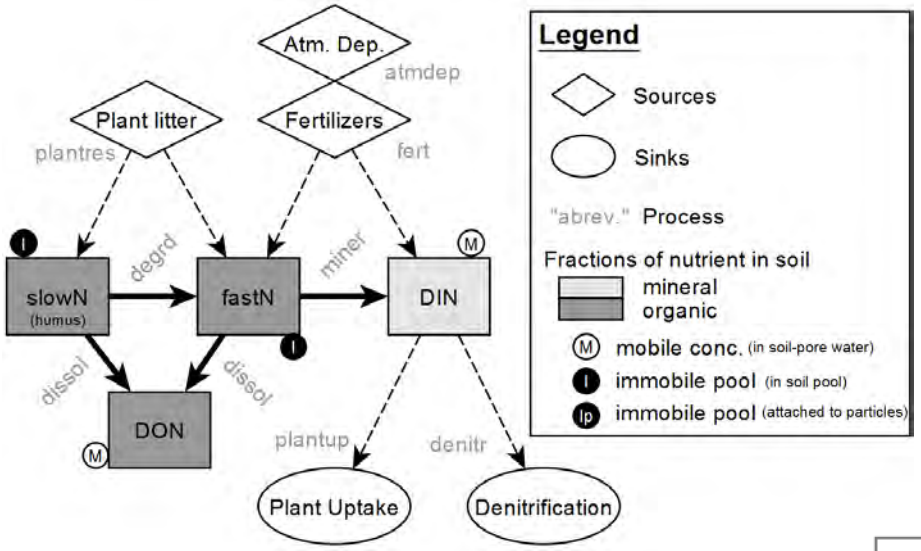
hypeweb.smhi.se/

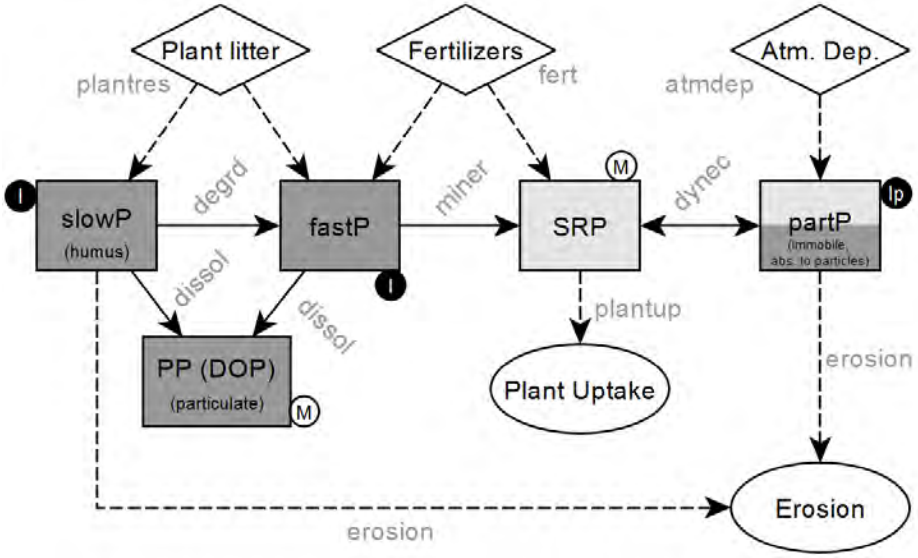
- **Some shortcomings**

1. Lacks representation of some important processes (e.g. blowing snow, infiltration/runoff transport in frozen soils, winter nutrient transformations)
2. Default daily timesetps (smaller time steps are critical for snowmelt simulations - uncertainty on the model performance at such time intervals)
3. Lack of modularity – there is no consistent separation between hydrological and transport and water quality modules, which hinders its coupling with "more adequate" background hydrological models (e.g. CRHM, MESH, CHM)

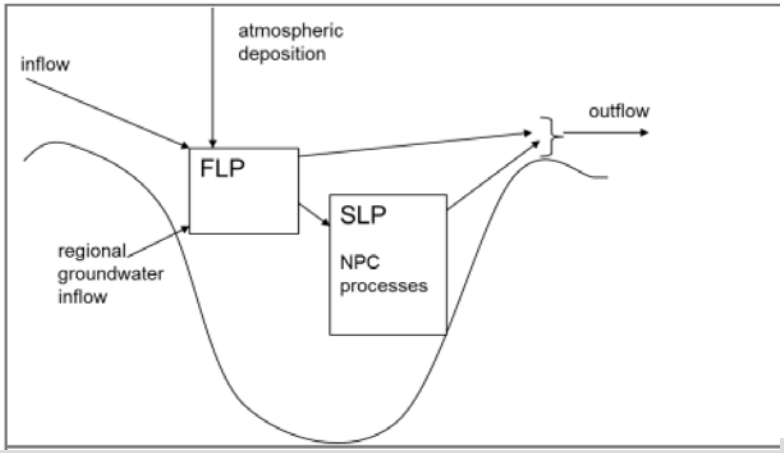
The HYPE model (developed by the Swedish SMHI)

- **Soil Processes**





- **Rivers and lakes**
  - a) Fast flowing (upper) layer
  - b) Slow-flowing (lower) layer



Recent advances on nutrient modelling

Snowpack:

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

Snowpack + Soil (field):

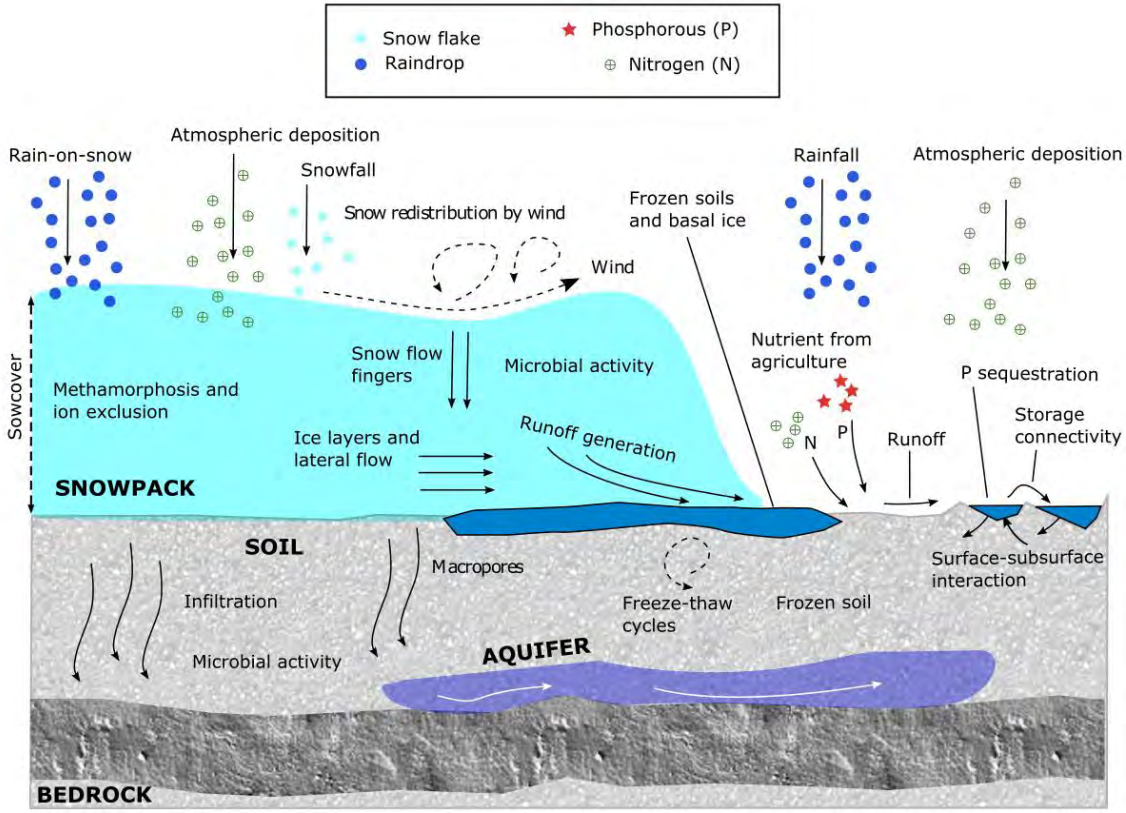
3. CRHM – WINTRA

Soil + Depress. St.:

4. CRHM – "Wetland MATLAB"

All:

5. CRHM-WQ modules



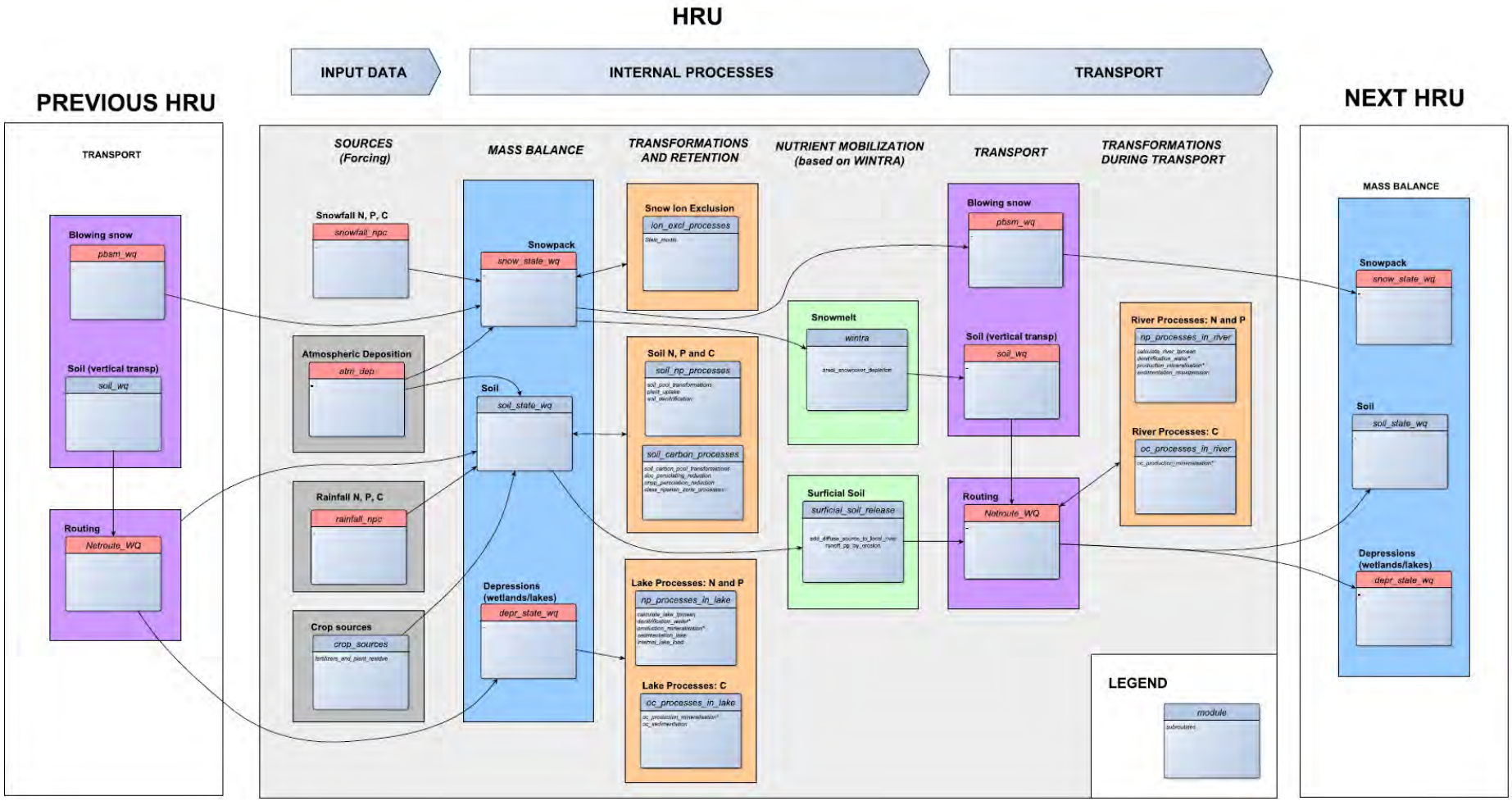
Taking in consideration the good insights of HYPE's water quality modules

CRHM-WQ (inspired by HYPE and WINTRA)

Model Classes:

- **SOIL** (*mobile-dissolved/particulate and immobile-pools*)
  - ***Runoff_pp_by_erosion*** (calculate_erosion, calculate_transport)
  - ***Soil_NP_processes*** (croip_sources, soil_pool_transformations, plant_uptake, soil_denitrification)
  - ***Soil_carbon_processes*** (soil_carbon_pool_transformation)
  - ***Balance_Spsoil*** (freudlich)
- **LAKES**
  - ***NP_processes_in_lakes*** (calculate_lake_tpmean, denitrification_water, production_mineralization, sedimentation_lake, internal_lake_load)
  - ***OC_processes_in_lakes*** (oc_production_mineralization)
- **RIVERS**
  - ***NP_processes_in_river*** (calculate_river_tpmean, sedimentation_resuspension)
  - ***OC_processes_in_river*** (oc_production_mineratization)

CRHM-WQ (inspired by HYPE and WINTRA)



Previously, in the WINTRA algorithm…

We addressed some of the problems identified:

a) Time step: hourly

b) Runoff-soil contact: controlled by the snow cover areal depletion factor

c) Adequate simulation of transport: Cold regions processes (CRHM)

d) Reduce the number of parameter to avoid parameter equifinality: only used 2 parameters for simulation of nitrogen

These findings will be integrated in the new water quality modules being developed within CRHM platform (CHRM-WQ).

Costa D, Roste J, Pomeroy J, et al. A modelling framework to simulate field-scale nitrate release and transport during snowmelt: the WINTRA model. Hydrological Processes. 2017.

Thank you.

Q&A

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