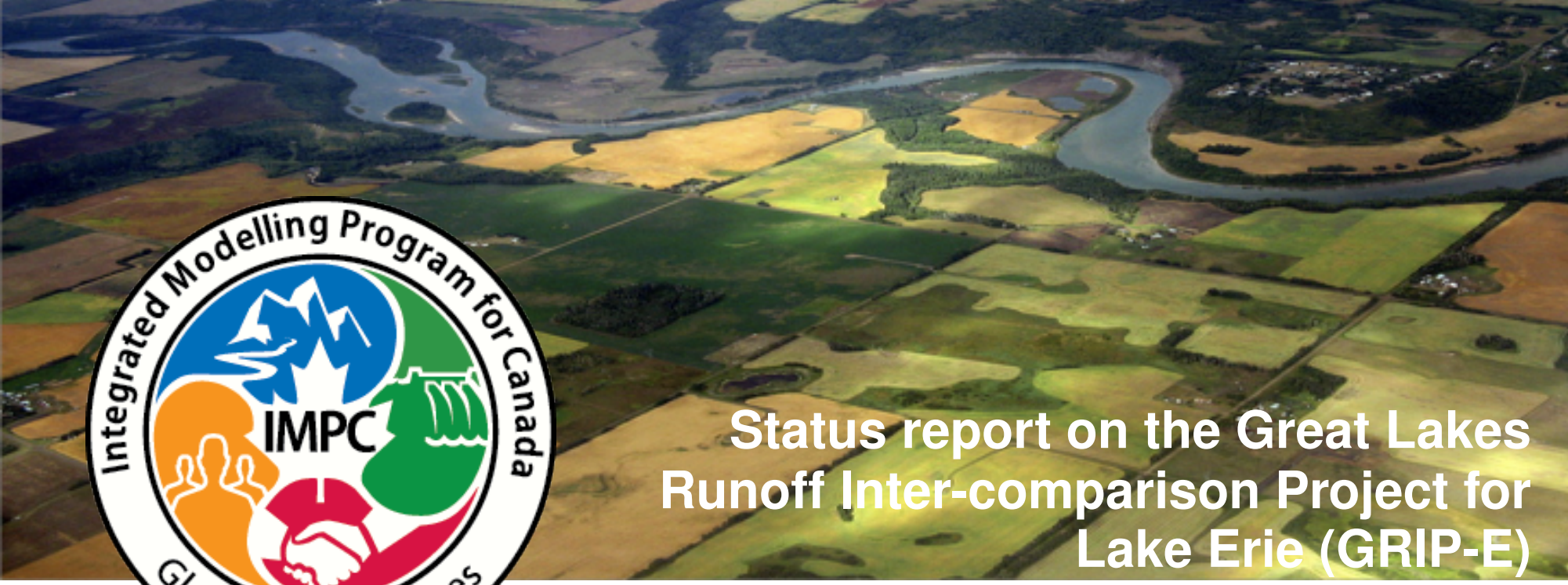

Status report on the Great Lakes Runoff Inter-comparison Project for Lake Erie (GRIP-E)

Juliane Mai, Bryan A. Tolson, Hongren Shen, Étienne Gaborit, Nicolas Gasset, Vincent Fortin, Maria Abrahamowicz, Dorothy Durnford, Young Lan Shin, Lauren M. Fry, Tim Hunter, Andrew D. Gronewold, 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

Environment and Climate Change Canada
Environnement et Changement climatique Canada

US Army Corps of Engineers®

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

UNIVERSITY OF NOTRE DAME

UNIVERSITY OF MICHIGAN

NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

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

Complexity

LBRM (lumped)

Lauren Fry (USACE)
Tim Hunter (NOAA-GLERL)
Drew Gronewold (NOAA-GLERL)

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v1: Shervan Gharari (U of Sask.)
v2: Hongren Shen (U of Waterloo)

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GEM-Hydro (land-surface hydr.)
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Maria Abrahamowicz (ECCC-MSC)
Dorothy Durnford (ECCC-MSC)
Young Lan Shin (ECCC-MSC)

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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Climate change scenario runs I

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Climate change scenario runs I

Phase II – harmonized climate and all other inputs

Phases of Inter-Comparison Project

for GRIP-E case study

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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

Climate change scenario runs I

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
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Climate change scenario runs I

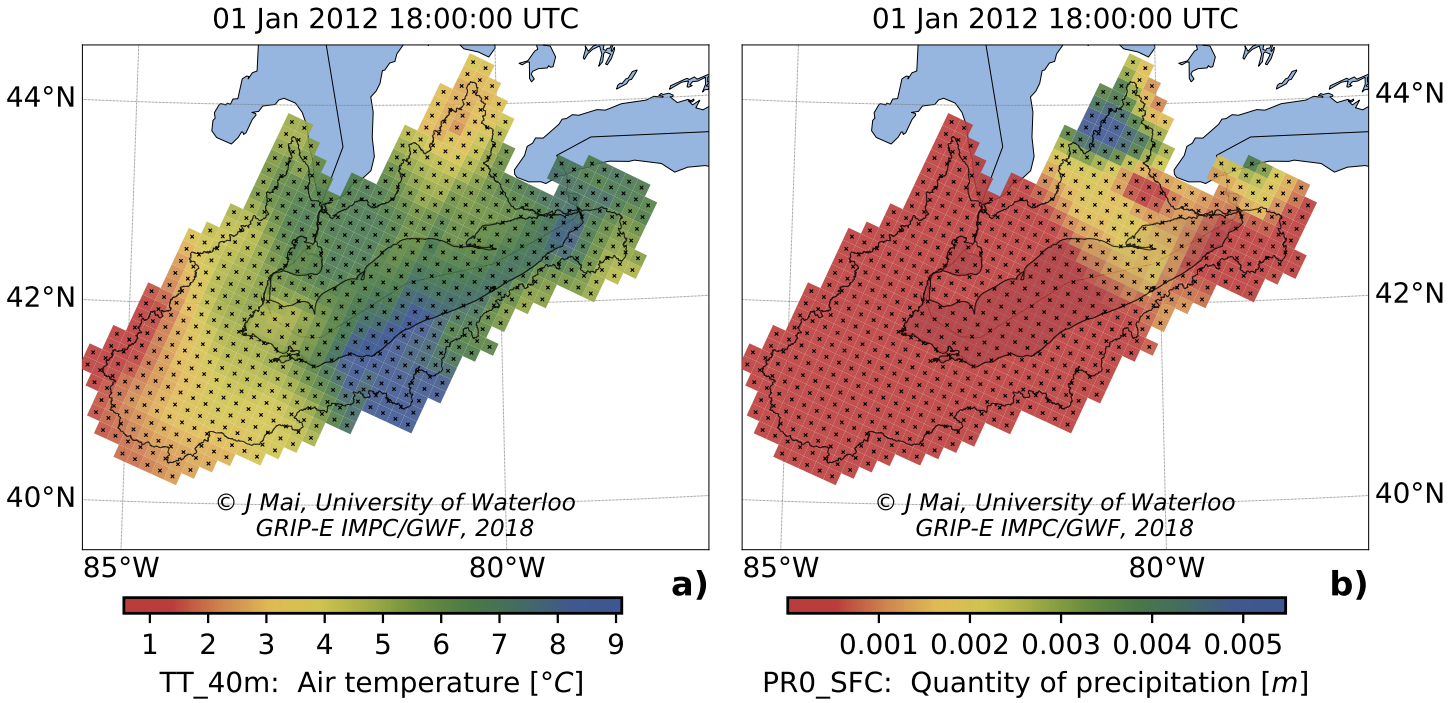
Phase II – harmonized climate and all other inputs

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

Climate change scenario runs II

Meteorologic forcings

Regional Deterministic Reforecast System (RDRS)



Data source:

Gasset, N., V. Fortin, M. Carrera, M. Dimitrijevic, É. Gaborit, G. Roy, and N. Gagnon (in prep.), Toward a 35 Years North American Precipitation and Land Surface Reanalysis, *Journal of Hydrometeorology*.

Meteorologic forcings

Regional Deterministic Reforecast System (RDRS)

Precipitation Rate	[m]	SFC
Inc. Shortwave Radiation	[W/m^2]	SFC
Inc. Longwave Radiation	[W/m^2]	SFC
Atmospheric Pressure	[mb]	SFC
Air Temperature	[°C]	40m
Specific Humidity	[kg/kg]	40m
Wind Components (along grid)	[kts]	40m
Corr. Wind Components (along W-E/S-N)	[kts]	40m
Wind Speed	[kts]	40m
Wind Direction	[degree]	40m

Data source:

Gasset, N., V. Fortin, M. Carrera, M. Dimitrijevic, É. Gaborit, G. Roy, and N. Gagnon (in prep.), Toward a 35 Years North American Precipitation and Land Surface Reanalysis, *Journal of Hydrometeorology*.

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

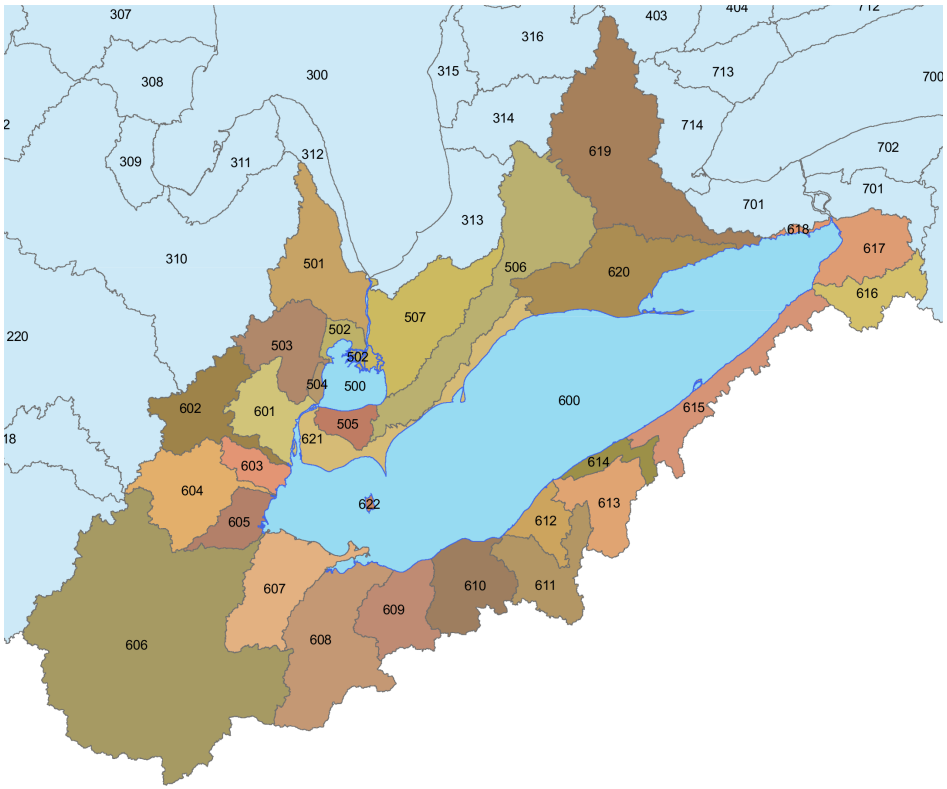


Figure: Sub-basin setup for Lake Erie including Lake St. Clair

Status LBRM model

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

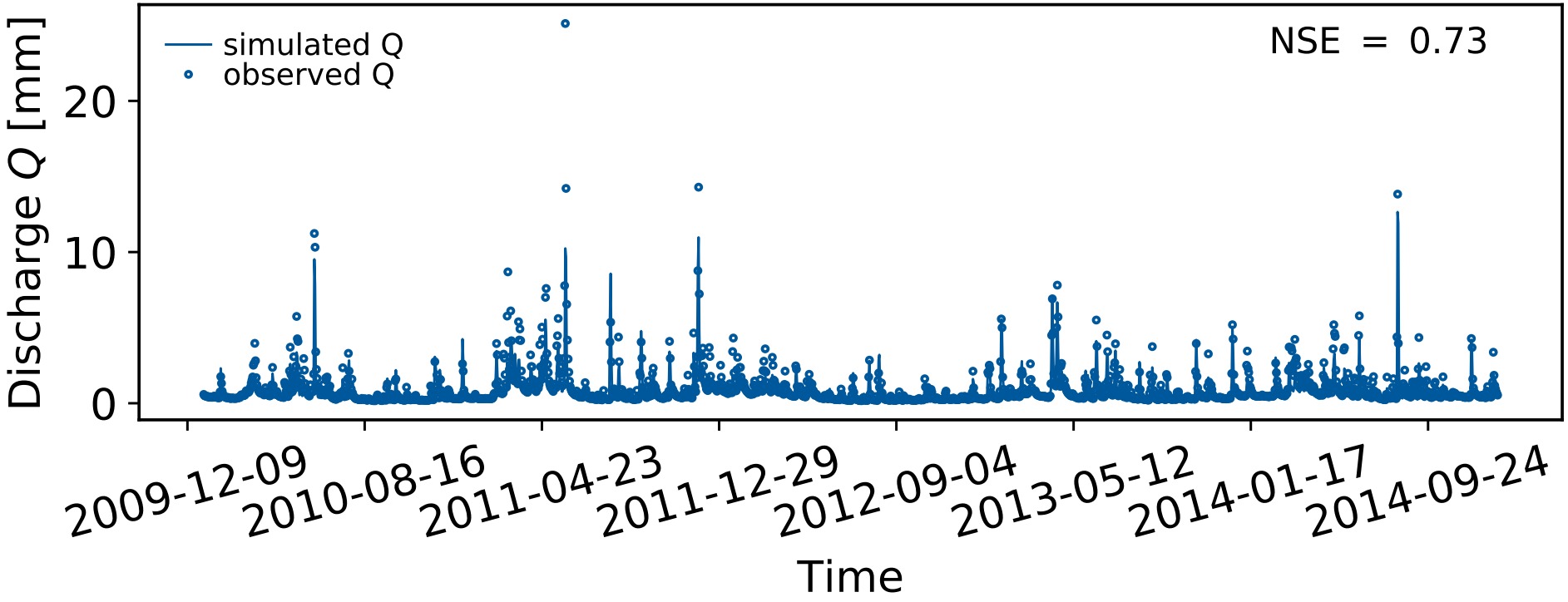


Figure: Simulated discharge for sub-basin #1 of Lake Erie (ID 601, period 2010-2014)

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

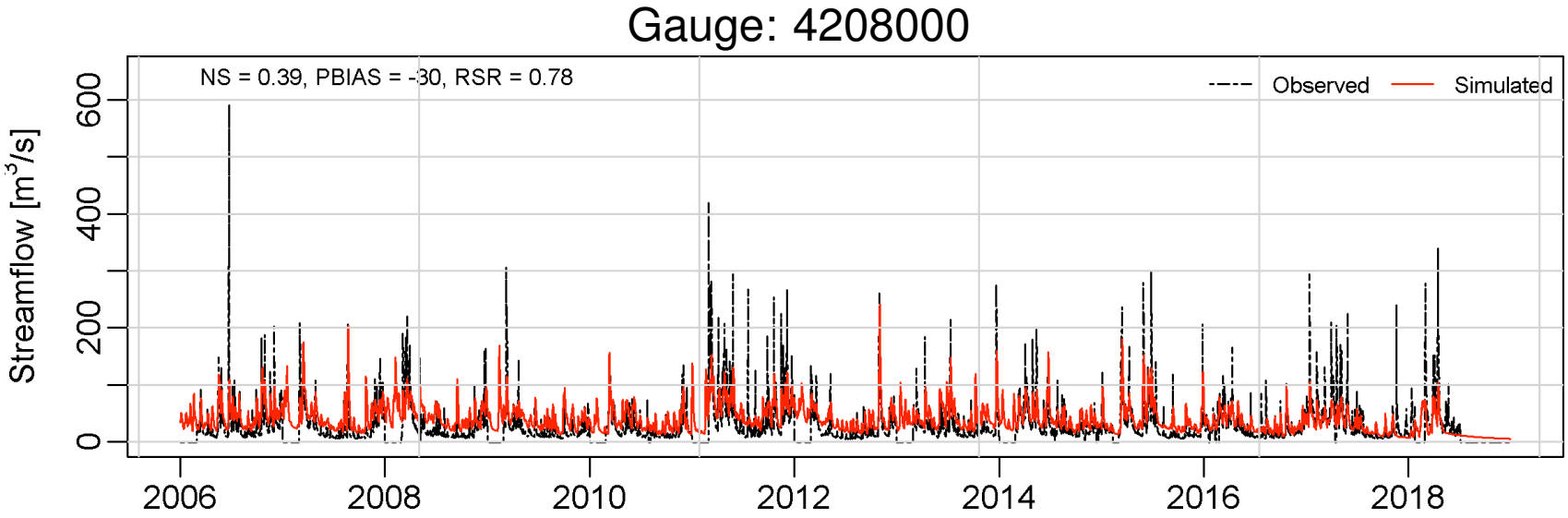
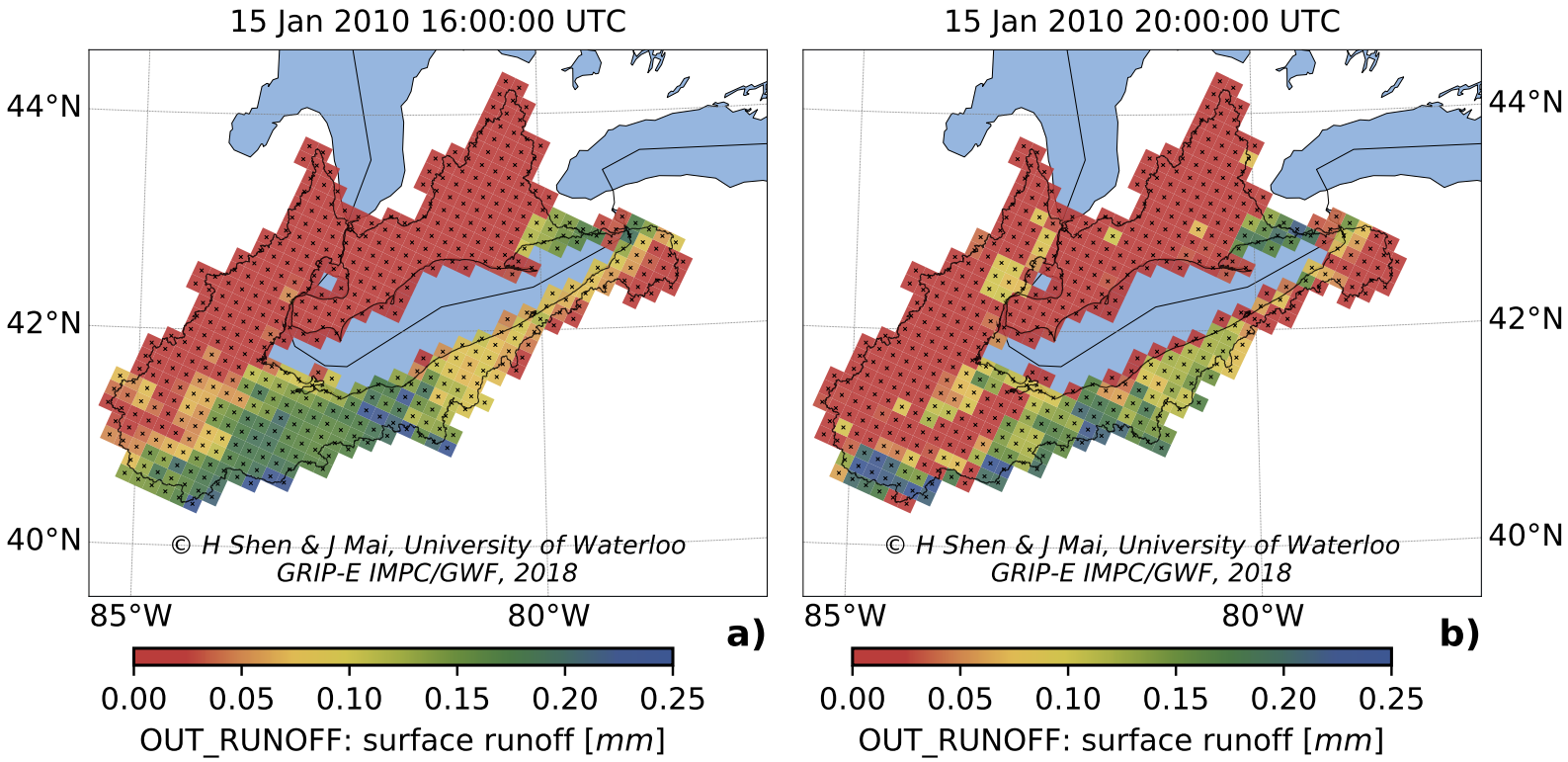


Figure: Cuyahoga River at Independence, OH. (NSE=0.39)

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

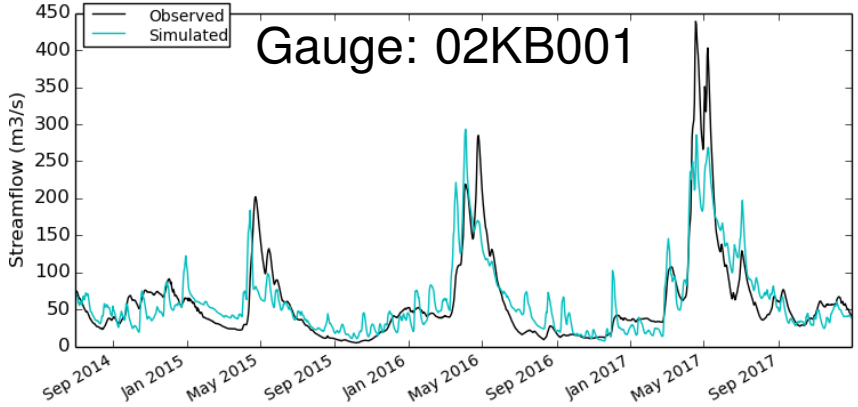


Figure: Petawawa River, Ottawa River watershed. (NSE=0.73)

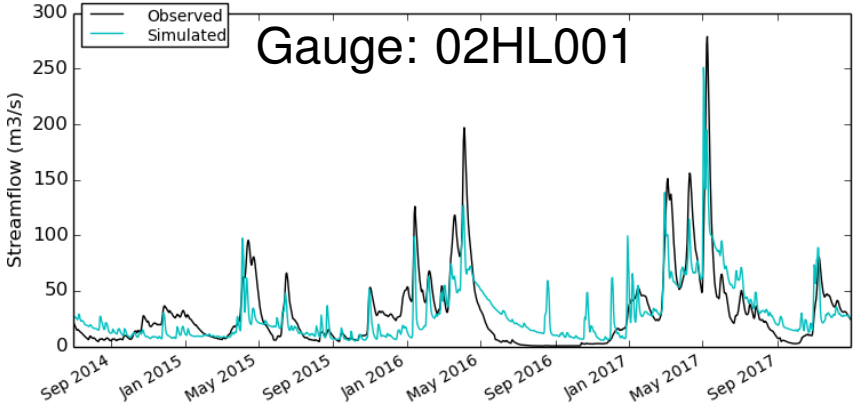


Figure: Moira River, Lake Ontario watershed. (NSE=0.59)

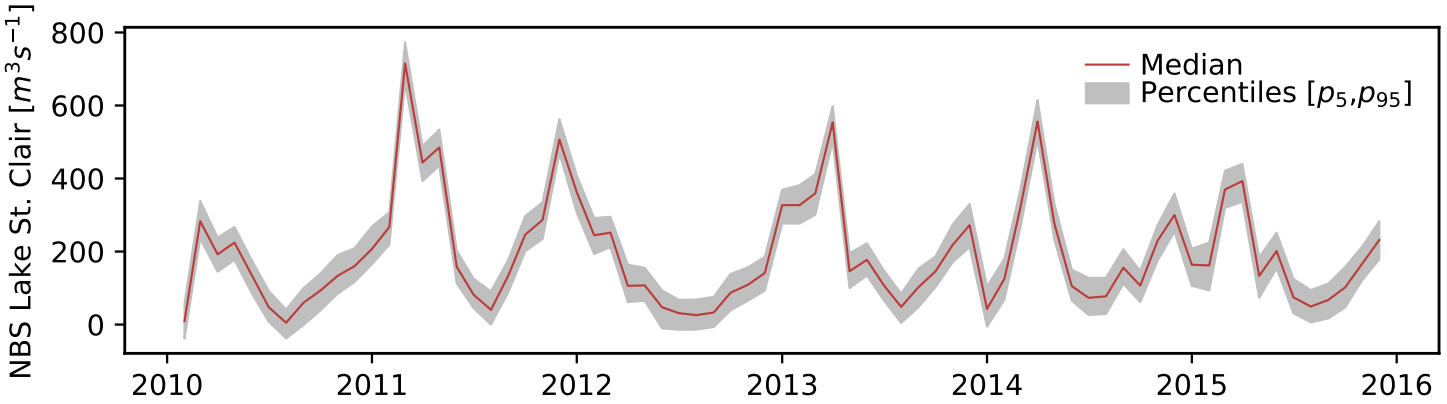
Status MESH model

– 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 format[1]
  - 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 version[2]
- VIC 5.0.1 image (NetCDF mode) is now simulating over Lake Erie[3]

[1] Data provided by Zhenhua Li (USask)

[2] Collaboration with Daniel Princz (GIWS)

[3] Work done by Hongren Shen (UWaterloo)

Integrated Modelling Program for Canada
Global Water Futures

GLOBAL WATER FUTURES

SOLUTIONS TO WATER THREATS IN AN ERA OF GLOBAL CHANGE

CANADA FIRST RESEARCH EXCELLENCE FUND | APOGÉE CANADA FONDS D'EXCELLENCE EN RECHERCHE

UNIVERSITY OF SASKATCHEWAN

UNIVERSITY OF WATERLOO

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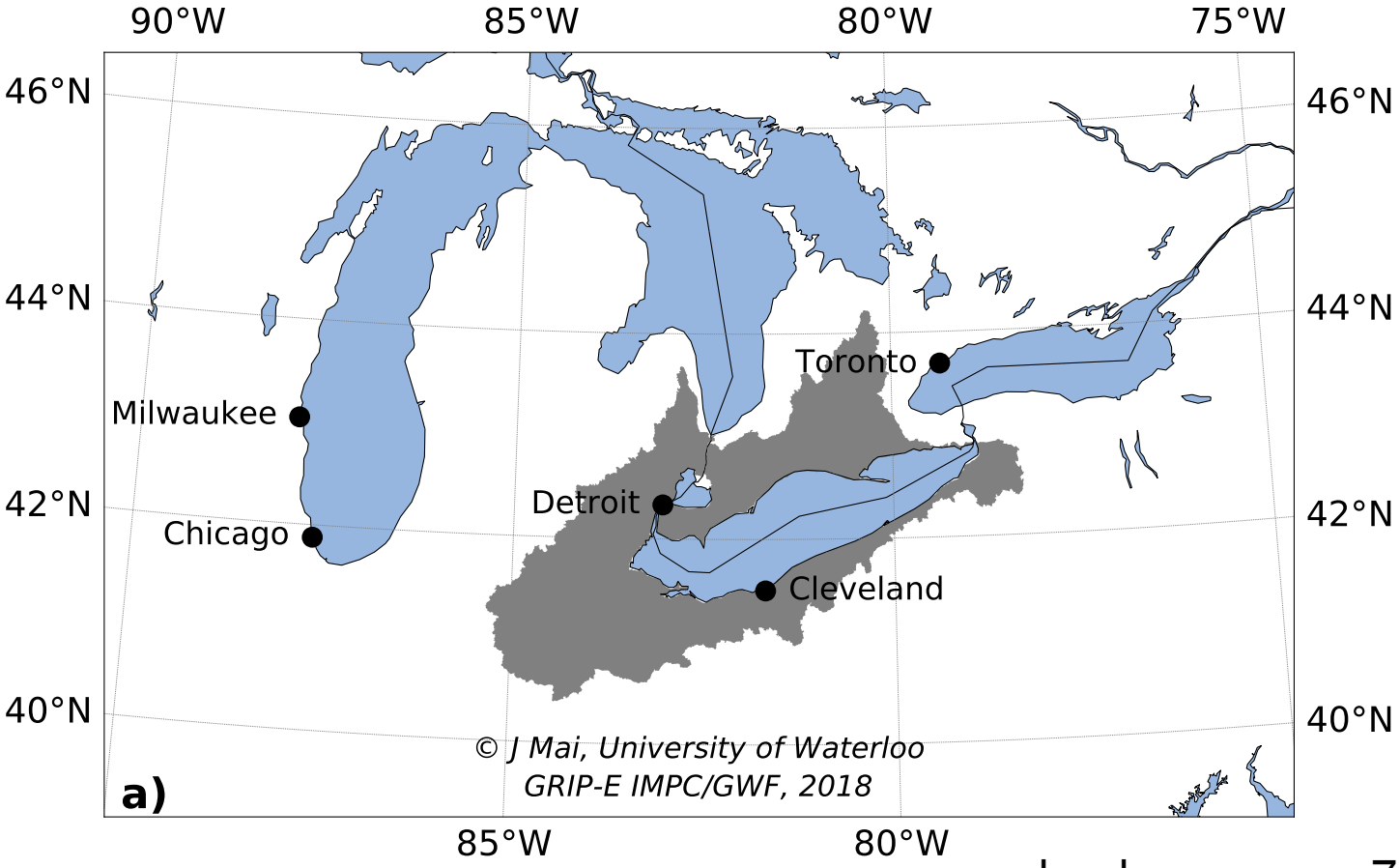
LAURIER Inspiring Lives.

Backup

Modeling domain



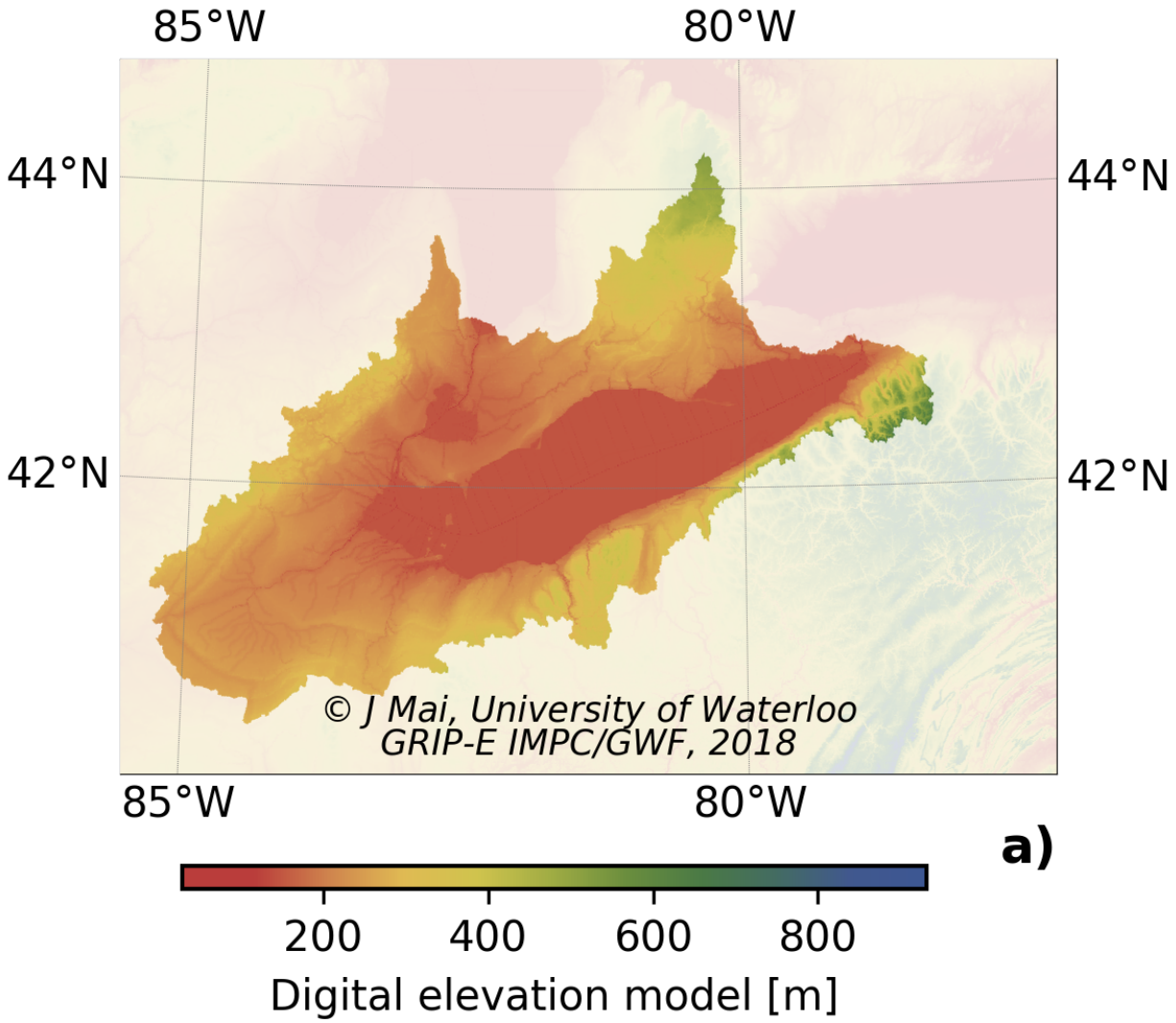
land area:	76 352 km^2
water bodies:	27 314 km^2
total area:	103 666 km^2

Data source:

Great Lakes Aquatic Habitat Framework database

Candidate Dataset

– Digital Elevation Model –



Data source:

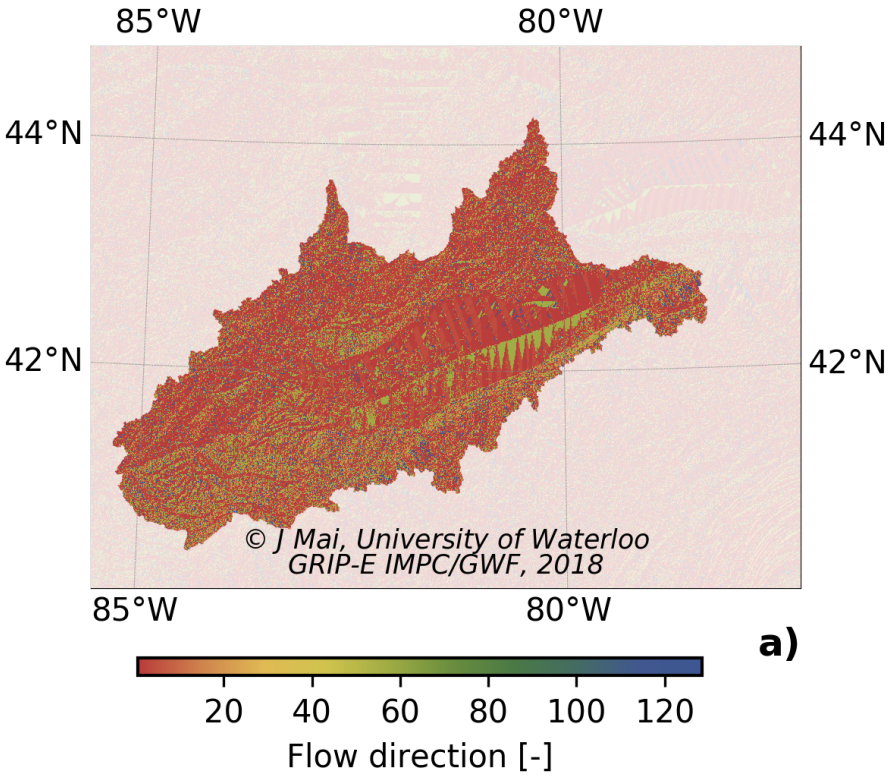
HydroSheds by USGS based on conditioned, global SRTM DEM at 3” (90m) res.

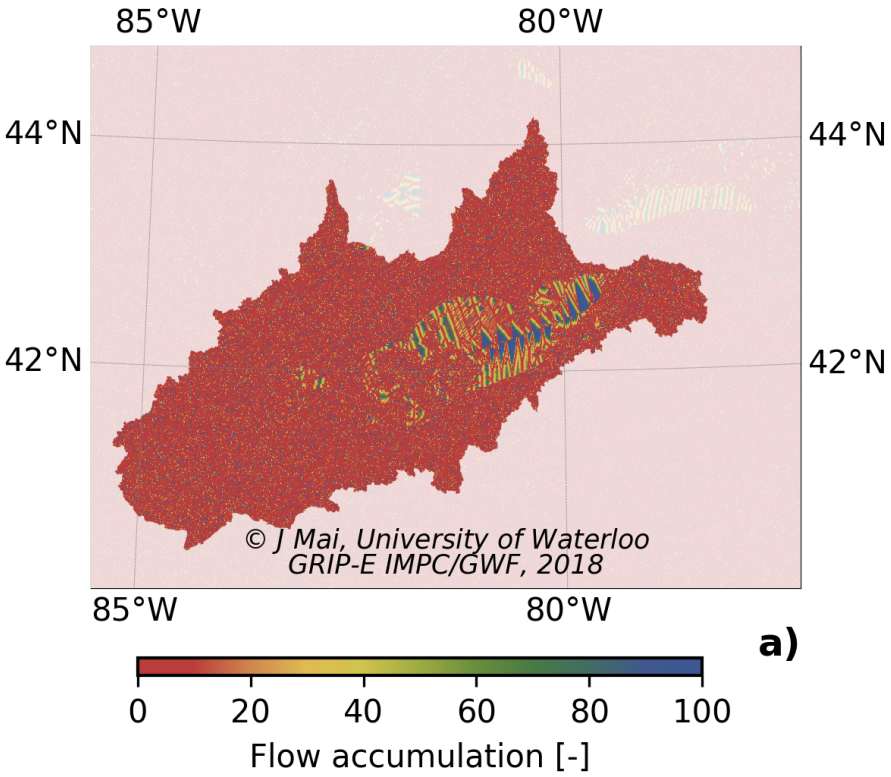
Alternative(s):

ASTER Global DEM from NASA, 1” (30 m)

Candidate Dataset

– Flow Direction and Accumulation –



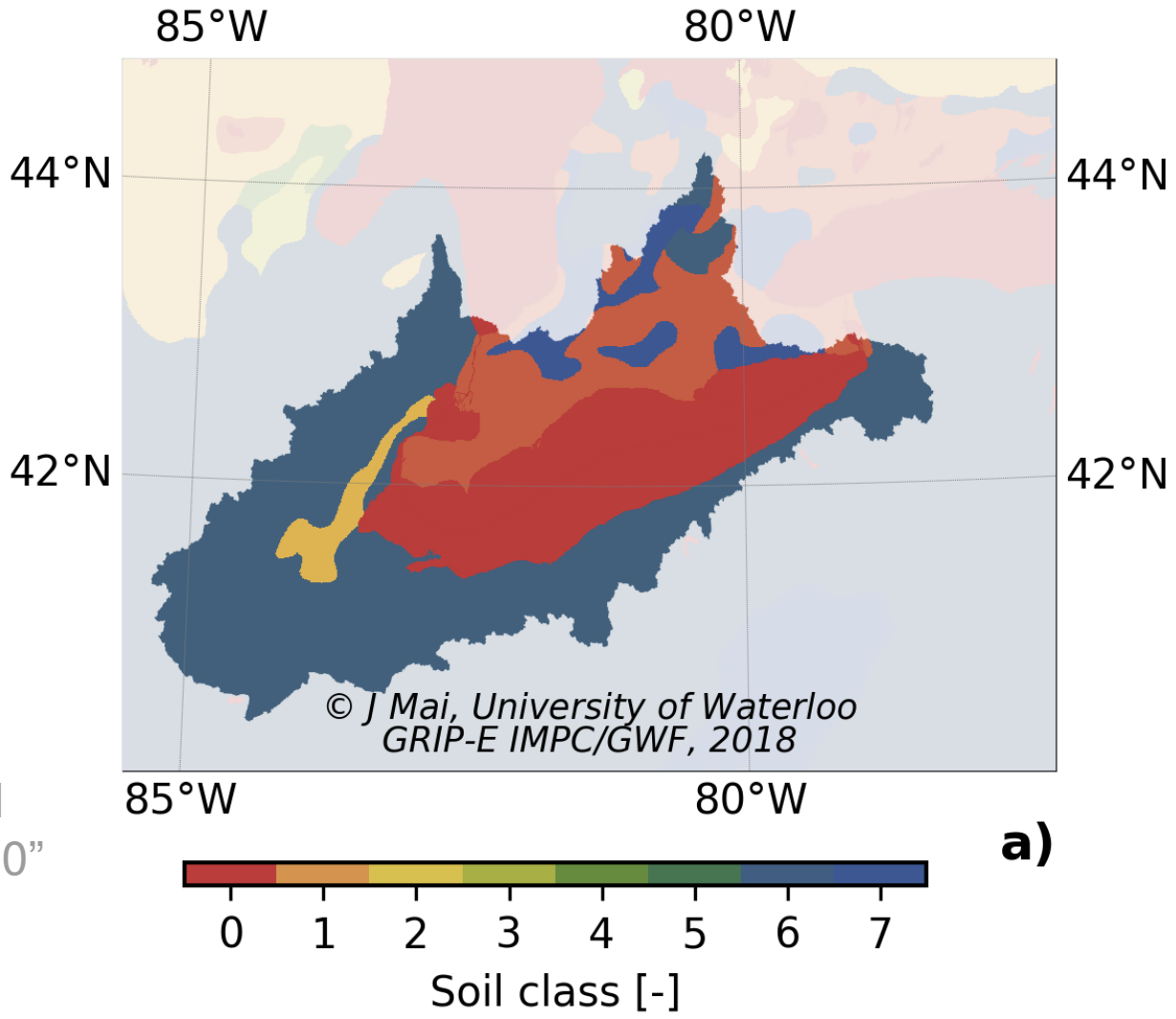


Data source:

generated from DEM at 3” (90m) resolution

Candidate Dataset

– Soil data –



Data source:

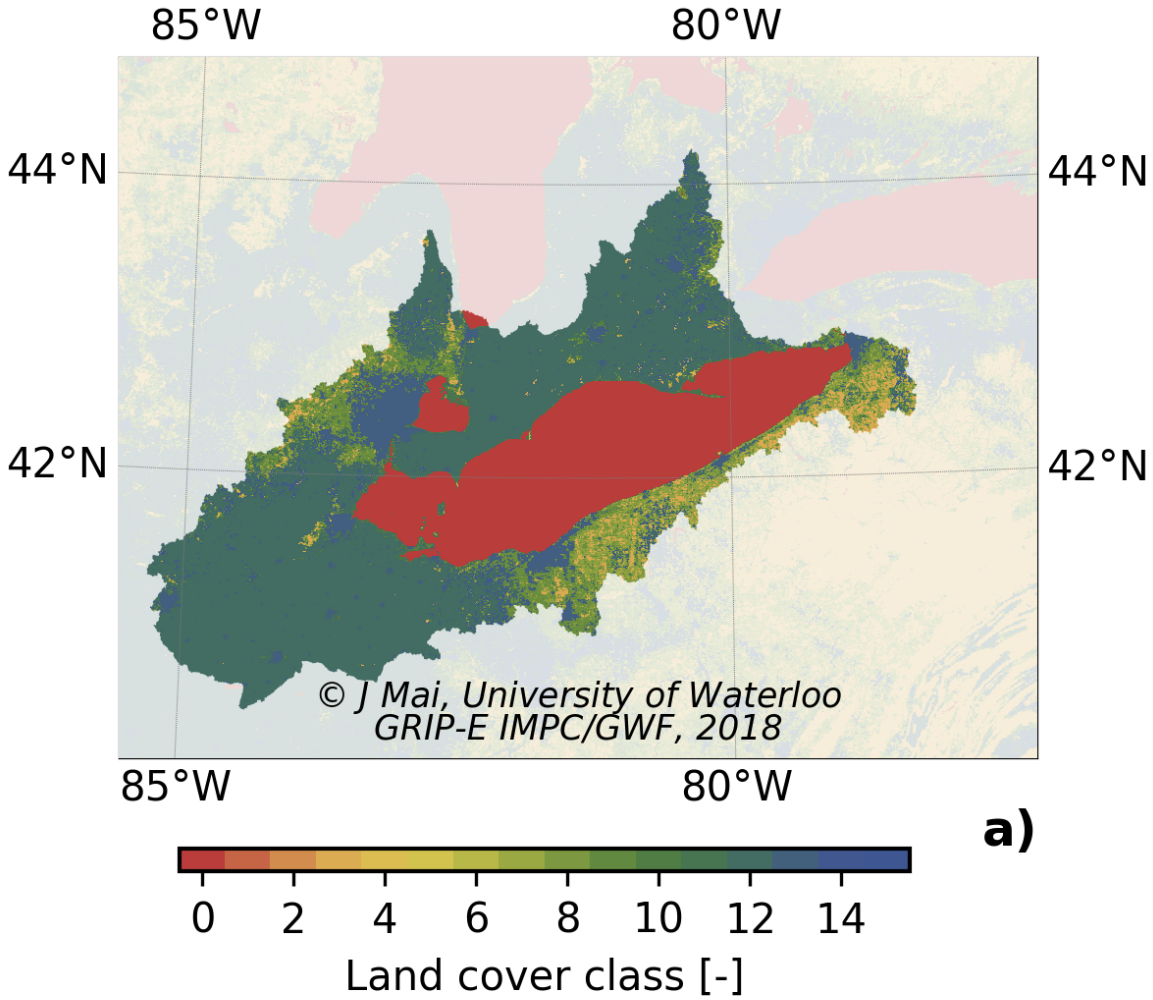
FAO Harmonized World Soil Database (HWSD) v1.2 at 30” (1km) resolution

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

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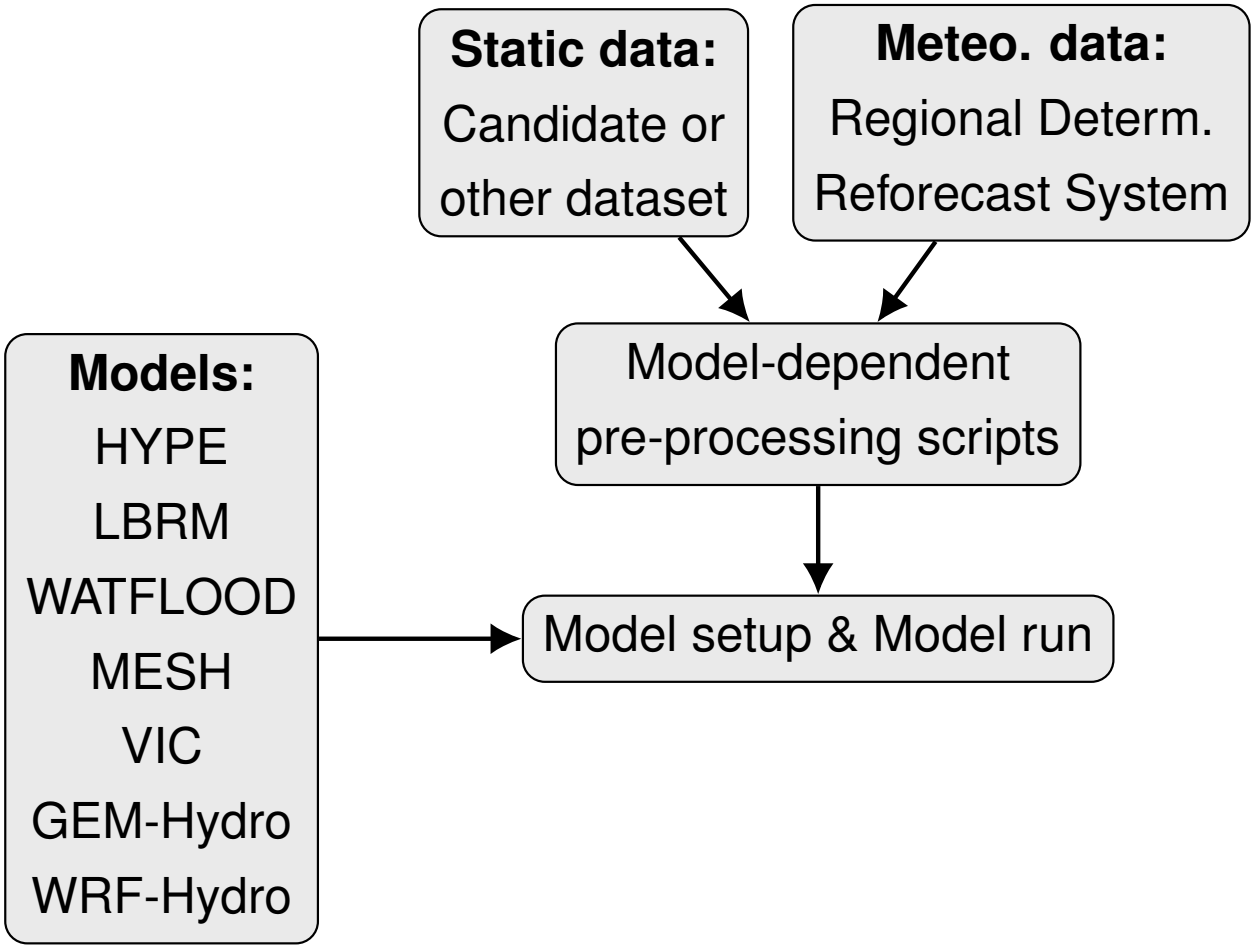
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Model-dependent pre-processing scripts
Model setup & Model run

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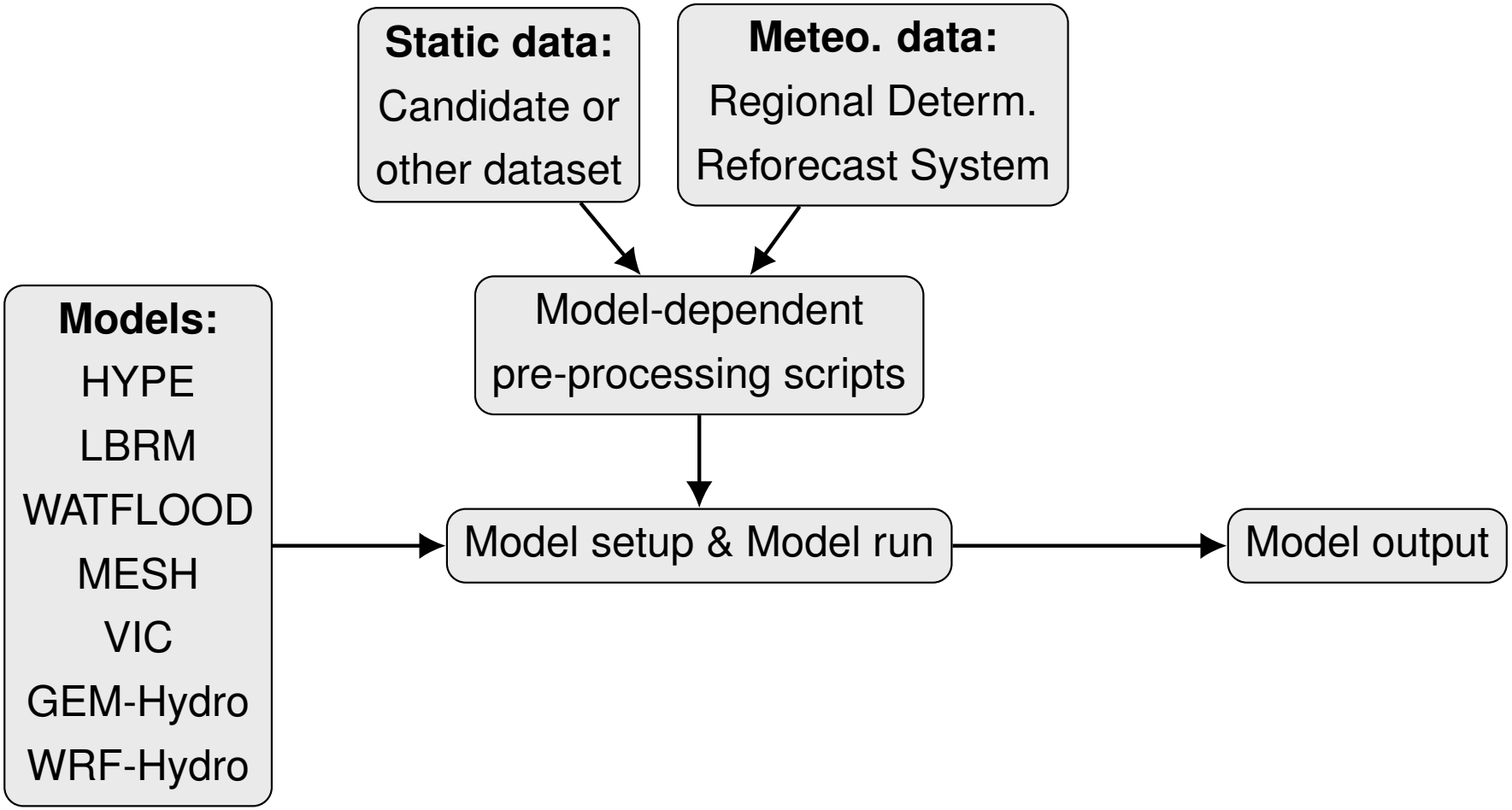
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Model output

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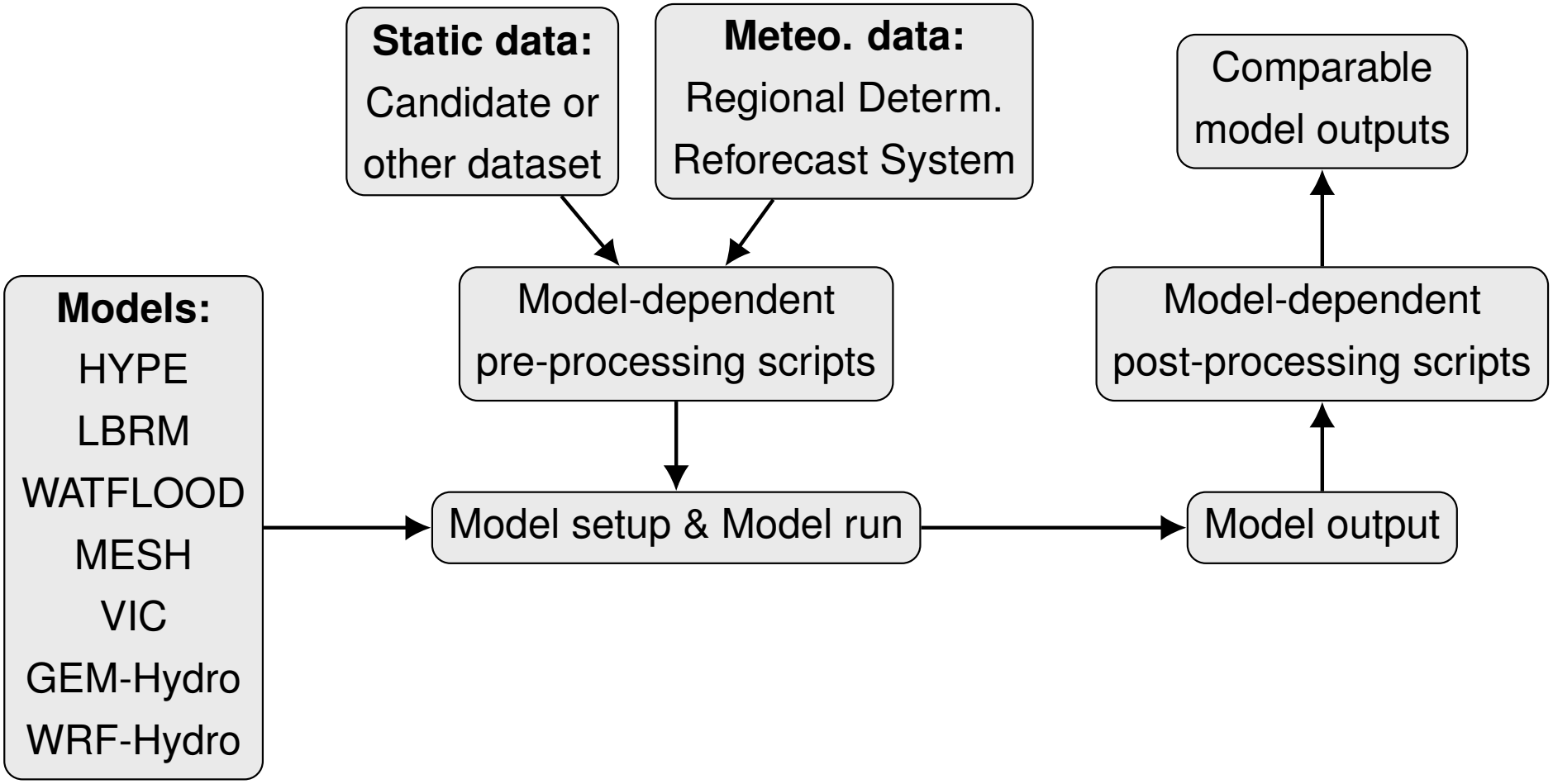
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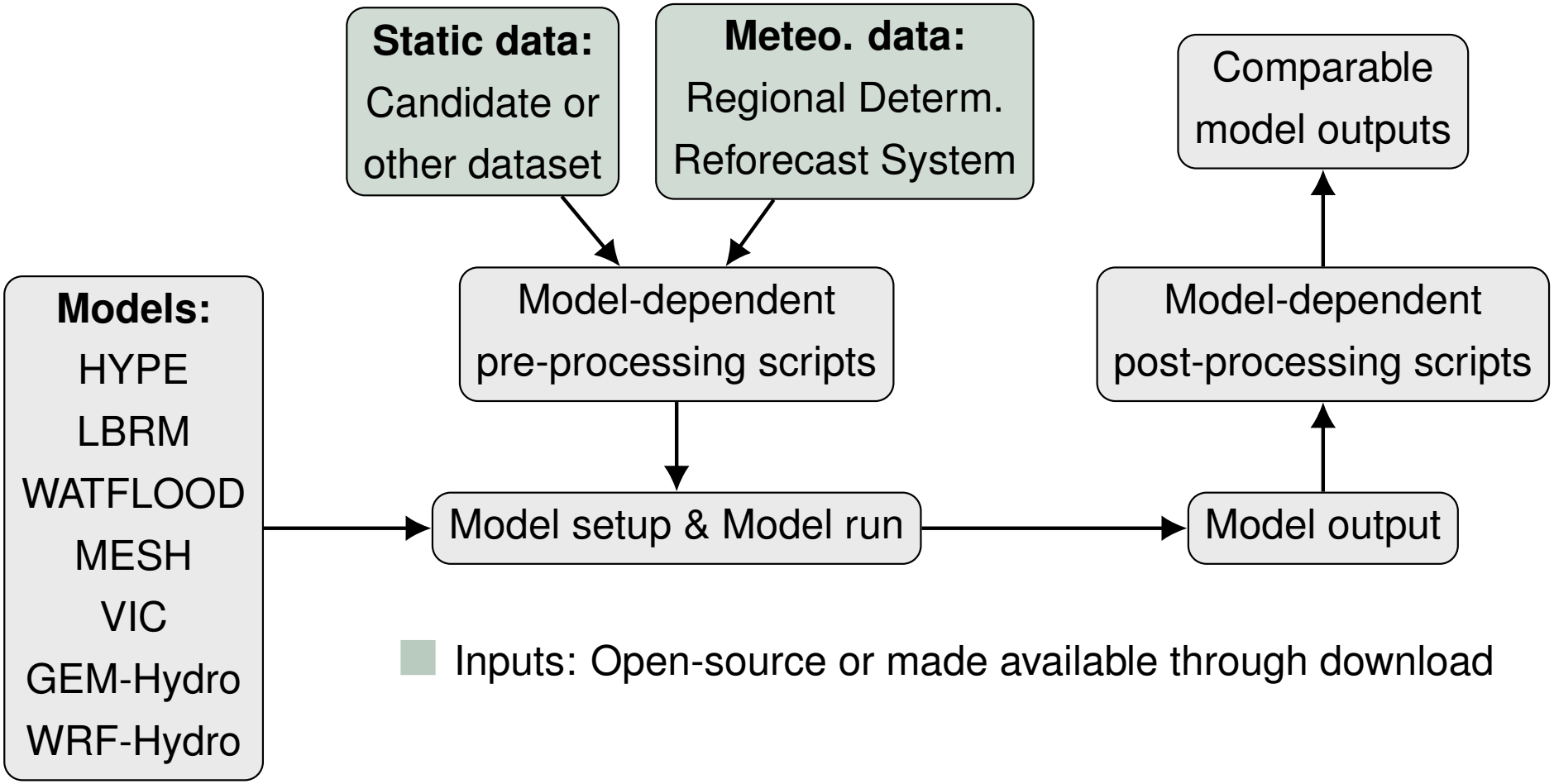
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Inputs: Open-source or made available through download

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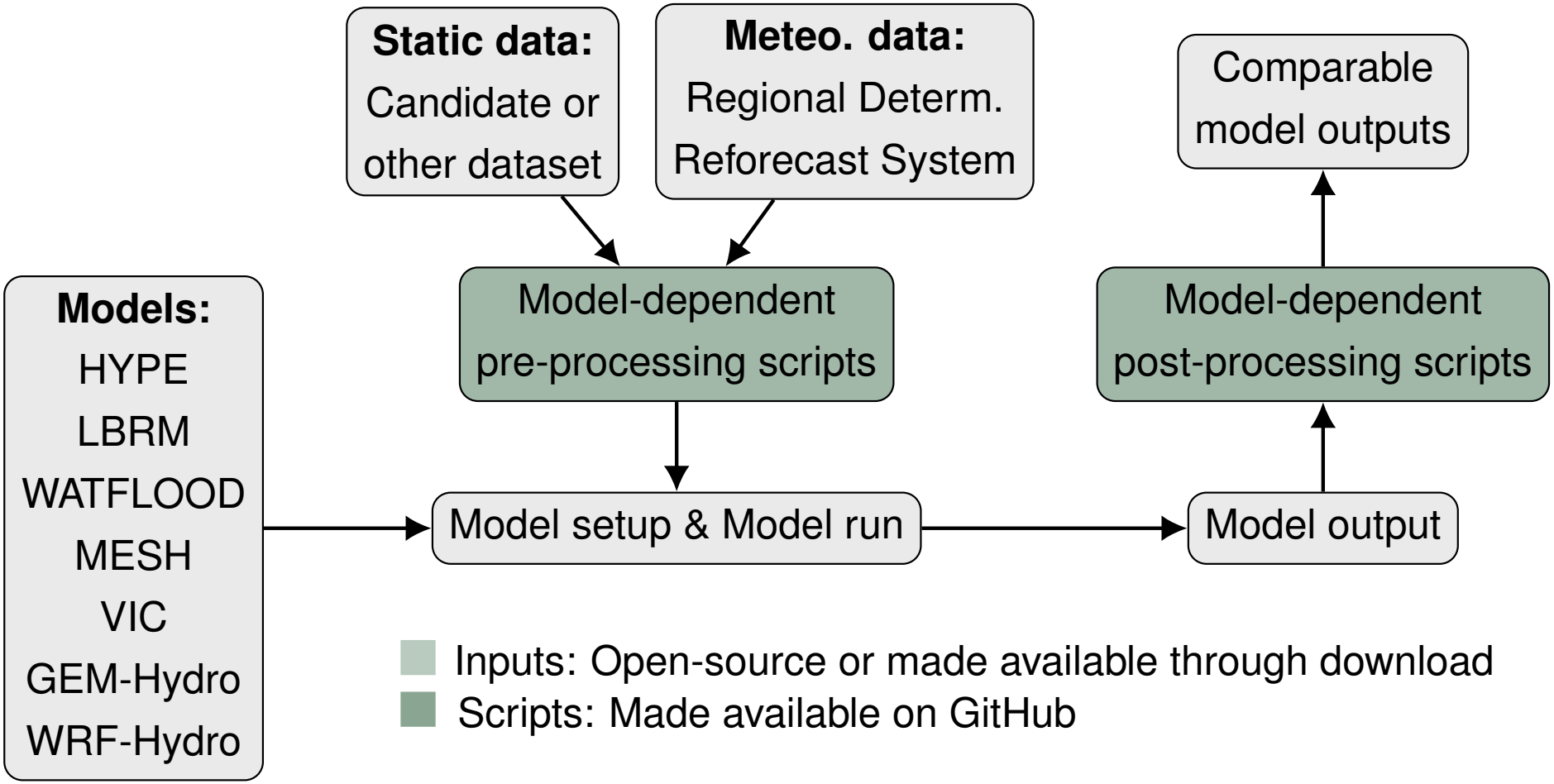
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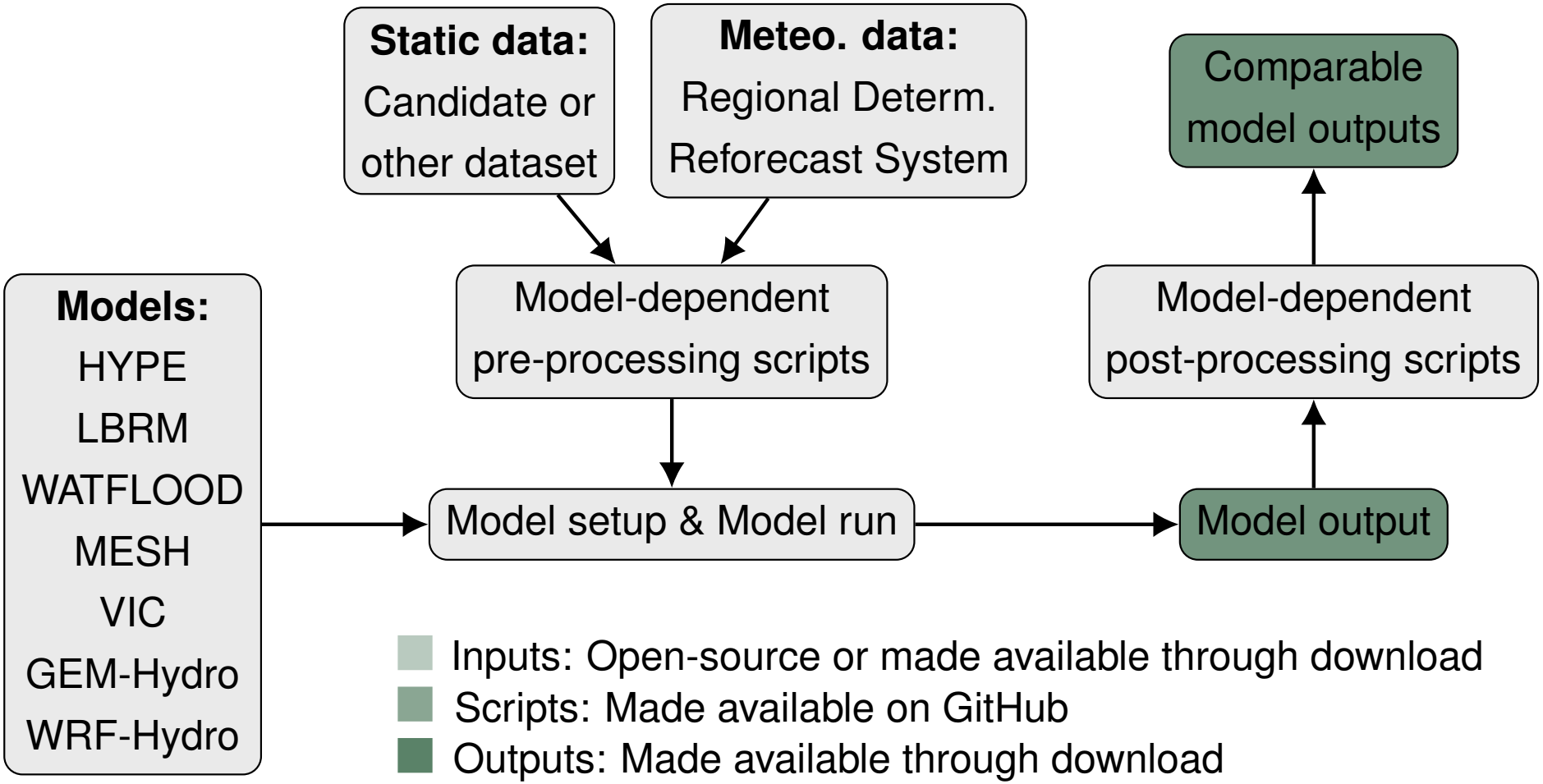
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