

MESH Overview and development updates





Global Water Futures

Active users and collaborators





UNIVERSITY OF SASKATCHEWAN Global Institute for Water Security USASK.CA/WATER





Environment and Climate Change Canada

Environnement et Changement climatique Canada









Bruce Davison, Al Pietroniro, Howard Wheater, 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



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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



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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





Alavi et al., 2015

A community model



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

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) Verseghy, 1991; Verseghy et al., 1993; Verseghy, 2000

WATDRAIN (WATROF)

Soulis et al., 2000; Soulis et al., 2009

WATROUTE

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



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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



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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



Razavi, et al.(2013), Evaluation of new control structures for regulating the Great Lakes system: a multi-scenario, multi-reservoir optimization approach, J. Water **Resources Planning and Management**

Release

www.usask.ca/water



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Ongoing developments...

Canada

Mackenzie River Basin (1,800,000 km²)



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



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Ongoing developments...

Canada Yukon River Basin (850,000 km²)



- Cloud-based forecasting system ٠
- Parameter ensembles
- Forcing ensembles
- NAEFS 30-day

400

300

200

100

0

17/07

Streamflow (m³s⁻¹)

gwf.usask.ca/impc

Juneau



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Ongoing developments...

Canada

Bow River at Banff (2,207 km²)





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



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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



Integrated Modelling Program for Canada Global Water Futures

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





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





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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

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Wiki

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



https://wiki.usask.ca/display/MESH/MESH+User+Page



Global Water Futures

Modules

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

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



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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)





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