Sensitivity and parameter variability of SWMM5 model in semi-urban distributed watershed

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Introduction

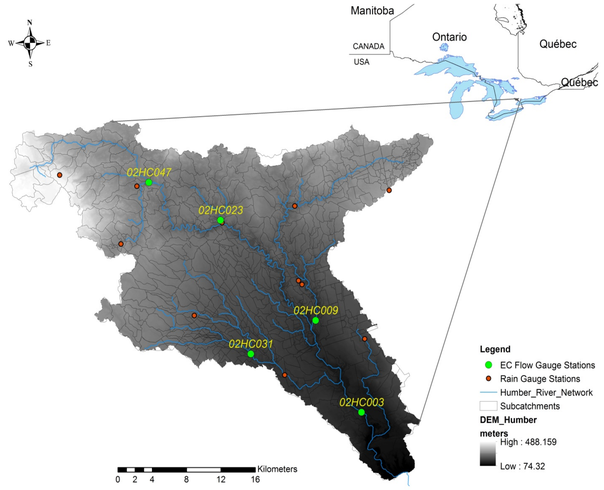
The nature of spatial parameter variability among calibration events is not well discussed in the literature. The objective of the study is to assess the sensitivity and Spatio-temporal parameter variability of SWMM5 model in the semi-urban watershed. The scope involves addressing the uncertainty in event-based parametrizations in a semi-urban area and proposing methods of minimizing.

The study is conducted in Humber River Wateshed, located in Southern Ontario and covers 911km2 drainage area. The sensitivity analysis was performed by using two methods: Regionalized Sensitivity Analysis and Cumulative Sum of the Normalized Reordered Output. The results of both sensitivity analysis indicate that Imperviousness (IM) followed by Drying time (DT) are the most sensitive SWMM5 parameters against NSE, Peak flow error and Volume error.

The variability of calibrated model parameters sets was assessed in terms of peak flow response and the discrepancy of two sensitive parameters. The result indicates a presence of high uncertainty in representing the most impervious areas of sub-catchments and pervious areas with rapid recovery time to become dry. The spatial and temporal variability implied the need to verify potential model parameters sets with robust validation methods.

To minimize the uncertainty (parameter variability) of event-based model parameterization in a semi-urban distributed, some robust calibration and validation approaches are proposed. These includes multi-site simultaneous calibration approach with rank and skill-based validation methods.

Study Area



Humber River watershed (discretization: 714 sub-catchments)
- Five flow gauging stations
- Ten rainfall gauge stations

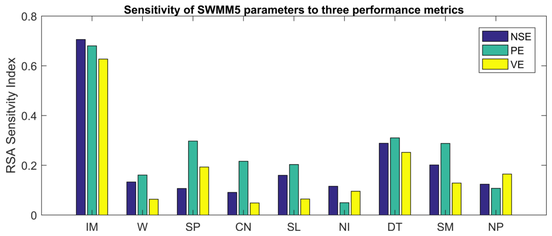
Methodology

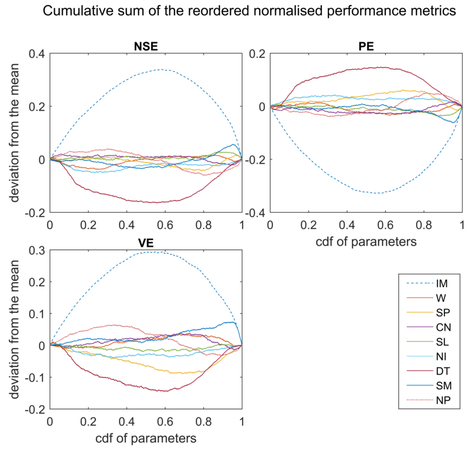
✓ **Sensitivity Analysis**
- Regionalized Sensitivity Analysis (RSA) or Hornberger-Spear-Young-method (Spear & Hornberger, 1980)
- Cumulative Sum of the Normalized Reordered Output (CUSUNORO) (Plischke, 2012)

✓ **Input-output mapping**
- Pareto Archived Dynamically Dimensioned Search (PA-DDS) (Asadzadeh & Tolson, 2013)
- Inputs: Nine SWMM5 parameters
- Outputs: Nash-Sutcliffe Efficiency (NSE), Peak flow Error (PE) and Volume Error (VE)

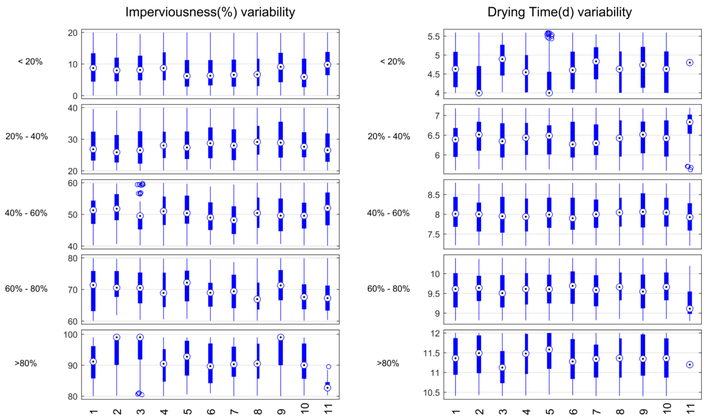
✓ **Spatio-temporal parameter variability analysis**
- Ten calibration events - multi-objective event-based calibration using PA-DDS
- Eleven model parameter sets: ten calibrated model parameter sets plus their model average
- Parameter variability of sensitive parameters across 714 sub-cathcments
- Variability of Peak flow response of eleven model parameter sets

Results

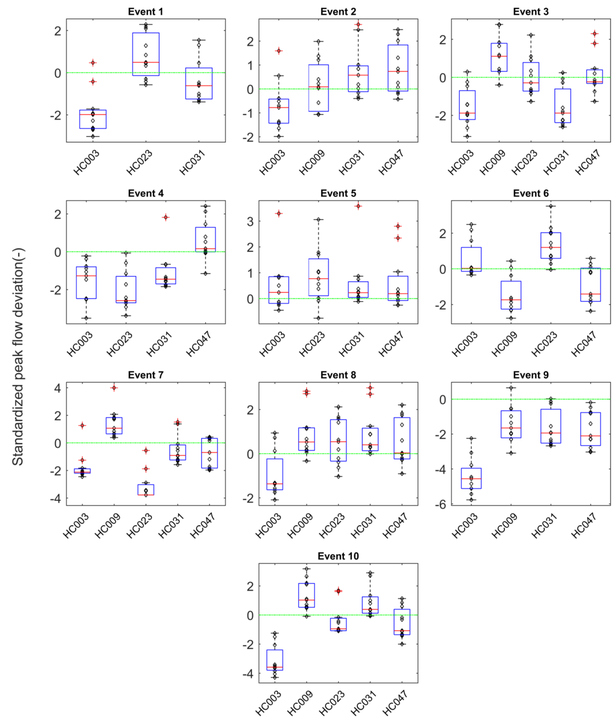




Parameter variability of 11 model parameter sets across 714 sub-catchments)



Peak flow variations of eleven model parameters sets in ten calibration events at different gauging stations



Conclusion and Recommendation

- ✓ Uncertainty in representing the most impervious areas and pervious areas with rapid decay time.
- ✓ Uncertainty in peak flow response by the optimum parameter sets
- ✓ Event based semi-urban distributed catchment may not solely be represented by the average of model parameter sets.
- ✓ Recommended measures: Robust calibration approaches and rank and skill based validation methods.

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