Project 2-1: Comparison of ensemble forecast methods for operational streamflow forecasting based on a single model

Dr. Bryan Tolson
Associate Professor
Department of Civil and Environmental Engineering
University of Waterloo

Project 2-1 Overview

Current HQP:

- PhD student Hongli Liu (100%)
- PDF Juliane Mai (50%)
- MASc Konhee Lee (since May)

Project 2-1 Overview

Modelling Case Studies to Date

1. Madawaska River Watershed
   → ONTARIO POWER GENERATION
2. Kaministiquai River Watershed
   → ONTARIO POWER GENERATION
3. Lake of the Woods Watershed
   → Lake of the Woods Control Board (ECCC)
   → Manitoba Hydro

Current Project 2-1 Activities and Results

Project Update on Year 3 Activities

Co-authors:

Hongli Liu, Julianne Mai, Robert Chlumsky, Konhee Lee, James Craig at UW, James Bomhoff (LWCB)
Also supported by OPG personnel (data and/or model support) Hongli Liu

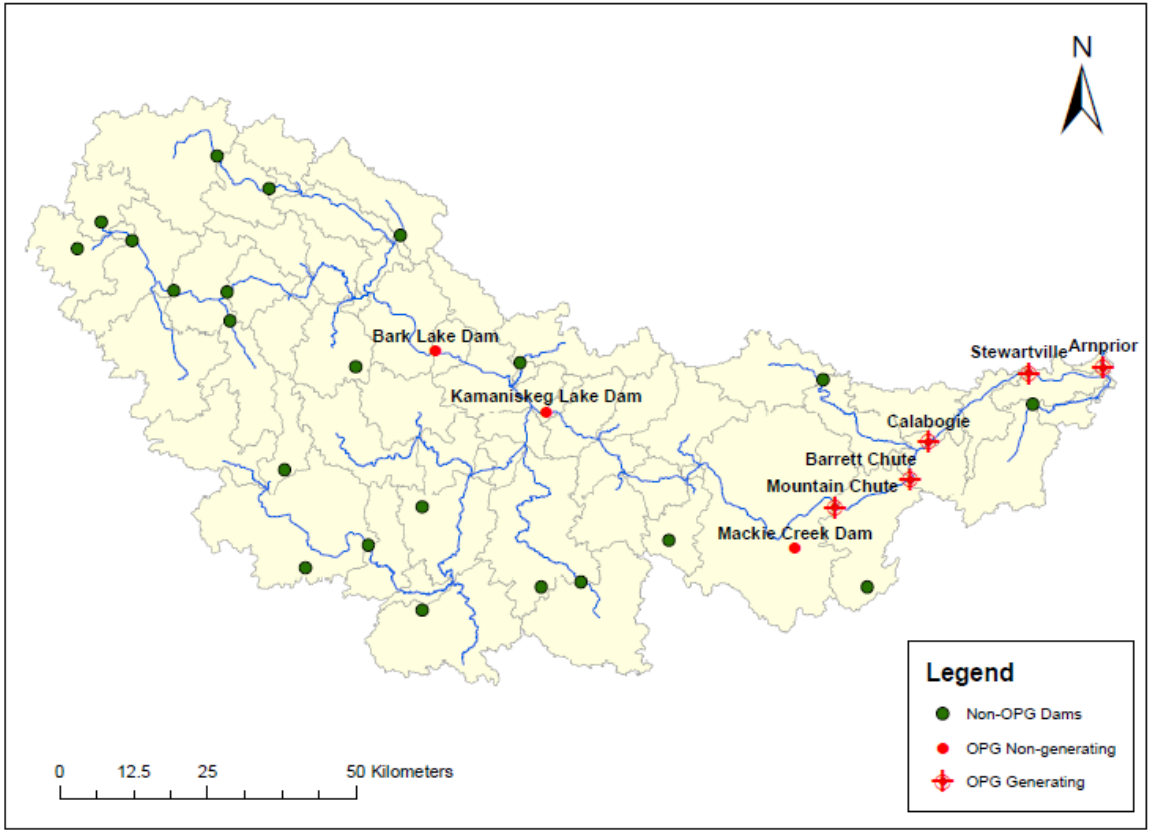
Activity Outline

- A1 – Madawaska model (Bark Lake) inflow forecasting
- A2 – Kaministiquai model building
- A3 – LWCB calibration enhancement
- A4 – Data uncertainty quantification
- A5 – *CaSPAr*: Canadian Surface Prediction Archive

Madawaska model development/calibration

- **Ultimate purpose**:
  - Forecast OPG reservoir inflows
  - Supports Project 2-5

- 12 of 22 Non-OPG dams have storage and rating curves
- 6 of 8 OPG dams have storage and rating curves



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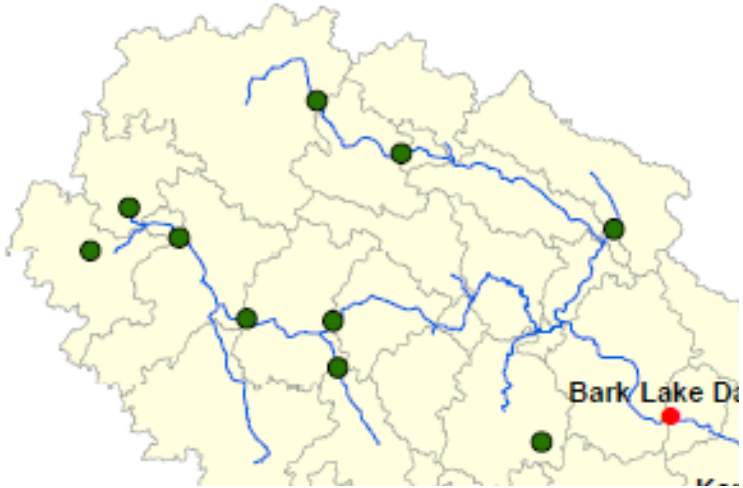
Madawaska model development/calibration

- **Bark Lake**:
  - Semi-distributed model calibrated, built in RAVEN
  - Two conceptual reservoirs simulated upstream
  - Bark Lake outflows specified according to OPG data
  - Precip. from rain gauge network
  - Calibrated to weighted obj. function of Bark Lake state and change in stage



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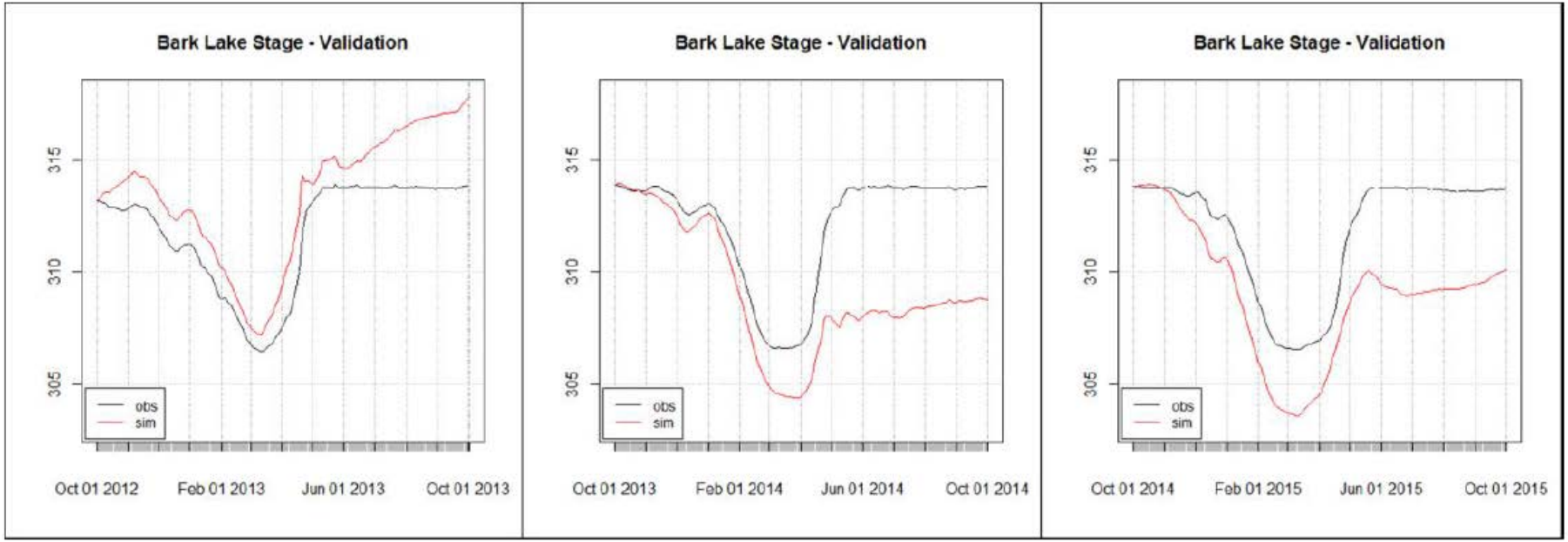
Madawaska model development/calibration

- **Bark Lake validation results:**



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Madawaska flow forecasting experiments: Bark Lake

- Very preliminary, worked closely with OPG
- Initial goal was to make open-loop forecasts for Bark Lake inflows using previous calibrated model
- Forecast products utilized:
  - RDPA http://collaboration.cmc.ec.gc.ca/science/outgoing/capa.grib/
  - RDPS http://dd.weather.gc.ca/model_gem_regional/10km/grib2/
  - GDPS http://dd.weather.gc.ca/model_gem_global/25km/grib2/
  - REPS http://dd.weather.gc.ca/ensemble/reps/15km/grib2/raw/
  - NAEFS http://dd.weather.gc.ca/ensemble/naefs/grib2/raw/
- No assessment of forecast data quality as of yet but we set up the system successfully!

Madawaska flow forecasting experiments: Bark Lake

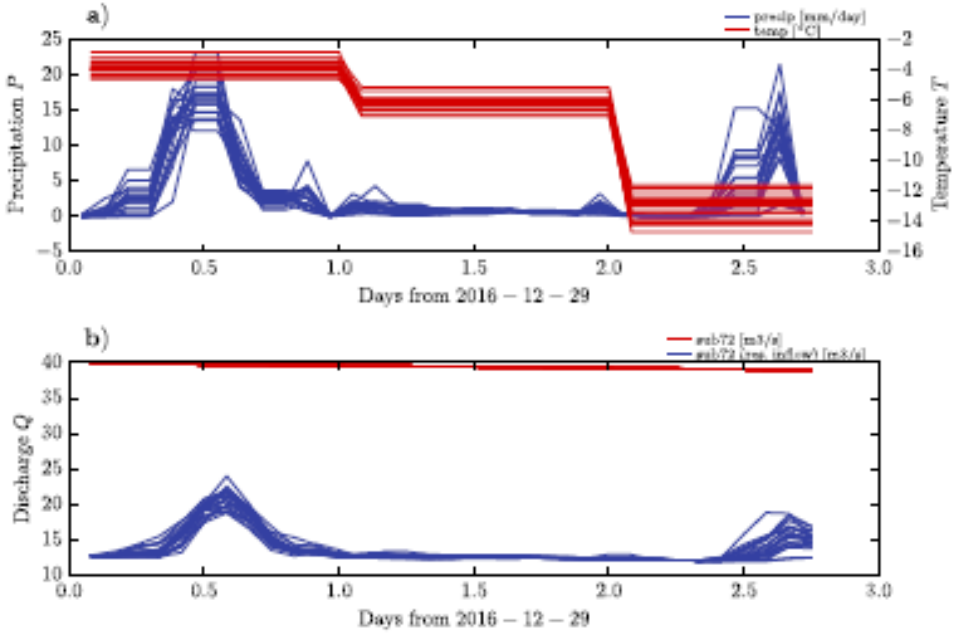

Figure 5: Simulation of 3 day forecast period using (a) the regional forecasts of 21 ensemble members (REPS) as precipitation and temperature inputs to (b) simulate the inflows (blue line) and outflows (red line) of the Bark Lake dam reservoir.

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A1

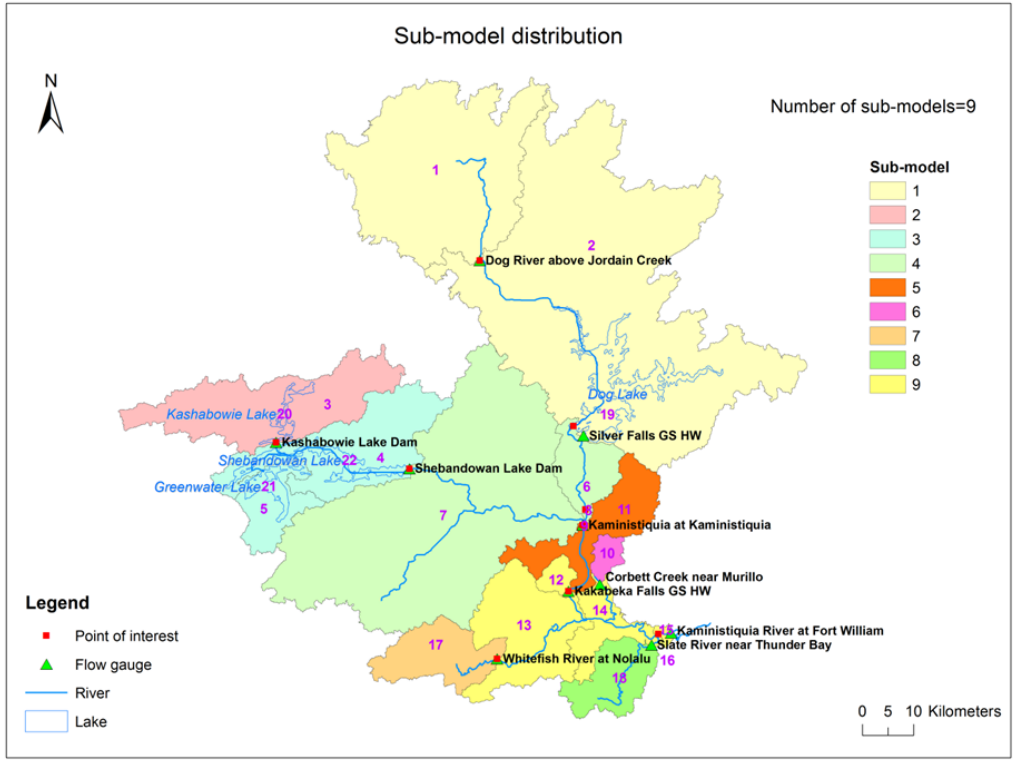
Madawaska flow forecasting experiments: Bark Lake

- Key things required to generate forecasts:
  - Forecast product (RDPA, RDPS, GDPS, REPS, NAEFS) conversion scripts created
  - These scripts convert GRIB2 format to NetCDF format
  - RAVEN hydrologic model supports NetCDF input file format for model input forcings

- Future:
  - Assess forecast quality …

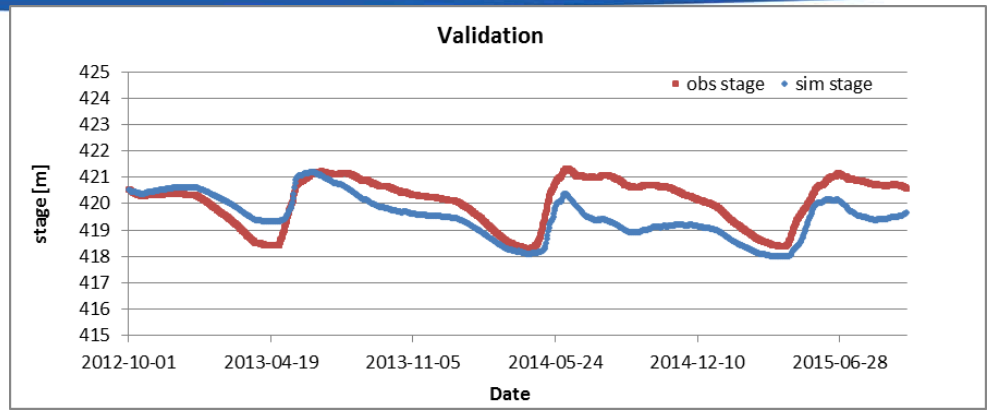
Kaministiquai model development/calibration

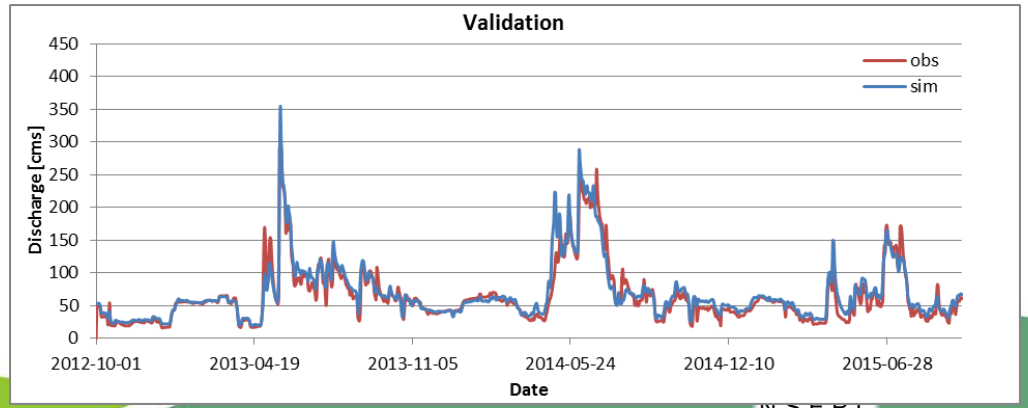
- **Ultimate purpose**:
  - Forecast OPG reservoir inflows. Daily and hourly.
  - Supports Project 2-5
- Only operational dams in basin are controlled by OPG and thus have good data for each of them
- Rainfall from CAPA
- Models from scratch:
  - GR4J
  - Semi-distributed (for hourly forecasting)



Kaministiquai model development/calibration

- Sequential calibration moving downstream
- Downstream models forced with upstream measured flows
- Some good results for Dog Lake
- and for Kam @ Kam gauge downstream of reservoirs (NSE=0.9)





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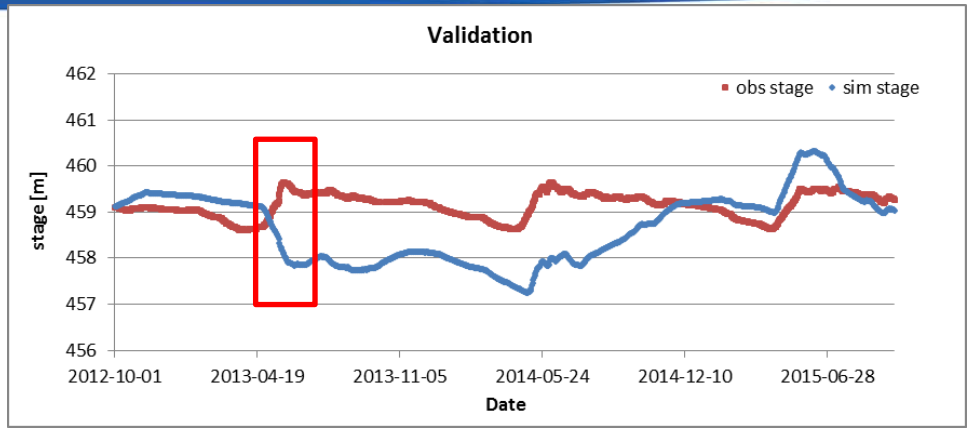
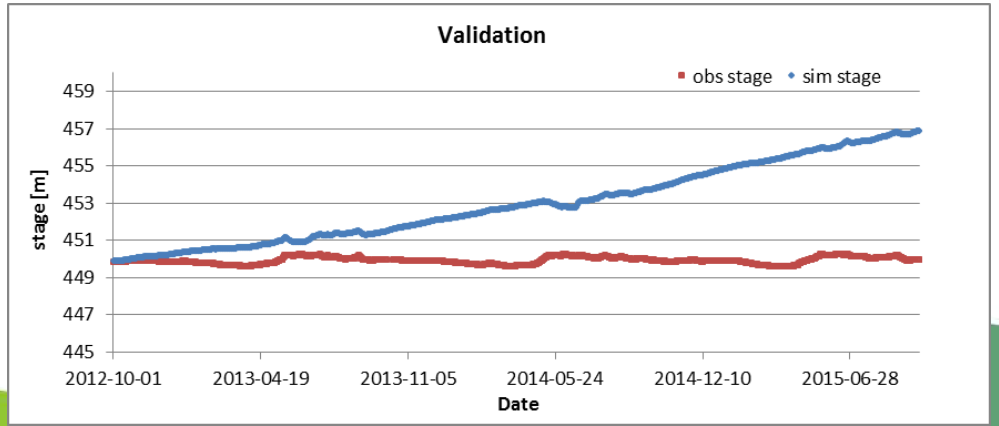
Kaministiquai model development/calibration

- Some not as good results
- Kashabowie Lake
- And then downstream, Shebandowan Lake

- For Shebandowan Lake data, 90% of estimated inflows flagged as possibly erroneous
- … CAPA does not use OPG precip gauges





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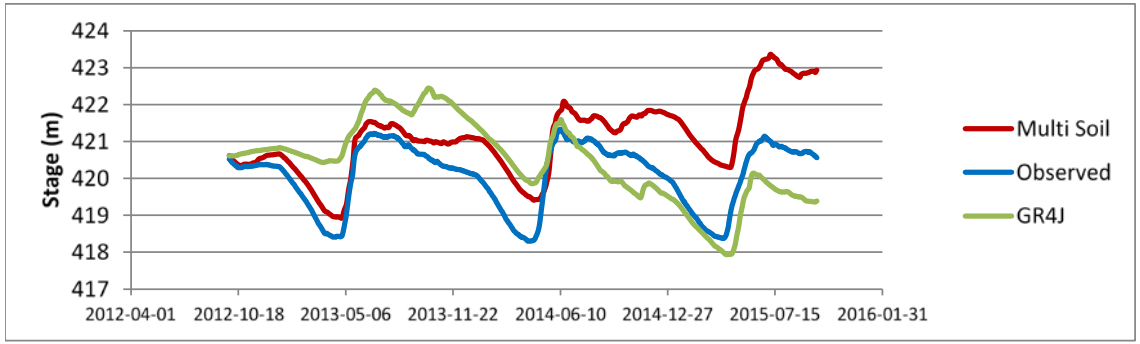
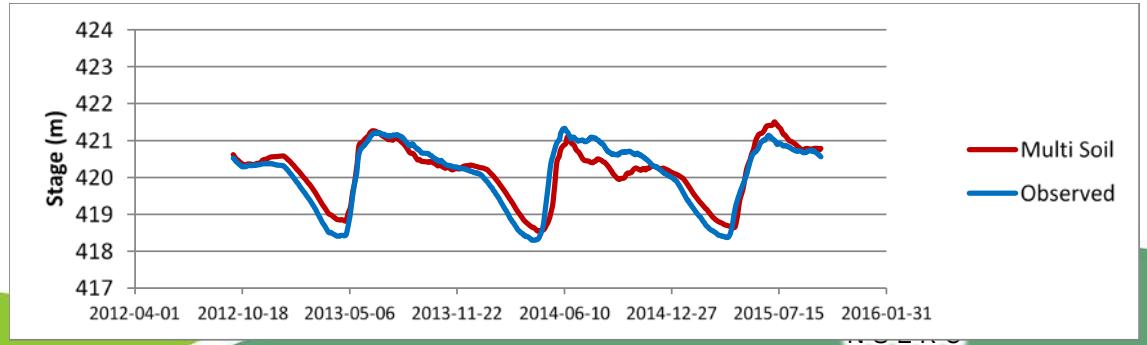
Kaministiquai model development/calibration

- Hourly model development requires moving away from GR4J
- Semi-distributed, multi-soil model (same as Madawaska)
- Initial result promising at Dog Lake
- Not so promising at other locations

Validation



Validation with Rain Correction (0.93)



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Kaministiquai model development/calibration

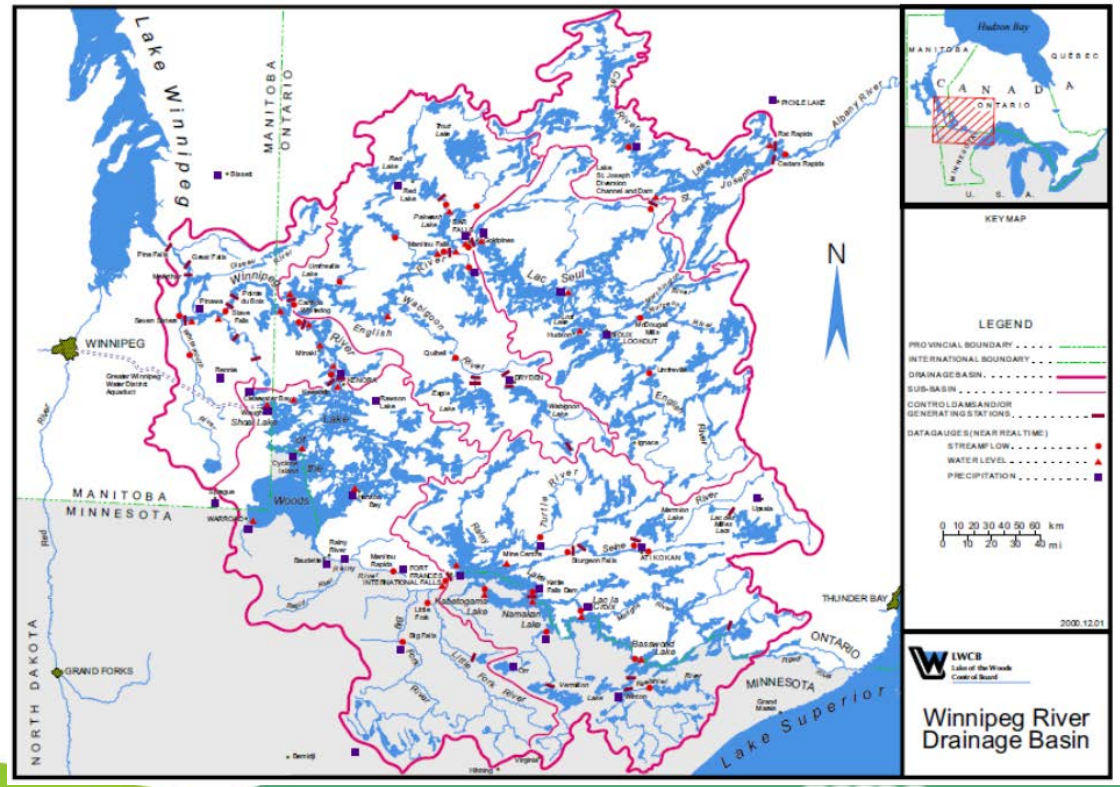
ONGOING WORK:

- Ideas on merging precip. gauges not used in CAPA with the CAPA product?
- Must quantify measurement uncertainty in reservoir levels and outflows so pointers to past work in this area would be helpful
- Hourly model calibration: CAPA inputs versus OPG gauges

A3

LWCB Calibration Enhancement: Watflood Model

- **Ultimate purpose**:
  - Forecast LWCB reservoir inflows
  - LWCB already forecasting with semi-distributed Watflood model
  - Can directly assess how calibration enhancements impact forecasts with a single model



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LWCB Calibration Enhancement: Watflood Model

- Current calibration formulation utilized by LWCB:
  - 149 model parameters
  - Dozens of streamflow gauges and four reservoir levels combined to form a flow weighted Nash-Sutcliffe objective function
- Test 1:
  - Synthetic test to show calibration methods (DDS, PADDS) actually capable of calibrating this many model parameters on budget of a few thousand model runs
  - Confirmed: NSE of 0.99 or higher achieved at all locations
- Test 2:
  - Formulate problem as multi-objective and solve with PADDS to find multiple calibration parameter sets
  - Weighted average of streamflow NSE
  - Weighted average of reservoir NSE
  - Ongoing …

A4

Data Uncertainty Quantification

- **See poster!**
  - We are working very hard to define and conduct meaningful synthetic calibration tests of method
  - Please see Hongli at poster to comment on this part of the work

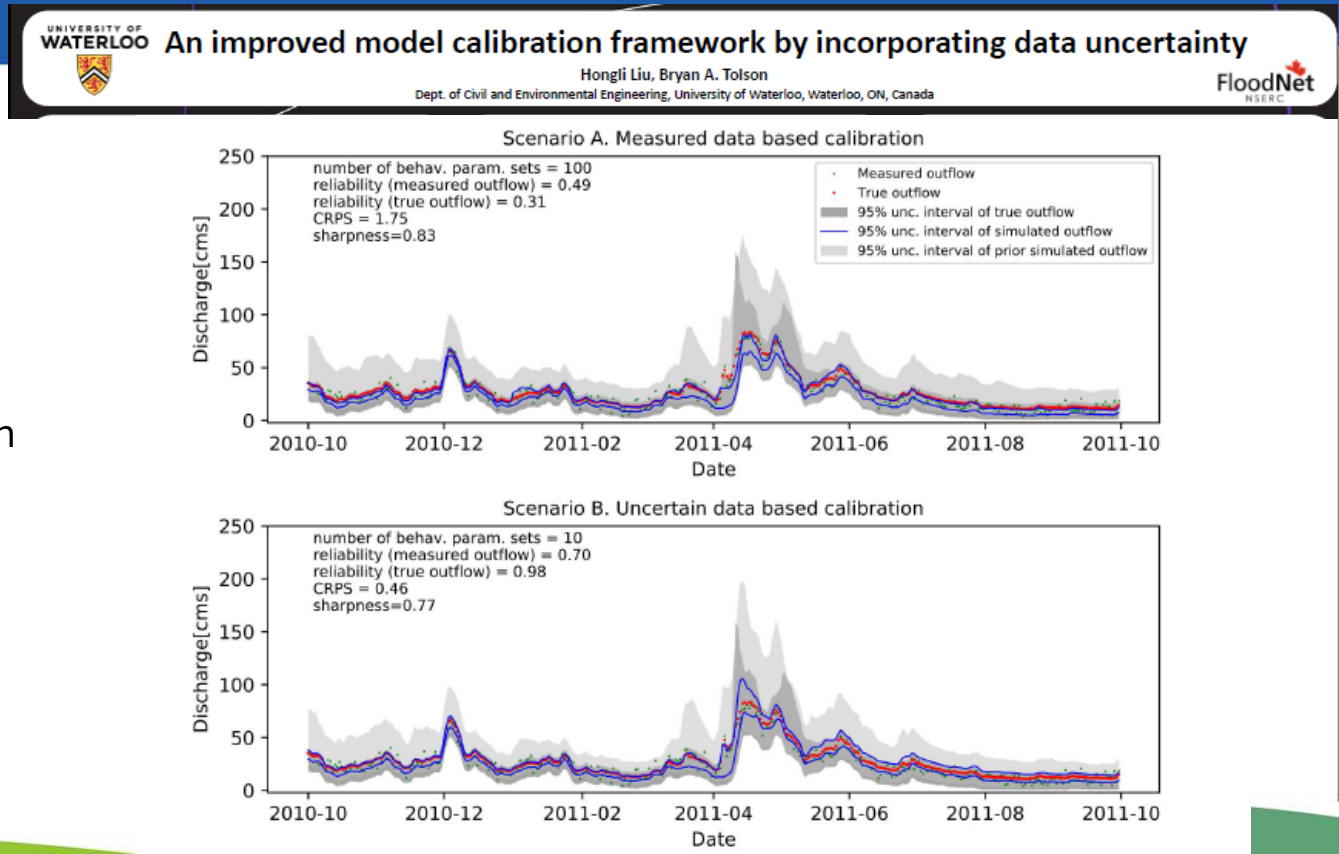

Figure 2. Validation period model performance comparison for two scenarios of one synthetic case

A5 CaSPAr – archive of historical climate forecasts for forecasting research

- After last year's AGM we decided to make this happen
- ECCC climate forecasts copied daily for inclusion in archive
- Compute Canada grant applied for last Fall - awarded in April this year
- Goal is to start providing some data through CaSPAr by Fall 2017

THANKS!

- **Questions?**

- **EXTRAS**

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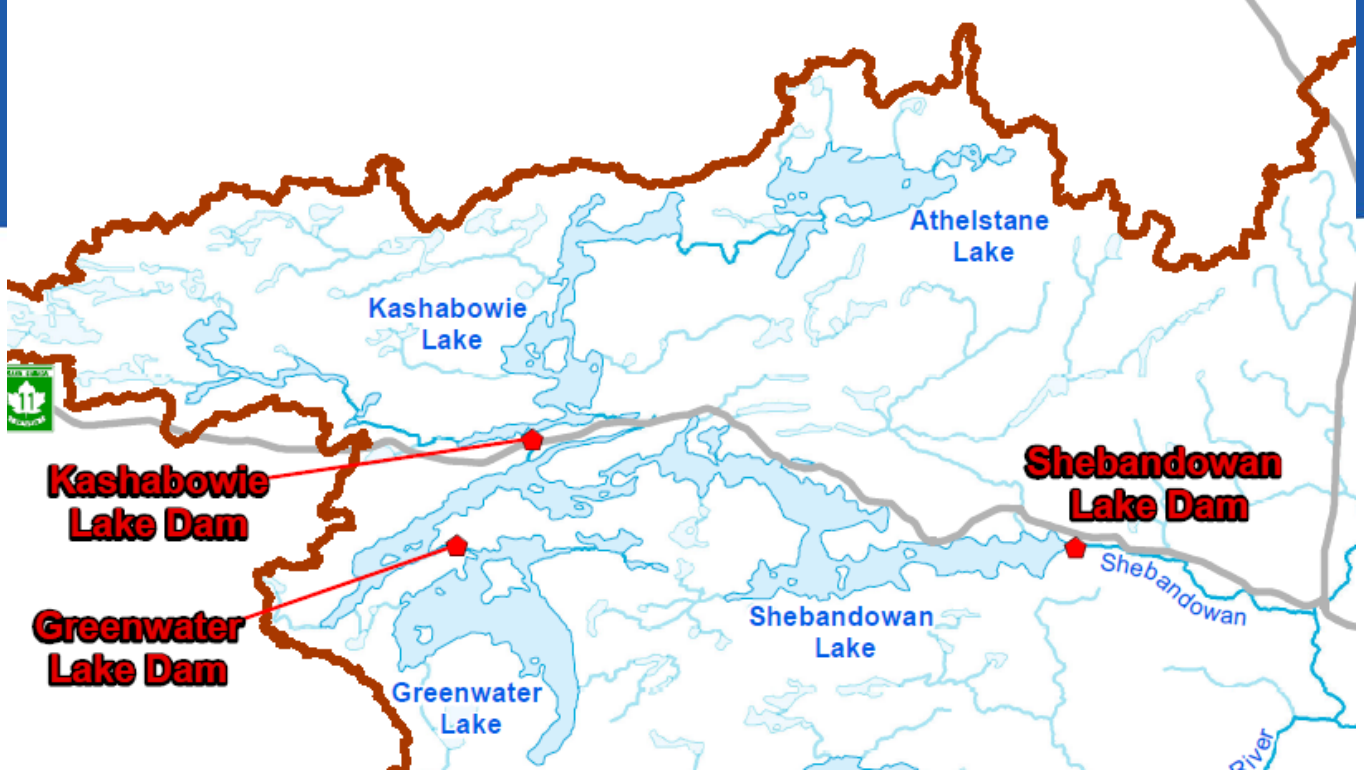

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