MESH

Overview and development updates

University of Saskatchewan
Global Institute for Water Security
www.usask.ca/water

gwf.usask.ca/impc

Standalone MESH

Modélisation Environnementale communautaire – Surface Hydrology

Integrated Modelling Program for Canada
Global Water Futures

2000 UW
- WATCLASS = CLASS 2.7 + sloped soil column with interflow (WATROF) + simple channel routing from Watflood, 1988 (WF_ROUTE)

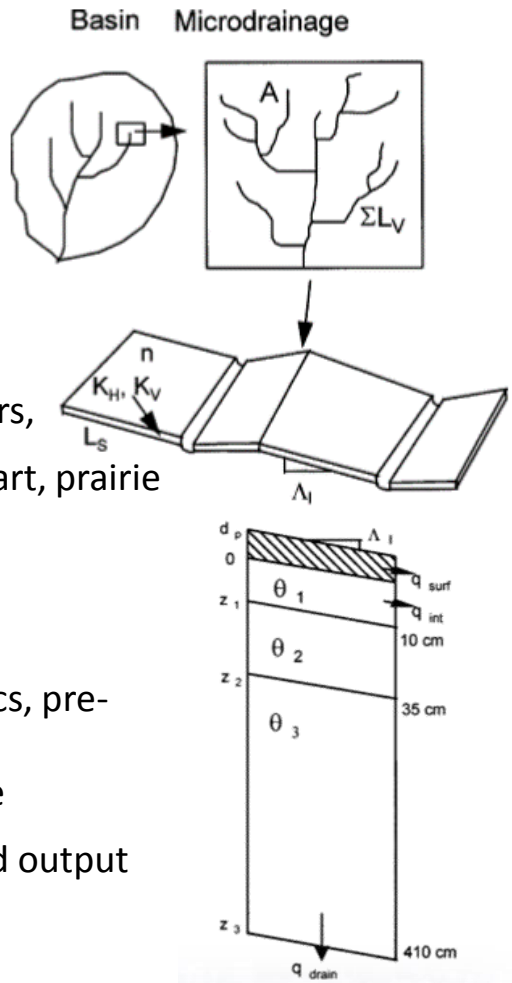
2007 ECCC
- "Standalone MESH" with CLASS 3.3.1, CMC MESH system
- MESH 1.2 with support WATFLOOD input files (r2c)

2011 IP3
- MESH 1.3 with CLASS 3.5, support + configurable > 3 soil layers, infiltration into frozen soils (hind-cast), gridded parameters + state assimilation/warm-start, prairie pothole runoff (PDMROF), compatibility with standalone Watroute (RTE), Wiki
- MESH 1.3 with CLASS 3.6 (new snow cover dynamics)

2014 CCRN
- Prairie blowing snow model (PBSM), binary file format for large-scale modelling, build-in calculation streamflow statistics, pre-emption + spin-up period

2018 GWF
- MESH 1.4 with MPI parallelization, mass scaling to HPC, inline integration of RTE, preliminary version of SVS, critical bug-fixing, better error messages, added input file and output file formats, water management representation, irrigation module, permafrost outputs, compatibility with standalone RBM

2019
- netCDF support, SVS update, GRIP-E analysis towards improved alignment with GEM-Hydro, hybrid resolution setup, point mode, HRU-based discretization, CLASS update (CTEM + CLASSIC), FEWS integration



Soulis et al., 2000

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Active collaborators

McMaster University

UNIVERSITY OF SASKATCHEWAN
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USASK.CA/WATER

UNIVERSITY OF WATERLOO

Environment and Climate Change Canada
Environnement et Changement climatique Canada

UNIVERSITY OF SASKATCHEWAN

UNIVERSITÉ DE SHERBROOKE

UNIVERSIDAD NACIONAL DE COLOMBIA

CentrEau
Centre québécois de recherche sur l'eau
Quebec Water Research Centre

UQO

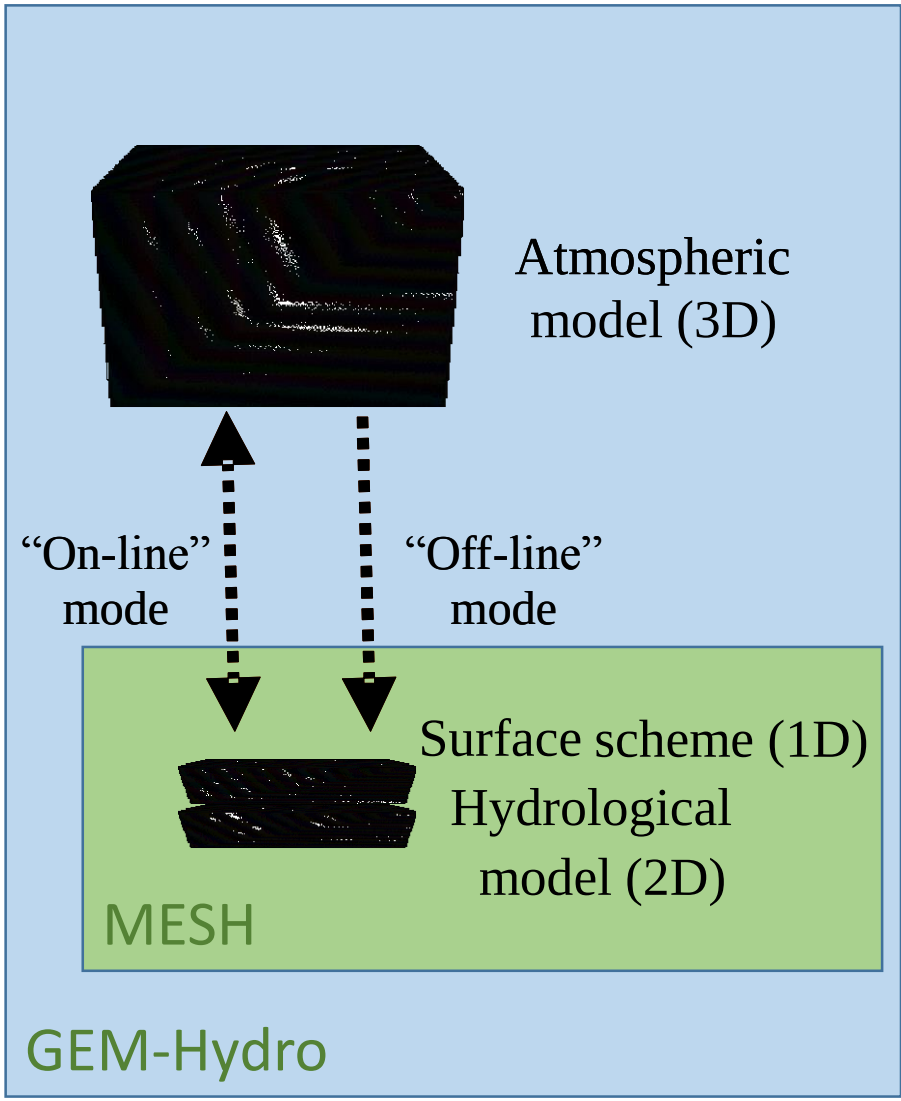
GWF

Yukon Government
Gouvernement

Gorgan University of Agricultural Sciences & Natural Resources

What is MESH?

- Climate model caliber Land Surface Scheme (LSS) coupled with hydrology
- Discretization and regional scale processes compatible with numerical weather prediction (NWP) model outputs
- Ability to run "Off-line" – decoupled from NWP infrastructure; suitable for calibration and/or sensitivity analyses of NWP models
- Scalable to high performance computing (HPC) clusters
- Portable to netbooks, laptops, desktops
- Support for various file formats for inputs and outputs, compatibility with other model-specific file formats (WATFLOOD, CLASS/CTEM) – compatible with efficient file formats, but still compatible with human-readable formats for teaching/training
- Flexible modes for discretization, ability to diagnose observation scale processes by running at point scale
- Ability to configure and activate/deactivate components via input files
- Accessible parameters
- Compared to GEM-Hydro, cannot be run in an "On-line" mode (no feedback is possible to atmosphere)



MESH "as a framework"

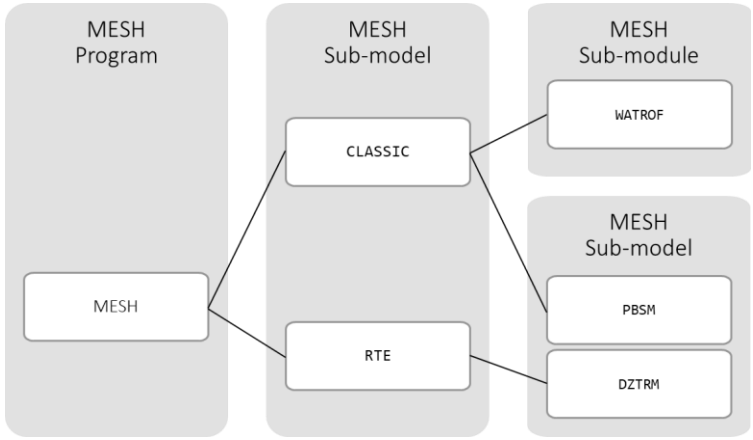
- Many floating variants:
  MESH-CLASS, MESH-SVS, "Mountain MESH",
  MESH-RBM,
  MESH-CTEM, MESH-SED
- Needed: Better organization and inline identification of MESH versions
  and active sub-components
- MESH "sub-models"?
  Models implemented in MESH that are not very interoperable with other 'sub-models' of the same type

  LSS: CLASS, CTEM, CLASSIC, SVS, ICEBAL
  Routing: WF_ROUTE, RTE
- MESH "sub-modules"?
  Interoperable with 'sub-models'

  LSS: WATROF, PDMROF, PBSM, FROZENINFILFLAG, Solar_Adjust, irrigation
  Routing: DZTRM, Elevation-Stage-Release table
- Needed: Better streamlining and movement of development algorithms
  and models back to base MESH version
- Needed: Better archival and movement of development setups and/or established domains
  back to MESH development for benchmarking/future-compatibility testing

Module	Coded	Tested
Canadian Land Surface Scheme (CLASS) 3.6	✓	✓
CLASSIC	×	×
Soil-Vegetation-Snow (SVS) 1	✓	✓
SVS 2	✓	✓
Canadian Terrestrial Ecosystem Model 2.1.1	✓	×
SUMMA	×	×
Prairie Blowing Snow Model	✓	✓
Infiltration into frozen soils	✓	×
Prairie pothole model (PDMROF)	✓	✓
Sloped interflow (WATROF)	✓	✓
WATROUTE (1988, RPN)	✓	✓
Dynamically Zoned Target Release Model	✓	✓
Irrigation demand (moisture-content based)	✓	✓

Module	Coded	Tested
Reservoir release curves	✓	✓
Simple aquifer, lower zone storage (Luo, 2012)	✓	×
Simple aquifer, lower zone storage (WATROUTE LZS)	✓	✓
Permafrost outputs	✓	✓
netCDF input (time-series)	✓	✓
netCDF output (time-series)	✓	×
Point glacier energy/water balance model (ICEBAL)	✓	✓
Canadian Small Lake Model	×	×
Wetland Model	×	×
Irrigation demand (PEVP based)	✓	×
Abstraction, diversion	✓	✓



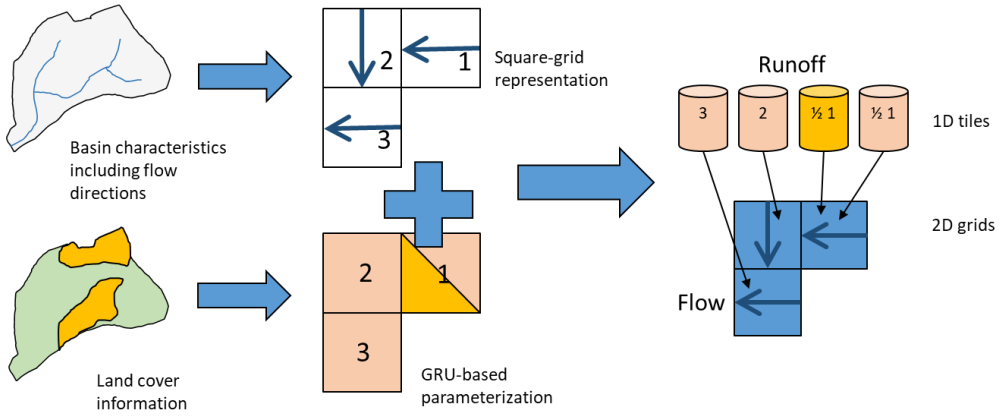
Discretization

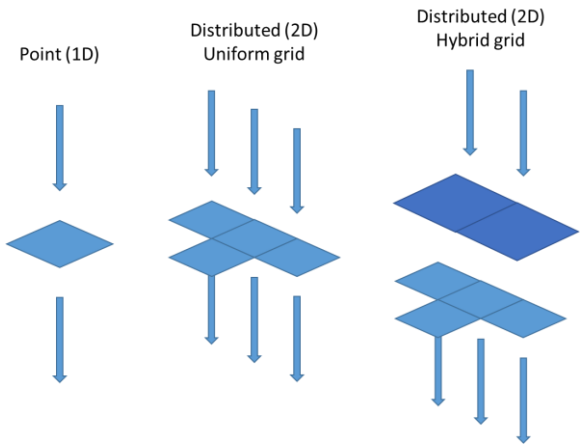
Active

- Distributed (2D) Uniform grid
  - Traditional grid-based implementation
  - Common grid specification for LSS, routing
  - All current examples of MESH in publication
- Point (1D)
  - No grid specification
  - Used to diagnose LSS at point/observatory scale

Experimental

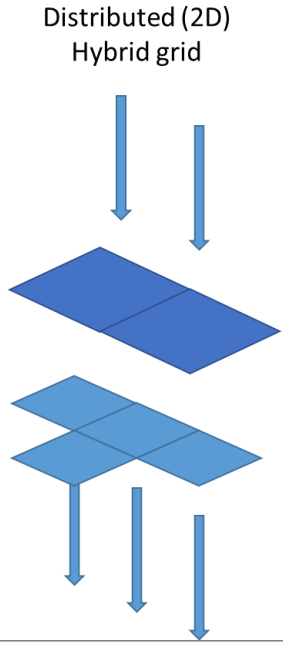
- Distributed (2D) Hybrid grid
  - Different grid specification allowed for LSS than for routing
  - Inline interpolation (using simple nearest)
  - Presently requires both grids to use same datum/ellipsoid and projection

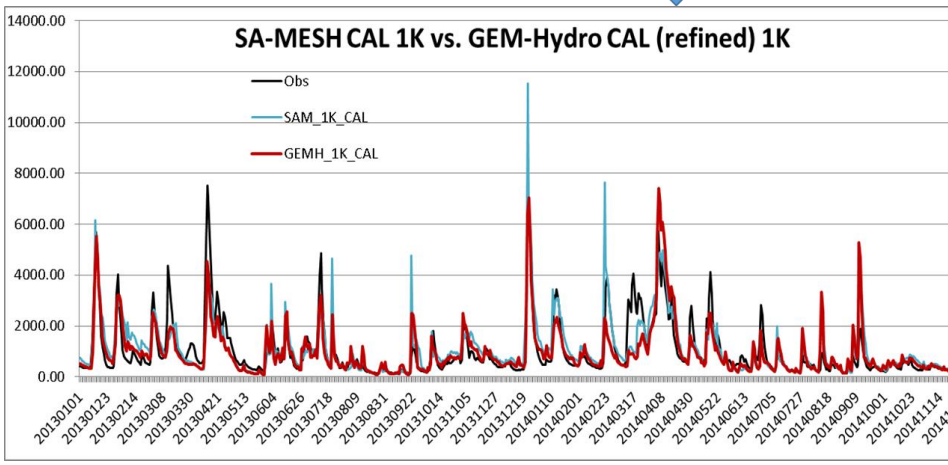




GRIP-E + GEM-Hydro alignment

- Existing implementation for GRIP-E
  - SVS updated in MESH
  - Scripts created to convert GEM-Hydro setups from 'Standard File Format' (FST) to r2c (point-by-point conversion)
  - Sub-grid GRUs/tiles deactivated (per GEM in GEM-Hydro)
  - Grid-based parameterization (fully-distributed)
  - Proper support added for Vegetation Fraction (VF) based weighted parameterization (to support all 26 sub-grid land cover types)
  - SVS modified to use user-specified soil layer discretization
  - Grid-based state initialization re-enabled for RTE (formerly disabled by CCRN-era MESH redevelopment)
- Initial findings
  - Calibrated parameter set of MESH does not perform the same in GEM-Hydro
- Identified issues
  - MESH missing non-SVS tiles: water, urban/town, etc..
  - SVS connector in MESH was implemented using an old SPS (GEM-Hydro) driver – out-of-date, does not match current SPS driver
- Next steps
  - Needed: A better strategy and support for moving updates between GEM-Hydro/MESH
    - (Also applies for CLASSIC/CLASS)
    - (Also applies for moving development/research code to operational systems)
  - MESH-SVS connector recoded based on current SPS driver
  - Implementation of the remaining GEM-Hydro tiles





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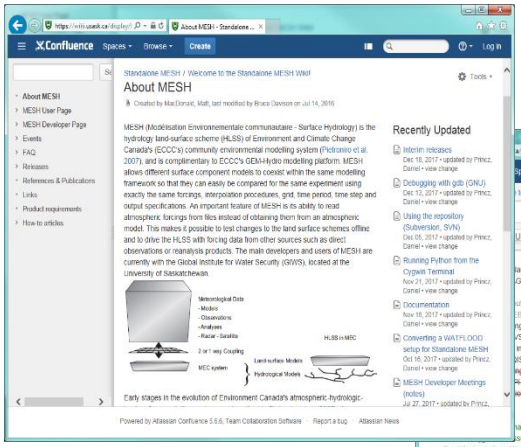
Wiki and code management

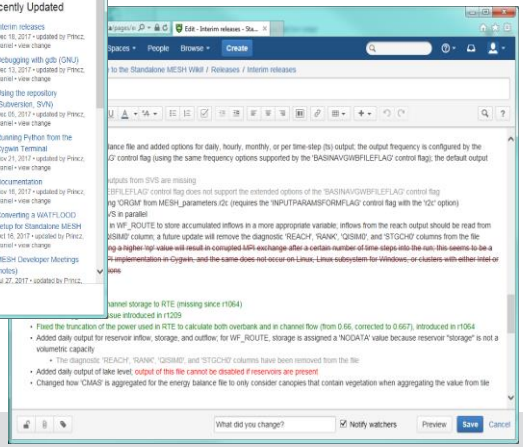
Wiki

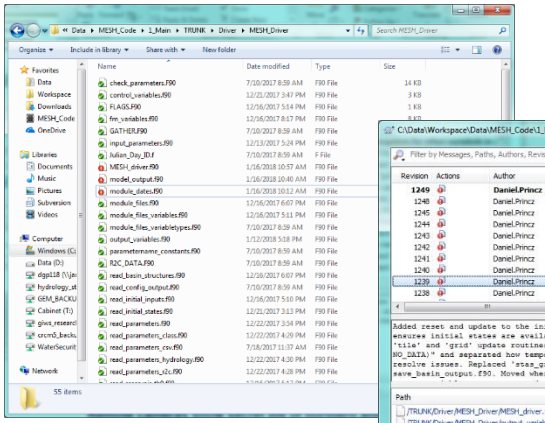
- Hosted at University of Saskatchewan
- Public access for viewing, controlled access for editing pages
- Confluence GUI, intuitive for editing pages
- Please contribute

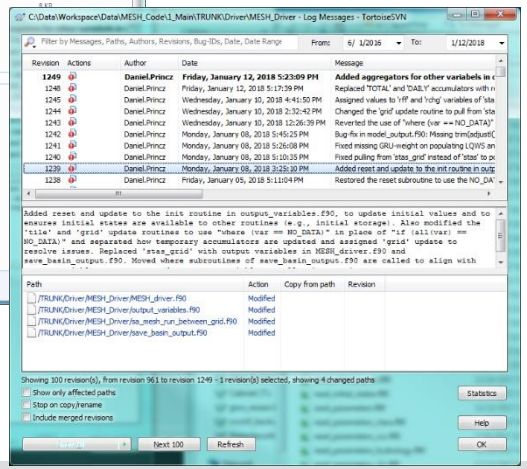
Repository (SVN)

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









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

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