Status report on the Great Lakes Runoff Inter-comparison Project for Lake Erie (GRIP-E)

Aim of Study

• Develop strategies to handle **cross-border issues** of available data and develop unifying approaches
• Test **relative performance** of different models
• Identify respective **strengths of models**, i.e., learning which models perform best under certain conditions
• Generating **multi-model ensembles** to quantify uncertainty of model outputs
• Impact of **modeling decisions** on model performance
Current Participating Models & Partners

LBRM (lumped)
Lauren Fry (USACE)
Tim Hunter (NOAA-GLERL)
Drew Gronewold (NOAA-GLERL)
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VIC (land-surface hydr.)
v1: Shervan Gharari (U of Sask.)
v2: Hongren Shen (U of Waterloo)

MESH (land-surface hydr.)
Amin Haghnegahdar (U of Sask.)
Daniel Princz (U of Sask.)
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GEM-Hydro (land-surface hydr.)
- Étienne Gaborit (ECCC-MSC)
- Maria Abrahamowicz (ECCC-MSC)
- Dorothy Durnford (ECCC-MSC)
- Young Lan Shin (ECCC-MSC)

MESH (land-surface hydr.)
- Amin Haghnegahdar (U of Sask.)
- Daniel Princz (U of Sask.)

WRF-Hydro (land-surface hydr.)
- Drew Gronewold (NOAA-GLERL)
- Lauren Read (NCAR)
- Katelyn Fitzgerald (NCAR)
Phases of Inter-Comparison Project for GRIP-E case study

**Phase I** – harmonize climate forcings only
Phases of Inter-Comparison Project
for GRIP-E case study

Phase I – harmonize climate forcings only

until Sep 1, 2018: model setup
 ↺ report on setup data used
 ↺ report on discretization used

until Oct 1, 2018: model calibration

until Nov 1, 2018: model validation
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- until Sep 1, 2018: model setup
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- until Nov 1, 2018: model validation

**Phase II** – harmonized climate and all other inputs
Phases of Inter-Comparison Project for GRIP-E case study

**Phase I** – harmonize climate forcings only

- until Sep 1, 2018: model setup
- ↷ report on setup data used
- ↷ report on discretization used
- until Oct 1, 2018: model calibration
- until Nov 1, 2018: model validation

**Phase II** – harmonized climate and all other inputs

- start Sep 1, 2018: input data harmonization
- start Nov 1, 2018: model setup
- start Jan 1, 2019: model calibration
- start Mar 1, 2019: model validation
Phases of Inter-Comparison Project for GRIP-E case study

**Phase I** – harmonize climate forcings only

until Sep 1, 2018: model setup
↷ report on setup data used
↷ report on discretization used
until Oct 1, 2018: model calibration
until Nov 1, 2018: model validation

**Phase II** – harmonized climate and all other inputs

start Sep 1, 2018: input data harmonization
start Nov 1, 2018: model setup
start Jan 1, 2019: model calibration
start Mar 1, 2019: model validation
Meteorologic forcings

Regional Deterministic Reforecast System (RDRS)

Data source:
## Meteorologic forcings

### Regional Deterministic Reforecast System (RDRS)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Level</th>
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<tr>
<td>Precipitation Rate</td>
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<td>SFC</td>
</tr>
<tr>
<td>Inc. Shortwave Radiation</td>
<td>[W/m²]</td>
<td>SFC</td>
</tr>
<tr>
<td>Inc. Longwave Radiation</td>
<td>[W/m²]</td>
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</tr>
<tr>
<td>Atmospheric Pressure</td>
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<tr>
<td>Specific Humidity</td>
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<td>Wind Components (along grid)</td>
<td>[kts]</td>
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<tr>
<td>Corr. Wind Components (along W-E/S-N)</td>
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</tr>
<tr>
<td>Wind Speed</td>
<td>[kts]</td>
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</tr>
<tr>
<td>Wind Direction</td>
<td>[degree]</td>
<td>40m</td>
</tr>
</tbody>
</table>

### Data source:

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

- other forcing data than RDRS used (in-house historical daily/hourly station data)
- no geophysical data (soil, land cover etc) used
- model resolution is daily and lumped to sub-basins
- calibration period: 1983-2000 (9 parameters)
- modeling period: Jan 1940 to May 2017

Figure: Sub-basin setup for Lake Erie including Lake St. Clair
Status LBRM model
– Tim Hunter & Drew Gronewold (GLERL), Lauren Fry (USACE) –

Figure: Simulated discharge for sub-basin #1 of Lake Erie (ID 601, period 2010-2014)
Status WATFLOOD model
– Frank Seglenieks (ECCC) –

- other forcing dataset than RDRS used (RDPS and CaPA)
- model and routing resolution are 20 km and 1 hr
- other modeling period used (2006-2018)
- heavily calibrated using data from about 2006-2014

Gauge: 4208000

Figure: Cuyahoga River at Independence, OH. (NSE=0.39)
Status VIC model
– v2: Hongren Shen (UWaterloo) –

• RDRS forcing dataset in NetCDF format used
• model resolution is 15 km and 1 hr (same as RDRS)
• routing with RAVEN and calibration in progress
Status GEM-Hydro model
– Étienne Gaborit (ECCC) –

- other forcing dataset than RDRS used
- model resolution is 10 km and 10 min (GEM-Surf (SPS), SVS)
- routing with Watroute (1 km and 30-600s)
- other modeling domain used (whole Great Lakes)
- other modeling period used (2014-2017)
- no town-energy-balance (TEB) model used yet

Figure: Petawawa River, Ottawa River watershed. (NSE=0.73)

Figure: Moira River, Lake Ontario watershed. (NSE=0.59)
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
System response measurements available

- Modeled discharge at selected gauging stations
  - Requires routing
  - Lumped models need to have sub-basins setup such that they match those stations
- Net basin supply for Lake Erie and Lake St. Clair
  - Probability distributions of monthly net basin supply known from Joeseph Smith & Drew Gronewold (2017)
Routing

- Offline routing in some models, e.g., VIC and GEM-Hydro
- Opens up possibility of **unified routing scheme** across models
- RAVEN routing is independent of model
- Routing for VIC and GEM-Hydro already performed with RAVEN
- Linkage to GWF Lake Futures project developing a pan-Canadian Lake and River routing tool (RAVEN) and database

Supported by GWF HQP:

- Ming Han (PhD student, U of Waterloo)
- Shervan Gharari (Core Modeling Team, U of Saskatchewan)
- Julie Mai (Core Modeling Team, U of Waterloo)
Support

• Provision of raw data for model building
• Interpolation of climate data to user-discretized model domain
• Automatic calibration support and limited deployment via OSTRICH
• Support for normalized approach of routing
• Deployment of model validation runs

Supported by GWF HQP:
Hongren Shen (PhD student, U of Waterloo)
Julie Mai (Core Modeling Team, U of Waterloo)
Deliverables & Activities of Interest

• Regional Deterministic Reforecast System (RDRS) utilized and conversion to NetCDF for easy subsetting
• Extraction tool built for WRF climate change scenario outputs:
  • Now in NetCDF format¹
  • Tool allows subsetting of variables of interest to basin/region, as well as time period of interest
• MESH model now runs under NetCDF climate forcings (e.g., those above) and is faster than ASCII-based version²
• VIC 5.0.1 image (NetCDF mode) is now simulating over Lake Erie³

¹ Data provided by Zhenhua Li (USask)
² Collaboration with Daniel Princz (GIWS)
³ Work done by Hongren Shen (UWaterloo)
GLOBAL WATER FUTURES
SOLUTIONS TO WATER THREATS IN AN ERA OF GLOBAL CHANGE
Backup
Modeling domain

Data source:
Great Lakes Aquatic Habitat Framework database

- land area: 76,352 km²
- water bodies: 27,314 km²
- total area: 103,666 km²
Candidate Dataset
– Digital Elevation Model –

**Data source:**
HydroSheds by USGS based on conditioned, global SRTM DEM at 3” (90m) res.

**Alternative(s):**
ASTER Global DEM from NASA, 1” (30 m)
Candidate Dataset
– Flow Direction and Accumulation –

Data source:
generated from DEM at 3” (90m) resolution
Candidate Dataset
– Soil data –

Data source:
FAO Harmonized World Soil Database (HWSD) v1.2 at 30” (1km) resolution

Alternative(s):
Soil Landscapes of Canada (SLC), 1:1 000 000
Candidate Dataset
– Land-cover data –

Data source:
Global 500m MODIS MCD12Q1 product from NASA incl. 6 classif. schemes (∼ UMD)

Alternative(s):
- ESA GlobCover 2009, 300 m
- 2010 Landsat dataset for North America, 30m
- Land use & cover from the Great Lakes Aquatic Habitat Framework (GLAHF)
- UMD Global Land Cover Classification from Global Land Cover Facility, 1 km
Candidate Dataset
– Land-surface model inputs –

- static data are also used in land-surface models (WRF-Hydro, GEM-Hydro)
- can be made available to other models
- replace the static datasets (DEM, flow direction/accumulation, soil, land-use)
Framework

**Static data:**
Candidate or other dataset

**Meteo. data:**
Regional Determ. Reforecast System

**Models:**
- HYPE
- LBRM
- WATFLOOD
- MESH
- VIC
- GEM-Hydro
- WRF-Hydro
Framework

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Model-dependent pre-processing scripts
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Model-dependent pre-processing scripts

Model setup & Model run
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Inputs: Open-source or made available through download
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