



MESH

Overview and development updates



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Active users and collaborators



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Environment and
Climate Change Canada

Environnement et
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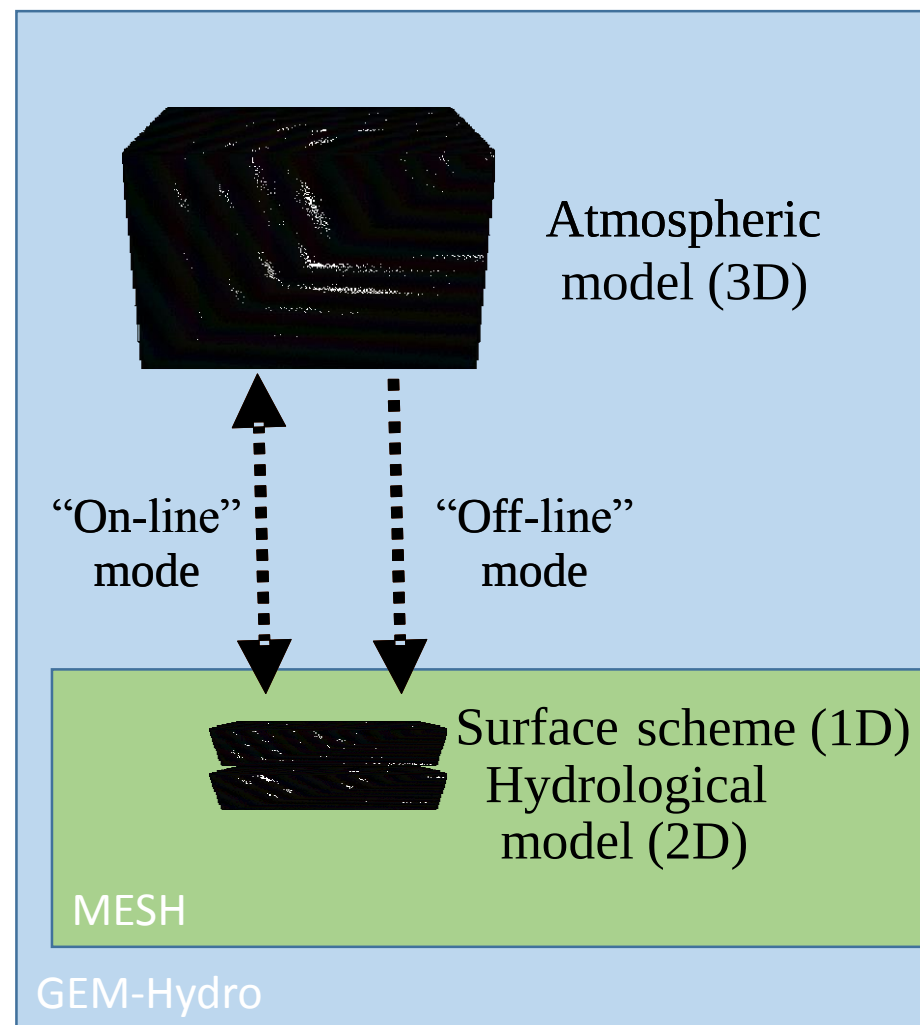
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Bruce Davison, Al Pietroniro, Howard Wheeler, John Pomeroy, Dan Princz, Ric Soulis, Fuad Yassin, Mohamed Elshaby, Saman Razavi, Vincent Fortin, Karl-Erich Lindenschmidt, Luis Morales, Amin Haghnegahdar, Dominique Richard, Youssef Loukili, Zelalem Tesemma, Prabin Rokaya, Stefan Sauer, Vincent Vionnet, Kurt Kornelsen, Arcadio Rodrigues, Moges Mamo, Ala Bahrami, Amin Elshorbagy, Kamrul Hossain, Matt Macdonald, Reza Bahremand, Etienne Gaborit, Erasmo Rodriguez, Andrew Ireson, Pedro Obando, Herbert Mkandla

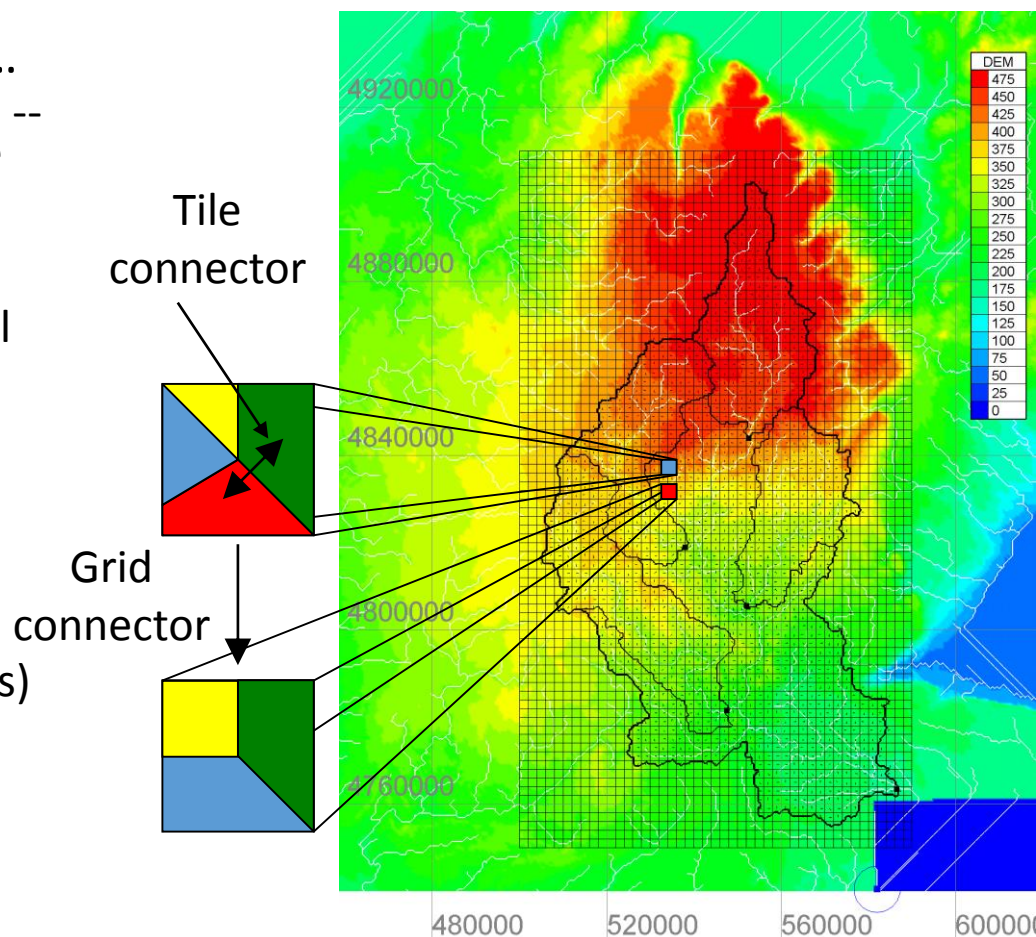
What is MESH?

- « Off-line » standalone model, decoupled from 3D Atmospheric model
- Able to ingest any source for meteorological forcings
- Ability to run « off-line » means its a suitable framework for calibration and sensitivity analyses
- No attachment to look-up tables, parameter values are accessible
- Compared to GEM-Hydro, cannot be run in an « on-line » mode
- Compared to GEM-Hydro, spatial discretization is required to be identical between the 1D Surface scheme and 2D Hydrological model



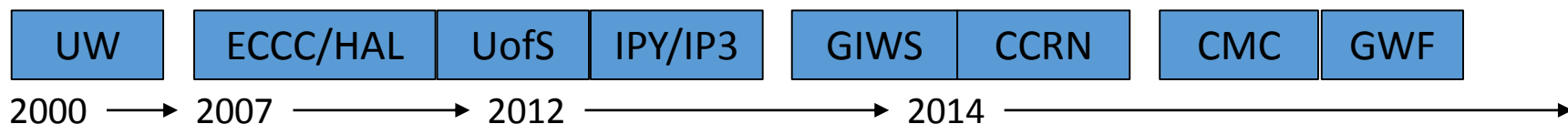
Flexibility: Basin discretization

- Parameters can be assigned by...
 - Grouped Response Unit (GRU) -- similar feature share the same parameter set, whether identified by land cover, soil characteristics, etc.
 - River class (for 2D Hydrological model)
 - Grid (i.e., fully distributed)
- Forcing can be distributed by...
 - GRU (e.g., for small basins, when considering point observations)
 - Grid (e.g., from climate models)
- Model can be run in a « point mode » to diagnose the 1D Surface model





A community model



- Community of practice
- Research and development shared between multiple institutions
- Source code freely distributed

SVS
Alavi et al., 2015

Water Management

PDM for Prairie Runoff (PDMROF)
Mekonnen et al., 2014

Prairie Blowing Snow Model (PBSM)
Pomeroy et al., 1993; MacDonald et al., 2009

Canadian Land Surface Scheme (CLASS)
Versegny, 1991; Versegny et al., 1993; Versegny, 2000

WATDRAIN (WATROF)
Soulis et al., 2000; Soulis et al., 2009

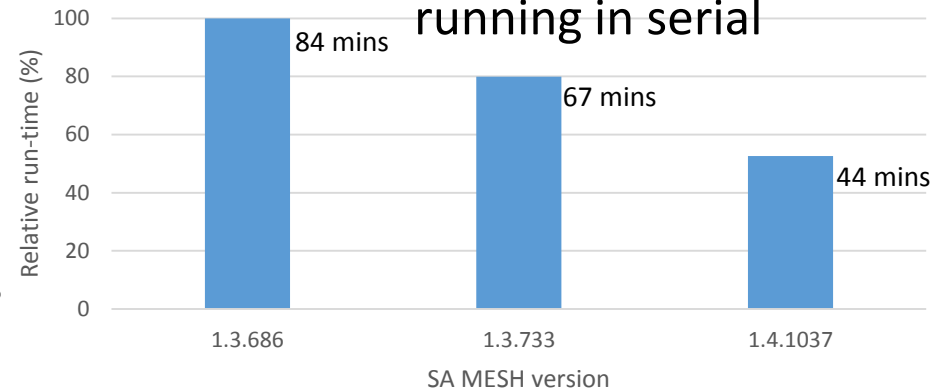
WATROUTE
Kouwen, 1988; Kouwen et al., 1993; Soulis et al., 2000



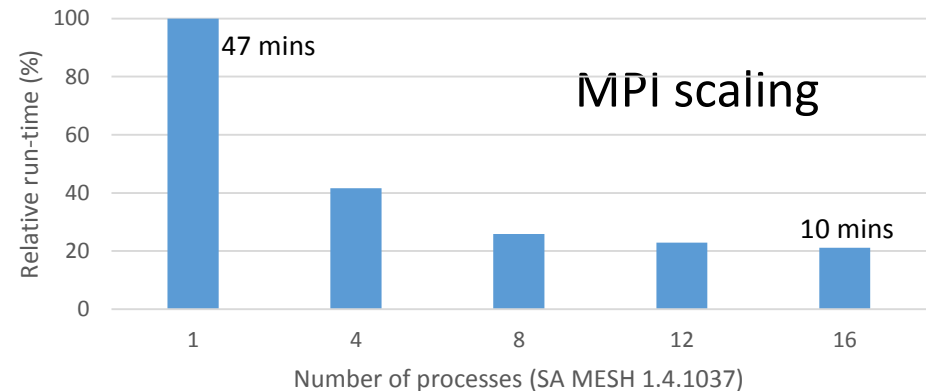
Scalability

- Runs on a laptop, desktop, workstation
- Scales to supercomputers and clusters
- Kept in standard to compile and run with freely available GCC compiler
- MESH code requires no special options or flags to compile

Improved performance
running in serial



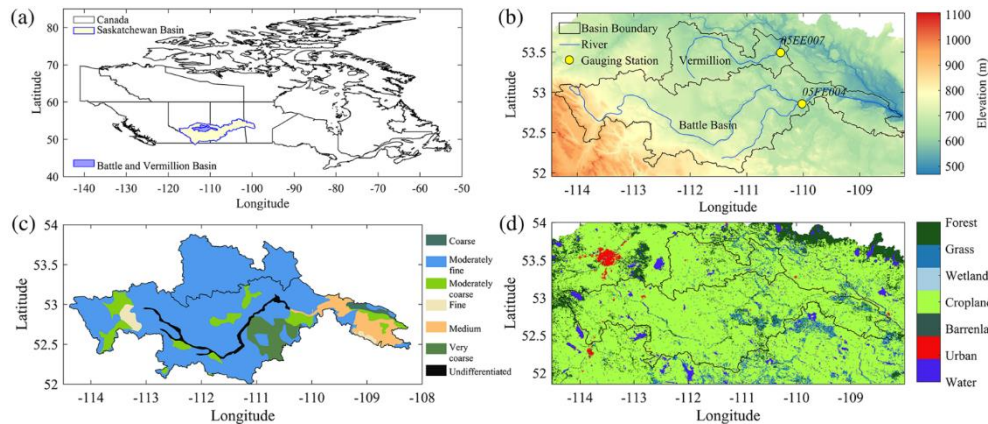
MPI scaling



Ongoing developments...

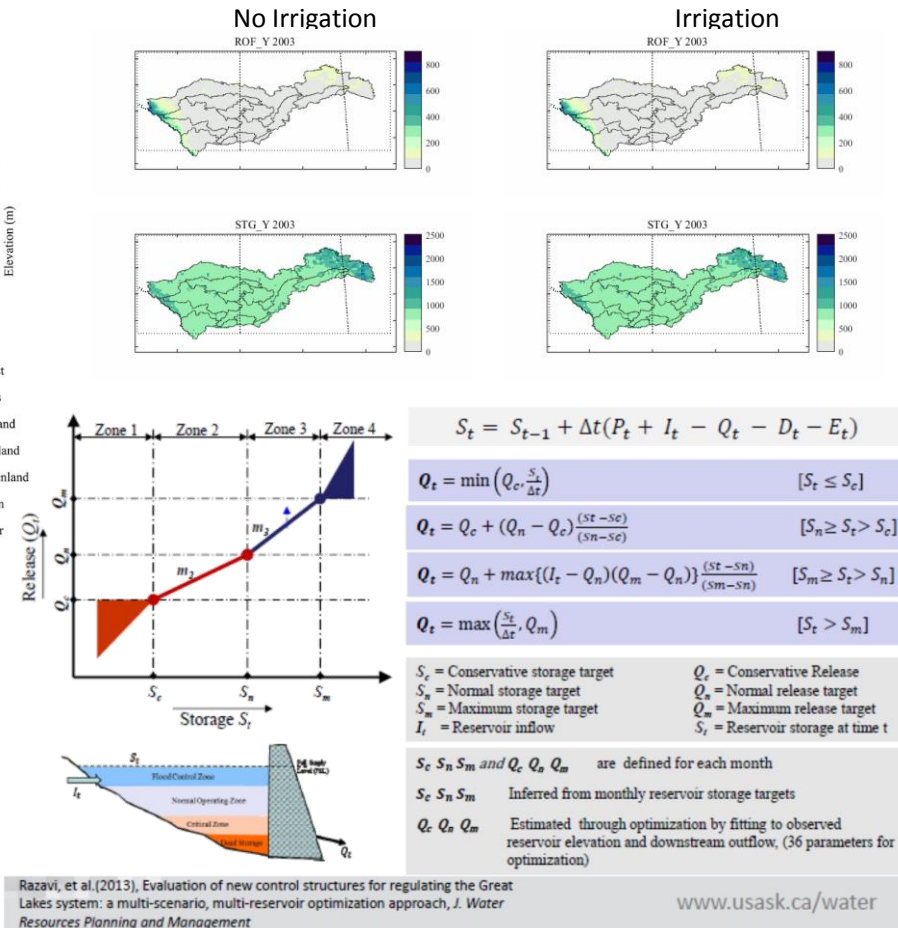
Canada

Saskatchewan River Basin (405,000 km²)



Enhanced identification of a hydrologic model using streamflow and satellite water storage data: A multicriteria sensitivity analysis and optimization approach, Volume: 31, Issue: 19, Pages: 3320-3333, First published: 01 July 2017, DOI: (10.1002/hyp.11267)

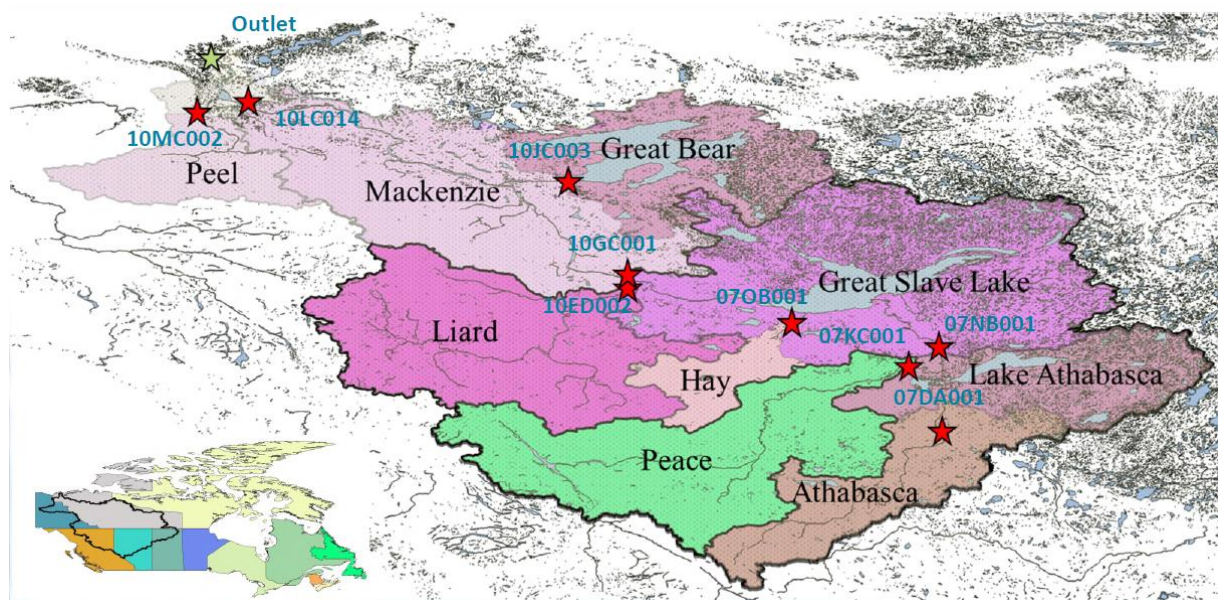
- Irrigation module
- Water abstraction and diversion
- Zone-based reservoir release
- Prairie blowing snow model
- Sloped interflow
- Prairie pothole model



Ongoing developments...

Canada

Mackenzie River Basin (1,800,000 km²)



- 50 layer deep soil profile
- Permafrost outputs
- Distributed soil parameterization
- Future climate scenarios

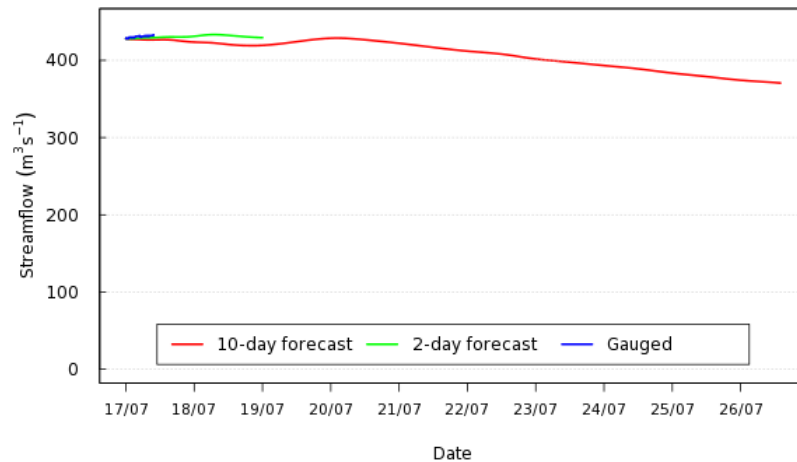


Ongoing developments...

Canada

Yukon River Basin (850,000 km²)

Streamflow Forecast for Liard River at Upper Crossing
Station 10AA001



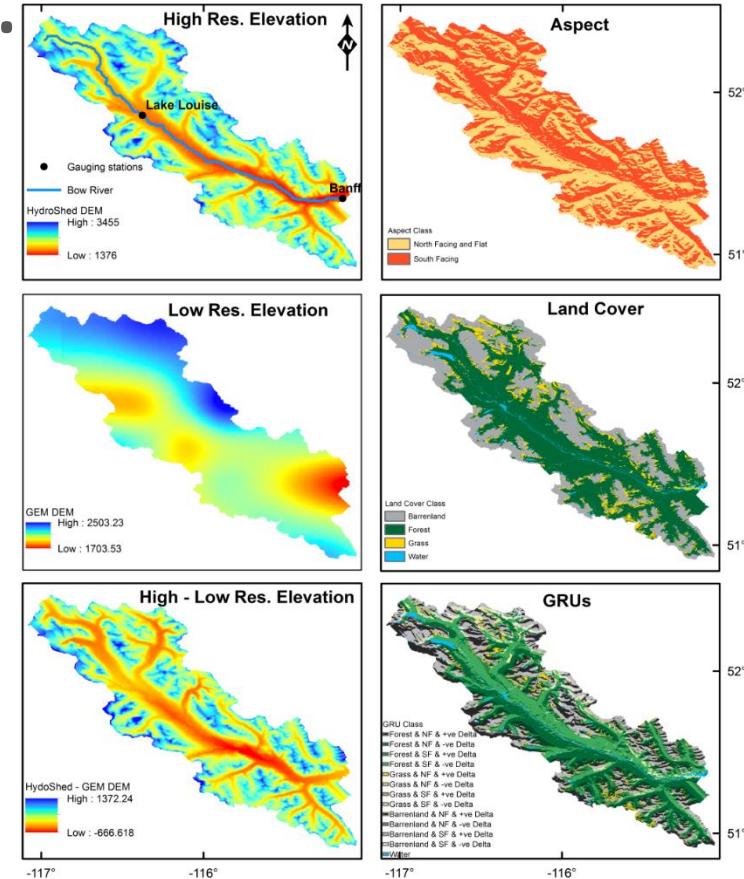
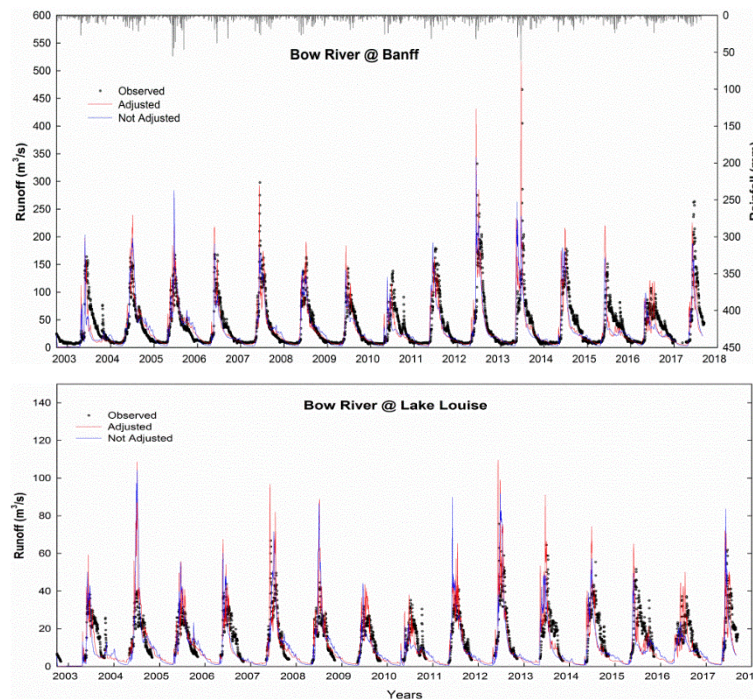
- Cloud-based forecasting system
- Parameter ensembles
- Forcing ensembles
- NAEFS 30-day



Ongoing developments...

Canada

Bow River at Banff (2,207 km²)



- Inline forcing corrections for slope, aspect, and elevation
- Prairie blowing snow model



International collaboration

Columbia

Coello River Basin (1,800 km²) within the
Magdalena Cauaca Basin (273,000 km²)



Iran

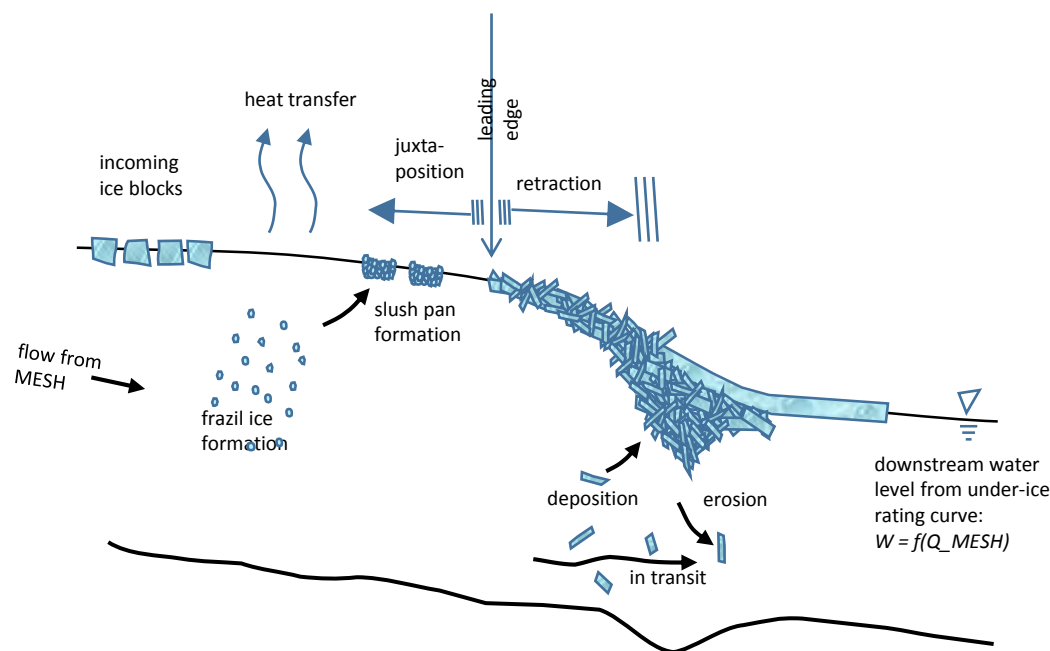
Sefidrud River Basin (65,000 km²)



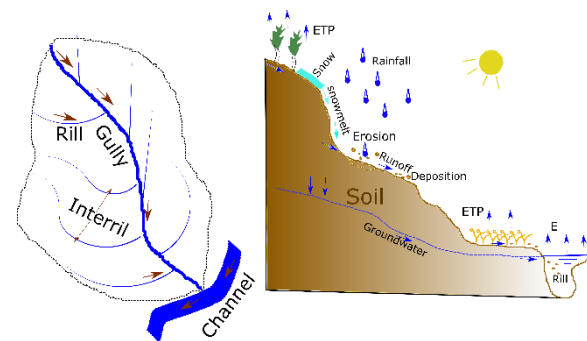
Israel Moselle River

Coupling with other models

MESH-RIVICE – Ice Jam flood modelling for the lower Athabasca

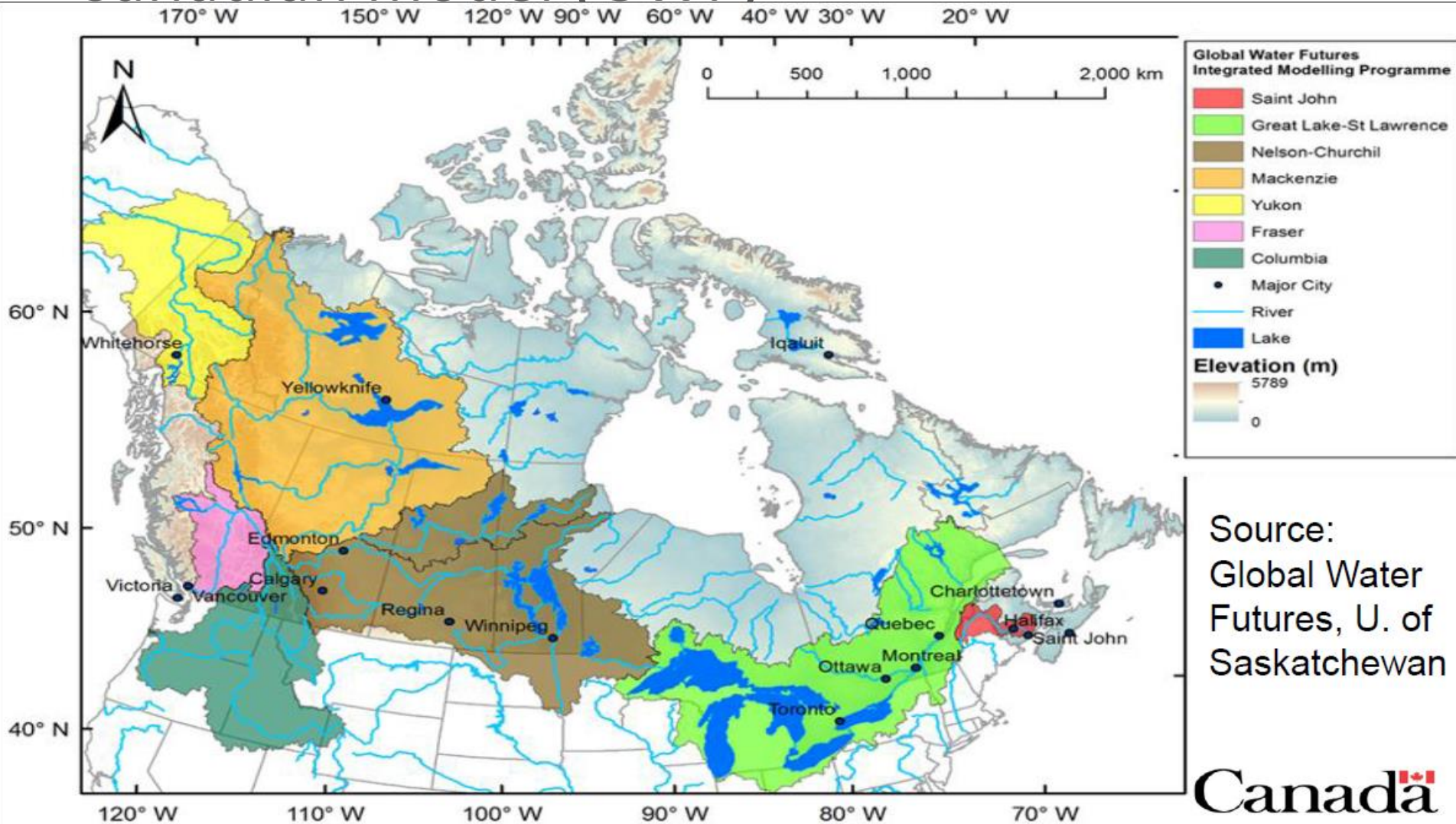


MESH-SED - Sediment & nutrient transport modelling for the Athabasca River basin





Basin-based approach towards a pan-Canadian model (GWF)

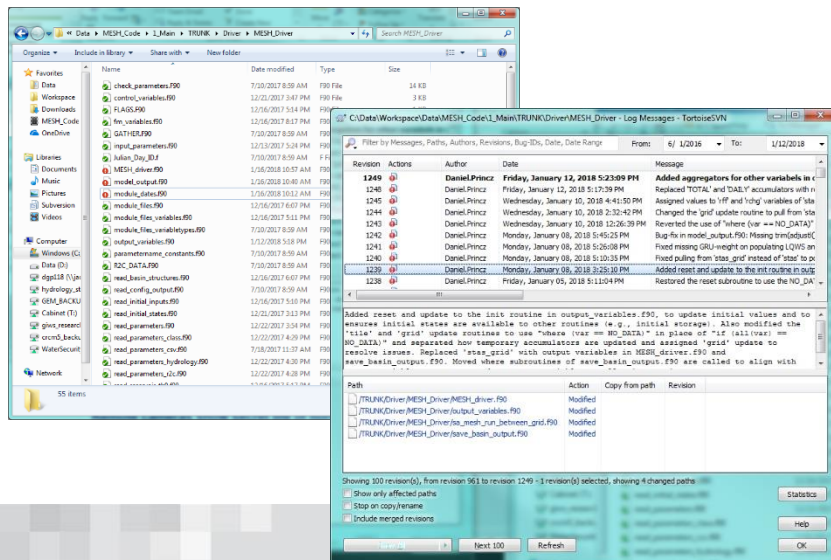




Support and code management

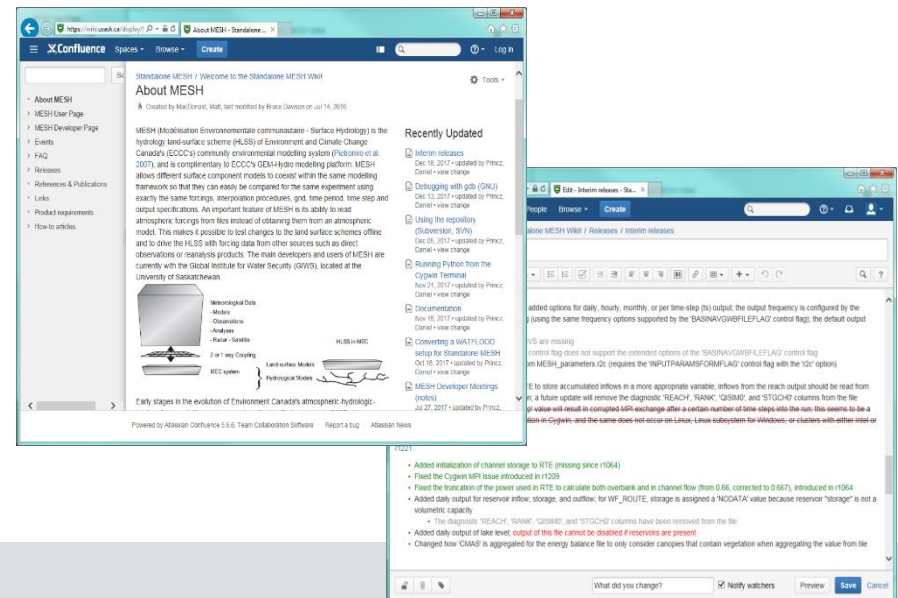
Repository (SVN)

- Subversion (SVN)
- Hosted at University of Waterloo
- Controlled access
- Multiple GUIs and command-based options across Linux, Mac and Windows



Wiki

- Confluence
- Hosted at University of Saskatchewan
- Public access for viewing, controlled access for editing pages
- Intuitive GUI for editing pages





Modules

Module	Coded	Tested
Canadian Land Surface Scheme (CLASS) 3.6	✓	✓
CLASS 3.6.1	✗	✗
Soil-Vegetation-Snow (SVS) 1	✓	✓
SVS 2	✓	✓
Canadian Terrestrial Ecosystem Model 2.1.1	✓	✗
Prairie Blowing Snow Model	✓	✓
Infiltration into frozen soils	✓	✗
Prairie pothole model (PDMROF)	✓	✓
Sloped interflow (WATROF)	✓	✓
WATROUTE	✓	✓
Zone-based reservoir release	✓	✓
Irrigation demand (moisture-content based)	✓	✓
Irrigation demand (PEVP based)	✓	✗
Abstraction, diversion	✓	✓

Module	Coded	Tested
Reservoir release curves	✓	✓
Simple aquifer, lower zone storage (Luo, 2012)	✓	✗
Simple aquifer, lower zone storage (Watroute)	✓	✓
Permafrost outputs	✓	✓
netCDF input (time-series)	✓	✓
netCDF output (time-series)	✗	✗
Point glacier energy/water balance model (ICEBAL)	✓	✗
Point lake energy balance model (Mackay)	✗	✗
Wetland representation	✗	✗





GRIP-E Model Intercomparison

- Setup borrowed from GEM-Hydro
- Same routing and routing parameterization as GEM-Hydro
- CLASS in place of SVS (SVS is used in GEM-Hydro)





Integrated Modelling
Program for Canada

Global Water Futures



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