# Conference Call – November 2018
# GRIP-E

Bryan A. Tolson, Juliane Mai, Hongren Shen, Étienne Gaborit, Nicolas Gasset, Dorothy Durnford, Young Lan Shin, Lauren M. Fry, Tim Hunter, Andrew D. Gronewold, Katelyn FitzGerald, Laura Read, Hervé Awoye, Tricia Stadnyk, Lacey Mason, Kevin Sampson, Alan F. Hamlet, Shervan Gharari, Saman Razavi, Amin Haghnegahdar, Daniel Princz, Alain Pietroniro, and Frank Seglenieks

University of Waterloo
University of Saskatchewan Global Institute for Water Security USASK.CA/WATER
National Oceanic and Atmospheric Administration, U.S. Department of Commerce
University of Notre Dame
Environment and Climate Change Canada / Environnement et Changement climatique Canada
US Army Corps of Engineers®
University of Michigan
NCAR National Center for Atmospheric Research

# Agenda

1. Round-table update of collaborators/ models
   - 3-5 min each
2. Routing framework
   - Hongren/ Ming will give an introduction (10min)
3. Performance metrics
   - Open discussion on metrics and methodology to compare model performances

# 1.

## Round-table update of collaborators/ models

# Status GEM-Hydro model

– Étienne Gaborit (ECCC) –

- used RDRS to report 2010-2014 model results
- model resolution is 10 km and 10 min (GEM-Surf (SPS), SVS)
- routing with Watroute (1 km and 30-600s)

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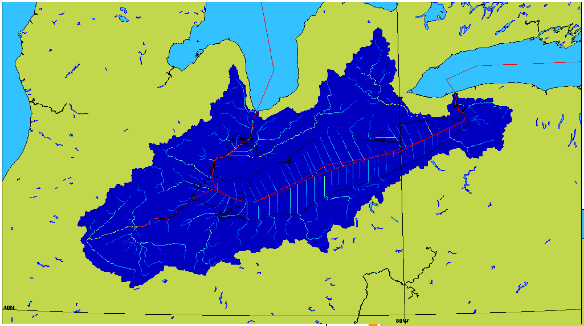
- used RDRS to report 2010-2014 model results
- model resolution is 10 km and 10 min (GEM-Surf (SPS), SVS)
- routing with Watroute (1 km and 30-600s)

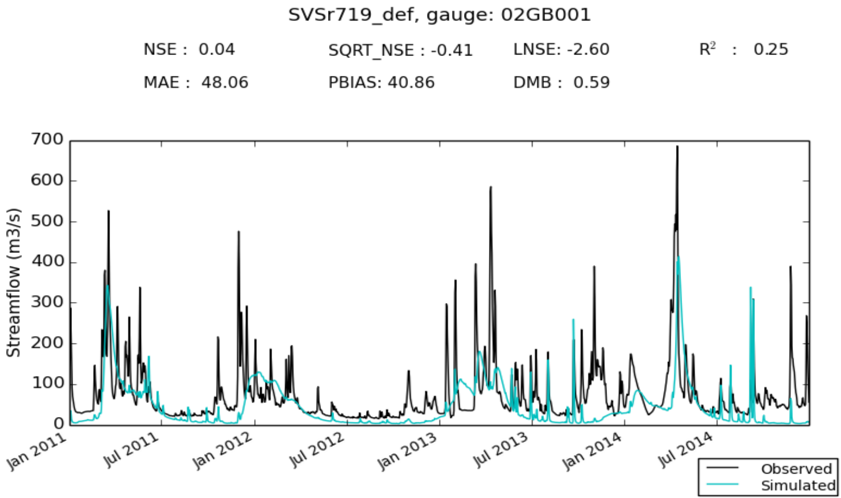
Étienne prepared some slides ...

GEM-Hydro implementation for GRIP-E




CCI_LC 2015 land cover
GSDE soil texture
HydroSHEDS 1km

Default GEM-Hydro simulations

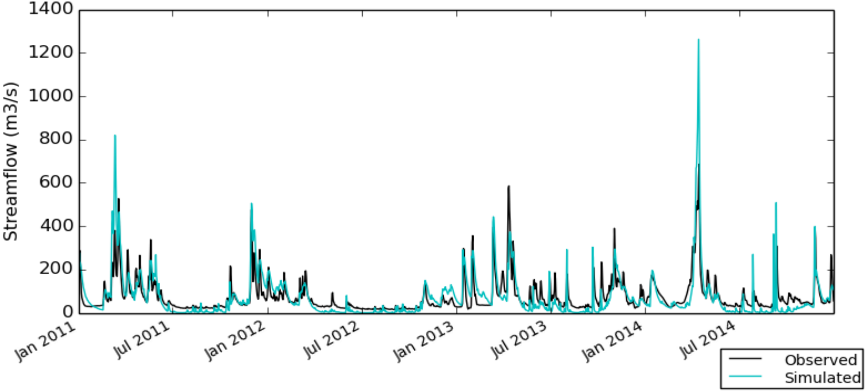


## Simulations after GEM-Hydro tuning

SVSr719_SVS_Watr_boost_CCILC_Rick_BGdecr, gauge: 02GB001

NSE : 0.37 SQRT_NSE : 0.19 LNSE: -3.06 $R^2$ : 0.69

MAE : 38.48 PBIAS: 3.20 DMB : 0.97



Median of scores for the tuned simulations, 2011-2014 period, 48 stations

| | NSE | SQ_NSE | LN_NSE | PBIAS |
|---|---|---|---|---|
| Tuned | 0.39 | 0.38 | -1.17 | 7.49 |

# GEM-Hydro Tuning performed

- Decrease evaporation by using Saturation capacity instead of field capacity when computing relative humidity of the ground (similar as multiplying all resistances by 2)
- Horizontal hydraulic conductivity X 4
- Vertical hydraulic conductivity X 2.2
- Mannings divided by 4
- No LZS

# Status MESH model

– Daniel Princz and Amin Haghnegahdar (USask) –

- same routing model and setup as used as for GEM-Hydro (Watroute setup shared between Dan and Étienne)
- initial runs use an out-of-box parameterization for CLASS land surface scheme
- model currently setup by Dan
- RDRS forcing, interpolated to MESH grid

# Status WATFLOOD model

– Frank Seglenieks (ECCC) –

- same routing model and setup as used as for GEM-Hydro with Watroute (setups shared between Étienne, Dan, and Frank)
- model currently setup by Dan and Frank
- RDRS forcing, interpolated to MESH grid

# Status WRF-Hydro model

– Drew Gronewold (NOAA), Laura Read & Katelyn FitzGerald (NCAR) et al. –

- WRF-Hydro is the framework used for NOAA's National Water Model (NWM); Great Lakes basin will be included as of FY2019
- long-term simulations/ calibration uses NLDAS data, but will be tested with RDRS dataset
- temporal model resolution is 300s for overland flow and 10s for channel routing
- spatial resolution is 1km for land-surface model and 250m for terrain routing model
- DEM used is the USGS NED 250 m.
- soil database used is the 1km STATSGO
- land cover data used NLCD 2011, reclassified to USGS 24

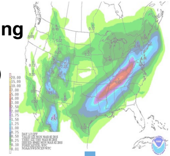
# National Water Model (NWM) WRF-Hydro Framework: Model Chain

*NWM uses NCAR supported community WRF-Hydro system*

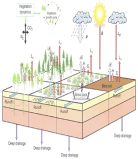
NWM: http://water.noaa.gov/about/nwm

WRF-Hydro: https://www.ral.ucar.edu/projects/wrf_hydro

1. NWM Forcing Engine (1 km grid)

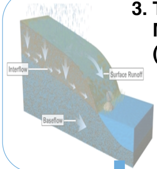


2. NoahMP LSM (1 km grid)

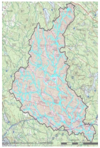


*2-way coupling*

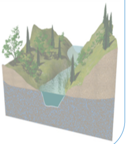
3. Terrain Routing Module (250 m grid)

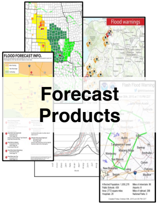



4. NHDPlus Catchment Aggregation (2.7M unique catchments and river reaches)



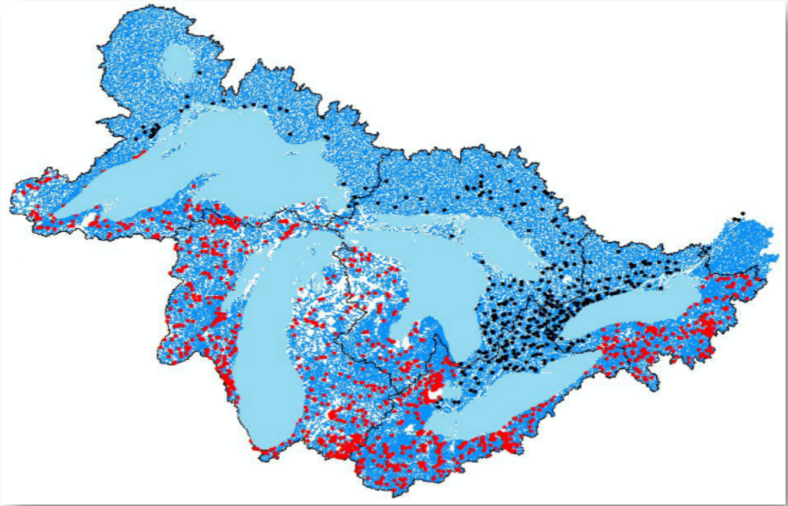
5. Channel & Reservoir Routing Modules






Forecast Products

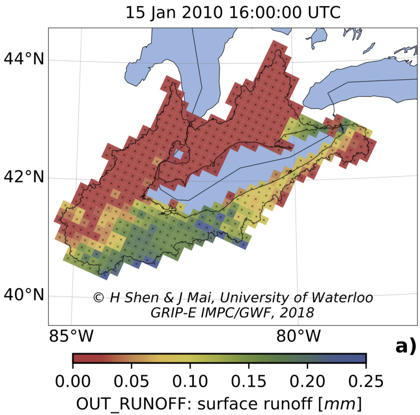
# Great Lakes Domain and Gauges (points)



# Status VIC model

– Hongren Shen (UWaterloo) –

- RDRS forcing dataset used
- used all other datasets from GitHub (soil, landcover, dem etc.)
- model resolution is 15 km and 1 hr (same as RDRS)
- routing with RAVEN in progress



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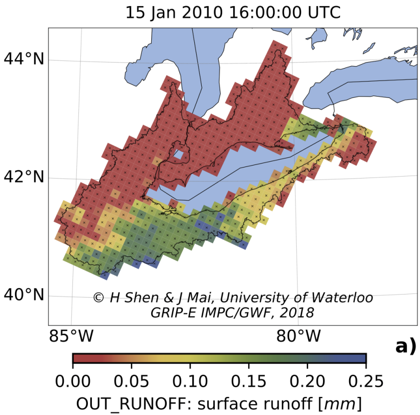


Hongren prepared some slides but will be shown later together with routing ...

# Status VIC model

– Alan Hamlet (U of Notre Dame) –

- uses VIC version ???
- model spatial resolution is 1/16°
- model temporal resolution is daily???
- land cover is MODIS at 500 m resolution
- forcing dataset used is a combination of multiple data sources,e.g., Daily Global Historical Climatology Network (GHCN-Daily) station records, the US Historical Climatology Network (US-HCN), the Adjusted and Homogenized Canadian Climate Data (AHCCD)
- RDRS forcing dataset can be used for reporting results

Byun, K., & Hamlet, A. F. (2018). Projected changes in future climate over the Midwest and Great Lakes region using downscaled CMIP5 ensembles. *Int J of Climatology*, 38(4), 531–553. http://doi.org/10.1002/joc.5388

# Status VIC-GRU model

– Shervan Gharari (USask) –

- RDRS forcing dataset used
- used all other datasets from GitHub (soil, landcover, dem etc.)
- model spatial resolution is defined by GRUs
- temporal resolution is hourly (outputs daily, monthly, yearly)
- routing with RAVEN in progress

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- used all other datasets from GitHub (soil, landcover, dem etc.)
- model spatial resolution is defined by GRUs
- temporal resolution is hourly (outputs daily, monthly, yearly)
- routing with RAVEN in progress

Shervan prepared some slides ...

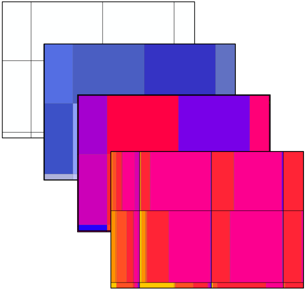
## Traditional VIC implementation

A cell size should be decided

Forcing should be aggregated

Soil parameter should be aggregated

Percentage of each land cover is only used for every grid. Spatial extent is lost.



## New VIC implementation

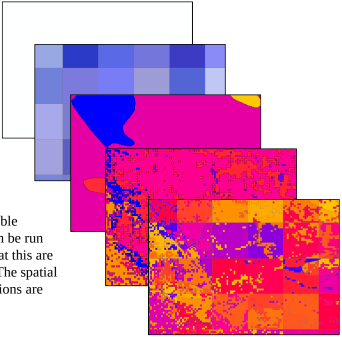
No cell size is needed

Forcing remains the original resolution

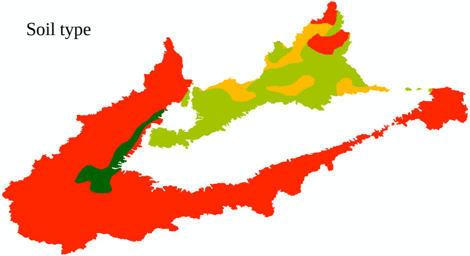
Soil parameter remains the original resolution

Land cover extent are preserved.

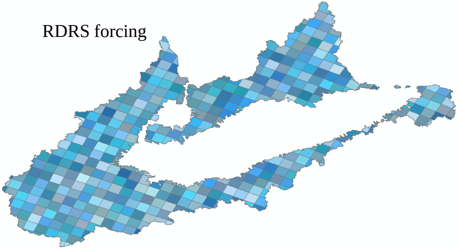
This is the highest possible resolution the model can be run for, resolution higher that this are computational burden. The spatial extent of model simulations are preserved.



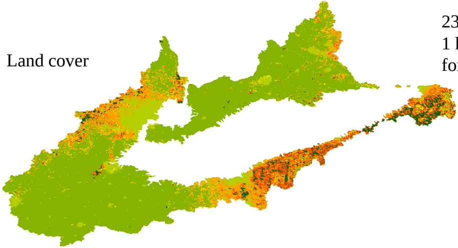
Soil type



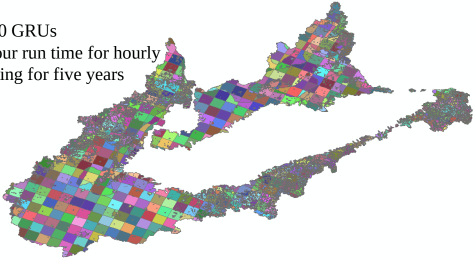
RDRS forcing



Land cover

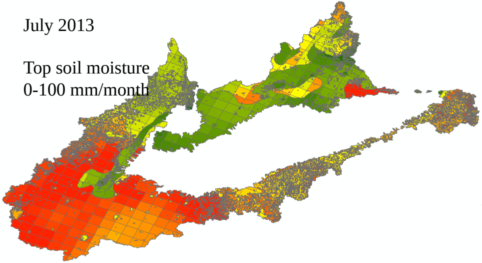


2380 GRUs
1 hour run time for hourly forcing for five years

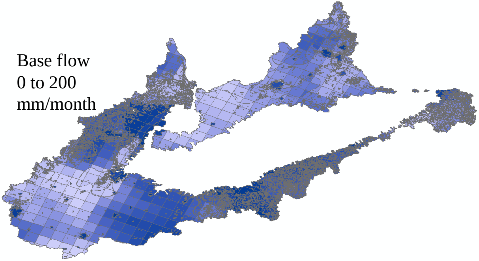


July 2013

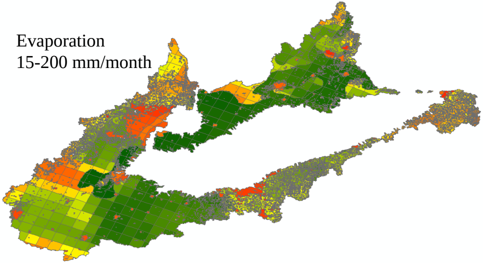
Top soil moisture
0-100 mm/month



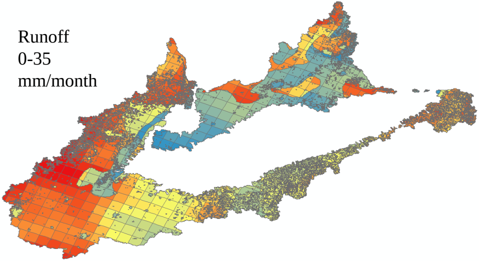
Base flow
0 to 200 mm/month



Evaporation
15-200 mm/month



Runoff
0-35 mm/month



# What was achieved so far

- The codes for fast set up of the VIC-GRU are ready. Preliminary model set up in 1-2 day.
- Codes to create the VIC-GRU input file from shapefiles, look up tables and *.nc forcing files.

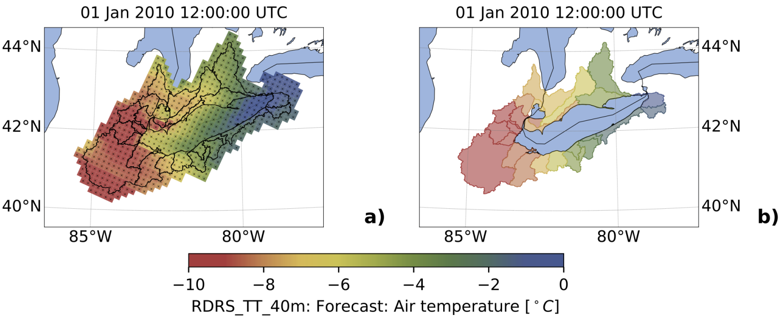
# To do or consider

- I would prefer using NALC instead of MODIS (or reshaping MODIS map to avoid misclassification such as Savannas in the study area; follow up with UW group)
- Work needed on the harmonization of fluxes from various soil types. This will done during calibration process. Might be challenging…
- How to consider the urban areas in VIC. Currently bare soil but he urban areas are significantly vegetated.
- Coupling Raven routing with VIC-GRU. Codes are ready to prepare the *.nc input to Raven routing. I can route myself if *.rvh *.rvp files are provided from UW group.
- I am aiming to use this case study as my work on effect of heterogeneity in large scale modeling.

# Status LBRM model

– Lauren Fry (USACE), Tim Hunter & Drew Gronewold (GLERL) –

- used RDRS data (sub-basin aggregated) for reporting
- no geophysical data (soil, land cover etc) used
- model resolution daily and lumped to sub-basins
- calibration period: 1983-2000 (9 parameters; other forcings)



# Status LBRM model

– Lauren Fry (USACE), Tim Hunter & Drew Gronewold (GLERL) –

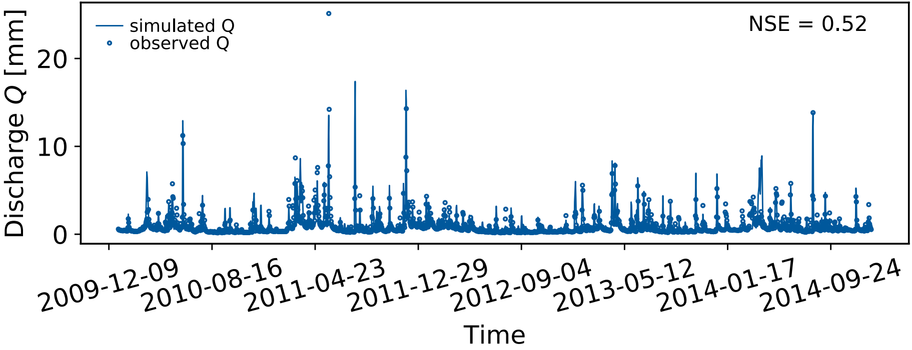



Figure: Simulated discharge for sub-basin #1 of Lake Erie (ID 601, 2010-2014)

# Status HYPE model

– Hervé Awoye and Tricia Stadnyk (UManitoba) –

Integrated Modelling Program for Canada

Global Water Futures

- HYPE v5.6.2
- RDRS will be used for reporting
- Forcing datasets for calibration: HydroGFD 2.0 (downloaded from Copernicus, https://doi.org/10.5194/hess-22-989-2018)
- Modeling resolution: Daily, sub-basin scale
- Soil database: HWSD v.1.2. reclassified using the T_Texture field in the database attribute
- Land cover database: ESA_CCI 2009

# 2.

## Routing framework



# A Routing Network for RAVEN in the Lake Erie Basin

**Hongren Shen, Ming Han, Bryan Tolson, Juliane Mai**

University of Waterloo, Nov 6, 2018

# Outline

1. Routing methodology in RAVEN
2. Required inputs for RAVEN as a routing only tool
3. Introduction of the routing network product
4. An example of RAVEN routing

# Routing schemes in RAVEN

- In-catchment routing

  Dump method, unit hydrograph

- In-channel routing

  Hydrologic method such as diffusive wave model and Muskingum-Cunge method

- Reservoir/Lake routing (optional)

  Stage-discharge and stage-volume curves

Craig, J.R., and the Raven Development Team, Raven user's and developer's manual (Version 2.8), URL: http://www.civil.uwaterloo.ca/jrcraig/Raven/Main.html

# Input Files for RAVEN as a Routing Only Tool

| | | |
|---|---|---|
| ➢ **Runoff generation results** | Runoff (surface runoff) and baseflow | **NetCDF format** |
| ➢ **Overlay calculation results** | Areal weights | **ASCII format (Provided in shp.)** |
| ➢ **Subwatershed characteristics** | Geo-information & topologies | **ASCII format (Provided in shp.)** |
| ➢ **River channel characteristics** | Channel profiles & relevant parameters | **ASCII format (Provided in shp.)** |
| ➢ **Lake information** | Topologies & relevant parameters | **ASCII format (Provided in shp.)** |
| ➢ **Other files (from template)** | Define relevant input file paths & parameters | Customized by users |

The routing network characteristics are determined by Ming Han's pan-Canadian routing product being developed under GWF Lake Futures project.

# Overview of the Routing Network Product

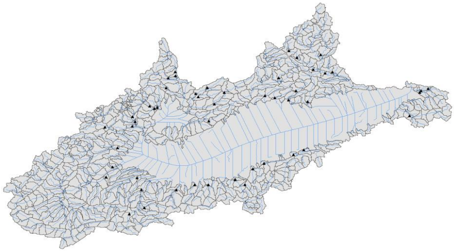
**Key features:**

| | |
|---|---|
| Subwatershed-based | 799 |
| Overlayed with the RDRS grids | 15 km grids |
| Lakes considered | 75 Lakes |
| Flow gauges considered | 49 (USGS & WSC) |
| Efficient to calibrate | ~5 min for a 5yr hourly simulation |

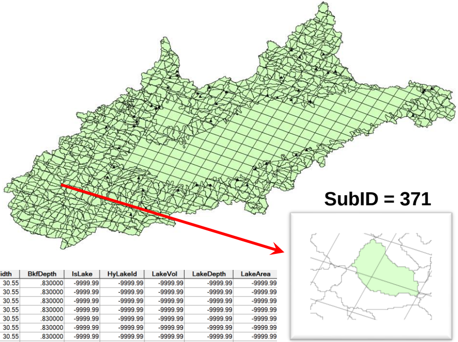
This product offers the basic geo-information and initial parameters required by most routing models, such as RAVEN.

# Quick Look at the Core Shapefiles

(a) Subwwatershed discretization & stream networks



(b) Overlay results with the RDRS grids




| FID | Shape | FID_finalc | gridcode | area | SubId | DowSubId | Area2 | Rivlen | RivSlope | BasinSlope | BkfWidth | BkfDepth | IsLake | HyLakeId | LakeVol | LakeDepth | LakeArea |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1761 | Polygon | 471 | 472 | 138279253.836 | 472 | 469 | 138279000 | 25391.4 | .002053 | .003528 | 30.55 | .830000 | -9999.99 | -9999.99 | -9999.99 | -9999.99 | -9999.99 |
| 1762 | Polygon | 471 | 472 | 138279253.836 | 472 | 469 | 138279000 | 25391.4 | .002053 | .003528 | 30.55 | .830000 | -9999.99 | -9999.99 | -9999.99 | -9999.99 | -9999.99 |
| 1763 | Polygon | 471 | 472 | 138279253.836 | 472 | 469 | 138279000 | 25391.4 | .002053 | .003528 | 30.55 | .830000 | -9999.99 | -9999.99 | -9999.99 | -9999.99 | -9999.99 |
| 1764 | Polygon | 471 | 472 | 138279253.836 | 472 | 469 | 138279000 | 25391.4 | .002053 | .003528 | 30.55 | .830000 | -9999.99 | -9999.99 | -9999.99 | -9999.99 | -9999.99 |
| 1765 | Polygon | 472 | 473 | 192082729.608 | 473 | 469 | 192083000 | 20346 | .002880 | .002715 | 30.55 | .830000 | -9999.99 | -9999.99 | -9999.99 | -9999.99 | -9999.99 |
| 1766 | Polygon | 472 | 473 | 192082729.608 | 473 | 469 | 192083000 | 20346 | .002880 | .002715 | 30.55 | .830000 | -9999.99 | -9999.99 | -9999.99 | -9999.99 | -9999.99 |
| 1767 | Polygon | 472 | 473 | 192082729.608 | 473 | 469 | 192083000 | 20346 | .002880 | .002715 | 30.55 | .830000 | -9999.99 | -9999.99 | -9999.99 | -9999.99 | -9999.99 |
| 1768 | Polygon | 472 | 473 | 192082729.608 | 473 | 469 | 192083000 | 20346 | .002880 | .002715 | 30.55 | .830000 | -9999.99 | -9999.99 | -9999.99 | -9999.99 | -9999.99 |
| 1769 | Polygon | 472 | 473 | 192082729.608 | 473 | 469 | 192083000 | 20346 | .002880 | .002715 | 30.55 | .830000 | -9999.99 | -9999.99 | -9999.99 | -9999.99 | -9999.99 |
| 1770 | Polygon | 473 | 474 | 30100139413.4000 | 474 | 1 | 3010010000 | 1041260 | .000251 | .004671 | 1205.98 | 14.66 | 1 | 9 | 499000 | 19.4 | 25767.8 |
| 1771 | Polygon | 473 | 474 | 30100139413.4000 | 474 | 1 | 3010010000 | 1041260 | .000251 | .004671 | 1205.98 | 14.66 | 1 | 9 | 499000 | 19.4 | 25767.8 |
| 1772 | Polygon | 473 | 474 | 30100139413.4000 | 474 | 1 | 3010010000 | 1041260 | .000251 | .004671 | 1205.98 | 14.66 | 1 | 9 | 499000 | 19.4 | 25767.8 |

| IsObs | MeanElev | FloodP_n | Q_Mean | Ch_n | Slope2 | Slope3 | INSIDE_X | INSIDE_Y | FID_LEB_RD | Lat | Lon | Area_befor | Row | Col | FGID | s_area |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -9999.99 | 361.924 | .035000 | 18 | .044753 | .001063 | .001586 | -81.071048 | 43.471953 | 948 | 43.357327 | -81.047607 | 225.976 | 17 | 29 | 948 | 3179319.69795 |
| -9999.99 | 361.924 | .035000 | 18 | .044753 | .001063 | .001586 | -81.071048 | 43.471953 | 953 | 43.417843 | -81.217499 | 226.058 | 18 | 29 | 953 | 42794261.6477 |
| -9999.99 | 361.924 | .035000 | 18 | .044753 | .001063 | .001586 | -81.071048 | 43.471953 | 1029 | 43.536491 | -81.13739 | 226.092 | 18 | 30 | 1029 | 29432548.3912 |
| -9999.99 | 361.924 | .035000 | 18 | .044753 | .001063 | .001586 | -81.071048 | 43.471953 | 1036 | 43.594112 | -80.886566 | 226.049 | 17 | 31 | 1036 | 3897034.40276 |
| -9999.99 | 354.526 | .034886 | 18 | .044753 | .001524 | .001586 | -81.14684 | 43.534788 | 945 | 43.475765 | -80.967316 | 226.024 | 17 | 30 | 945 | 4572087.01824 |
| -9999.99 | 354.526 | .034886 | 18 | .044753 | .001524 | .001586 | -81.14684 | 43.534788 | 953 | 43.417843 | -81.217499 | 226.058 | 18 | 29 | 953 | 26404596.4615 |
| -9999.99 | 354.526 | .034886 | 18 | .044753 | .001524 | .001586 | -81.14684 | 43.534788 | 1028 | 43.596966 | -81.3078 | 226.188 | 19 | 30 | 1028 | 5744857.81563 |
| -9999.99 | 354.526 | .034886 | 18 | .044753 | .001524 | .001586 | -81.14684 | 43.534788 | 1029 | 43.536491 | -81.13739 | 226.092 | 18 | 30 | 1029 | 154336022.546 |
| -9999.99 | 354.526 | .034886 | 18 | .044753 | .001524 | .001586 | -81.14684 | 43.534788 | 1035 | 43.655041 | -81.056854 | 226.137 | 18 | 31 | 1035 | 1929960.42856 |
| -9999.99 | 178.756 | .036033 | 28055.4 | .027557 | .000058 | .000058 | -81.238415 | 42.147858 | 0 | 41.752922 | -81.478363 | 225.29 | 14 | 17 | 0 | 224420157.298 |
| -9999.99 | 178.756 | .036033 | 28055.4 | .027557 | .000058 | .000058 | -81.238415 | 42.147858 | 5 | 42.854824 | -79.285278 | 225.216 | 7 | 30 | 5 | 195436292.025 |
| -9999.99 | 178.756 | .036033 | 28055.4 | .027557 | .000058 | .000058 | -81.238415 | 42.147858 | 10 | 41.862171 | -82.631226 | 225.82 | 20 | 15 | 10 | 225820240.158 |
| -9999.99 | 178.756 | .036033 | 28055.4 | .027557 | .000058 | .000058 | -81.238415 | 42.147858 | 11 | 41.871426 | -80.99292 | 225.17 | 12 | 19 | 11 | 196582861.617 |

# An example of the RAVEN Routing Configuration

| | |
|---|---|
| ➢ **Hydrological model** | VIC image 5.1.0, runoff & baseflow generated |
| ➢ **Temporal scale** | 1hr data from 2010-01-01 00:00:00 to 2014-12-31 23:00:00 |
| ➢ **Input for Raven** | VIC results in NetCDF,<br>Files provided by this product,<br>Other configuration files (refer to the RAVEN manual) |
| ➢ **Routing methods** | In-catchment: Dump method<br>In-channel: Diffusive wave method<br>Lakes: Stage-discharge curve |
| ➢ **Run time** | 4-5 min |

# An example of the RAVEN Routing Configuration

## (a) Input file config.

test.rvi*

```
# ---------------------------------------------------------
# Raven Input file
# Grid base rainfall-runoff model test
# ---------------------------------------------------------
# --Simulation Details ------------------------------------
:StartDate          2010-01-01 00:00:00
#:EndDate           2014-12-31 24:00:00
:Duration           7304                     # 6hr step
:Method             ORDERED_SERIES
:TimeStep           06:00:00

:RunName            LEB_routing_trial1
#
# --Model Details ---------------------------------
:Routing                 ROUTE_DIFFUSIVE_WAVE
:CatchmentRoute          ROUTE_DUMP
:SoilModel               SOIL_ONE_LAYER
:RechargeMethod          RECHARGE_DATA
#
# --Hydrologic Processes---------------------------
:Alias        Topsoil SOIL[0]
#
:HydrologicProcesses
  :Precipitation         PRECIP_RAVEN         ATMOS_PRECIP     PONDED_WATER
  :Flush                 RAVEN_DEFAULT        PONDED_WATER     SURFACE_WATER
  :Flush                 RAVEN_DEFAULT        ATMOSPHERE       SURFACE_WATER
  :Recharge              RAVEN_DEFAULT        ATMOS_PRECIP     SOIL[0]
  :Baseflow              BASE_LINEAR_ANALYTIC SOIL[0]          SURFACE_WATER
:EndHydrologicProcesses
```

## (b) Subwatershed characteristics

test.rvh

```
# ---------------------------------------------
# Raven HRU Input file
#  lake catchment emulation
# ---------------------------------------------
SubBasins
 :Attributes   NAME  DOWNSTREAM_ID       PROFILE REACH_LENGTH  GAUGED
 :Units        none           none          none           km    none
 1      sub1    -1     Chn_1     12.9433     0
 2      sub2    556     Chn_2     3.87314     0
 3      sub3    556     Chn_3     3.89518     0
```

test.rvh

```

:HRUs
  :Attributes AREA ELEVATION  LATITUDE  LONGITUDE   BASIN_ID  LAND_USE_CLASS  VEG_CLASS   SOIL_PROFILE  AQUIFER_PROFILE   TERRAIN_CLASS   SLOPE   ASPECT
  :Units       km2         m       deg        deg       none            none       none           none             none            none     deg      deg
  1         99.3248    185.057    42.9440537709    -78.9193304431    1    FORESТ    FOREST    SOILPROF    [NONE]    [NONE]    0.00568751    200
  2         16.8592    187.579    42.8827297705    -78.7995353042    2    FOREST    FOREST    SOILPROF    [NONE]    [NONE]    0.00381055    200
  3         12.7708    186.827    42.8427726531    -78.797815178    3    FOREST    FOREST    SOILPROF    [NONE]    [NONE]    0.00330343    200
```

## (c) Channel profile config.

modelchannel.rvp

```
:ChannelProfile               Chn_1
  :Bedslope                 0.0003863
  :SurveyPoints
    0           189.057
    16.0           185.057
    740.3           185.057
    751.78           179.317
    1090.97           179.317
    1102.45           185.057
    1826.75           185.057
    1842.75           189.057
  :EndSurveyPoints
  :RoughnessZones
    0           0.0632759
    740.3           0.035
    1102.45           0.0632759
  :EndRoughnessZones
:EndChannelProfile

##############new channel ##############################
:ChannelProfile               Chn_2
  :Bedslope                 0.00352094
  :SurveyPoints
    0           191.579
    16.0           187.579
    127.32           187.579
    129.98           186.249
    180.32           186.249
    182.98           187.579
    294.3           187.579
    310.3           191.579
  :EndSurveyPoints
  :RoughnessZones
    0           0.03
    127.32           0.035
    182.98           0.03
  :EndRoughnessZones
:EndChannelProfile
```

## (d) Lake config.

TestLake.rvh

```
:Reservoir   Lake_9    ########
  :SubBasinID  474
  :HRUID    1198
  :Type RESROUTE_STANDARD
  :WeirCoefficient  0.6
  :CrestWidth 1205.98
  :MaxDepth 19.4
  :LakeArea     25767800000.0
:EndReservoir
############################################
###New Lake starts
:Reservoir   Lake_66    ########
  :SubBasinID  475
  :HRUID    1199
  :Type RESROUTE_STANDARD
  :WeirCoefficient  0.6
  :CrestWidth 889.83
  :MaxDepth 2.9
  :LakeArea     1161170000.0
:EndReservoir
```

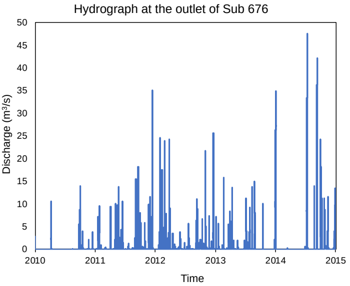
## (e) Grid weights

GriddedForcings2.txt

```
:GridWeights
   #
   # [# HRUs]
   :NumberHRUs         799
   :NumberGridCells   1326.0
   #
   # [HRU ID] [Cell #] [w_kl]
   1      226        0.0994921484019
   1      227        0.321662319807
   1      265        0.274128684419
   1      266        0.304716847372
   2      226        0.649609331567
   2      227        0.350390668433
   3      226        0.935354542345
   3      187        0.0646454576549
```

# A Quick Look at RAVEN Routing Results

| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | time | date | hour | precip [mm/ | sub676 [m3/s] | sub677 [m3/s] | sub678 [m3/s] | sub679 [m3/s] |
| 2 | 0 | 2010-01-01 | 00:00.0 | --- | 2.86796 | 6.81493 | 10.4476 | 10.86 |
| 3 | 0.25 | 2010-01-01 | 00:00.0 | 0 | 2.79806 | 5.99263 | 10.0189 | 10.6538 |
| 4 | 0.5 | 2010-01-01 | 00:00.0 | 0 | 1.36425 | 4.30514 | 8.31753 | 10.0189 |
| 5 | 0.75 | 2010-01-01 | 00:00.0 | 0 | 0.000519064 | 2.02924 | 6.83264 | 8.31764 |
| 6 | 1 | 2010-01-02 | 00:00.0 | 0 | 0.000856038 | 0.440571 | 4.9023 | 6.83279 |
| 7 | 1.25 | 2010-01-02 | 00:00.0 | 0 | 0.00119007 | 0.187543 | 2.10711 | 4.90249 |
| 8 | 1.5 | 2010-01-02 | 00:00.0 | 0 | 0.00152089 | 0.0809411 | 0.632685 | 2.10734 |
| 9 | 1.75 | 2010-01-02 | 00:00.0 | 0 | 0.00184859 | 0.036234 | 0.144342 | 0.632959 |
| 10 | 2 | 2010-01-03 | 00:00.0 | 0 | 0.00217348 | 0.0176886 | 0.0383626 | 0.144658 |
| 11 | 2.25 | 2010-01-03 | 00:00.0 | 0 | 0.00249558 | 0.0101995 | 0.0196542 | 0.0387183 |
| 12 | 2.5 | 2010-01-03 | 00:00.0 | 0 | 0.00281491 | 0.0073812 | 0.0149939 | 0.0200501 |
| 13 | 2.75 | 2010-01-03 | 00:00.0 | 0 | 0.00313151 | 0.00653439 | 0.0141748 | 0.0154296 |
| 14 | 3 | 2010-01-04 | 00:00.0 | 0 | 0.00344538 | 0.00651805 | 0.0144127 | 0.01465 |
| 15 | 3.25 | 2010-01-04 | 00:00.0 | 0 | 0.00375657 | 0.00684984 | 0.0149432 | 0.014927 |
| 16 | 3.5 | 2010-01-04 | 00:00.0 | 0 | 0.00406508 | 0.00732588 | 0.0155213 | 0.0154963 |
| 17 | 3.75 | 2010-01-04 | 00:00.0 | 0 | 0.00437094 | 0.00786002 | 0.0161293 | 0.0161129 |
| 18 | 4 | 2010-01-05 | 00:00.0 | 0 | 0.00467418 | 0.00841586 | 0.0167638 | 0.016759 |
| 19 | 4.25 | 2010-01-05 | 00:00.0 | 0 | 0.00497483 | 0.00897805 | 0.0174217 | 0.0174313 |
| 20 | 4.5 | 2010-01-05 | 00:00.0 | 0 | 0.00527288 | 0.00954011 | 0.0181002 | 0.0181267 |
| 21 | 4.75 | 2010-01-05 | 00:00.0 | 0 | 0.00556838 | 0.0100993 | 0.0187969 | 0.0188424 |
| 22 | 5 | 2010-01-06 | 00:00.0 | 0 | 0.00586134 | 0.0106546 | 0.0195093 | 0.0195759 |
| 23 | 5.25 | 2010-01-06 | 00:00.0 | 0 | 0.00615179 | 0.0112055 | 0.0202355 | 0.0203249 |
| 24 | 5.5 | 2010-01-06 | 00:00.0 | 0 | 0.00643975 | 0.0117517 | 0.0209735 | 0.0210873 |
| 25 | 5.75 | 2010-01-06 | 00:00.0 | 0 | 0.00672523 | 0.0122934 | 0.0217215 | 0.0218612 |
| 26 | 6 | 2010-01-07 | 00:00.0 | 0 | 0.00700827 | 0.0128304 | 0.0224782 | 0.0226449 |
| 27 | 6.25 | 2010-01-07 | 00:00.0 | 0 | 0.00728887 | 0.0133628 | 0.0232419 | 0.0234368 |
| 28 | 6.5 | 2010-01-07 | 00:00.0 | 0 | 0.00756707 | 0.0138907 | 0.0240115 | 0.0242355 |
| 29 | 6.75 | 2010-01-07 | 00:00.0 | 0 | 0.00784287 | 0.0144141 | 0.0247857 | 0.0250398 |
| 30 | 7 | 2010-01-08 | 00:00.0 | 0 | 0.00811631 | 0.0149329 | 0.0255636 | 0.0258484 |




The simulated hydrographs are stored with the observed ones in a .csv file.

# Next Steps

- Support people who wish to overlay the subwatershed with customized forcing grids
- Support auto-calibration using this product with Ostrich

# Thanks!

Feel free to contact us if you have any question about the product.

hongren.shen@uwaterloo.ca

**Hongren Shen, Ming Han, Bryan Tolson, Juliane Mai**

University of Waterloo, Nov 6, 2018

# 3.

## Performance metrics

# Performance metrics

models will be compared regarding **daily streamflow** at specified gauges (objective #1 and #2) and **net basin supply** (objective #3)

**Potential metrics**

KGE
NSE
logNSE
sqrtNSE
MAE
RMSE
PBIAS
$R^2$
RSR (ratio RMSE and std.-dev. of obs.)
normalized bias (applicable to compare multiple basins together)
normalized MAE (applicable to compare multiple basins together)
FDC
and many more ...

**Possible objectives**

”local”: max(performance each gauge individually)
”global”: max(mean performance of all gauges)
”global”: max(worst performance among all gauges)
”global”: max(area-weighted average of all gauges)
or other ...

# Performance metrics

- we want to be as open as possible regarding metrics and calibration strategies
- it however will be easier to compare if we agree on a few options
- **ToDo:** Julie will create a poll for:
  - favored metrics of each collaborator
    (e.g. ”Potential metrics” on previous slide)
  - favored strategy to achieve overall good performance across multiple gauges
    (e.g. ”Possible objectives” on previous slide)
  - answer to the question if your model will need to be predict streamflow in ungauged basins
- Results will be discussed in next meeting (Dec 4, 2018)

# Thanks everybody for providing updates and joining the call!

Next conference call:
Tuesday Dec 4, 2018

Please let me know your GitHub usernames such that I can add you!