Watershed Model Parameter Estimation in Low Data Environments

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Abstract

Watershed scale models are essential for determining best management practices (BMPs), but they contain many parameters that modelers cannot directly measure. Modelers commonly estimate these parameters through a calibration process based on observed streamflow and nutrient data. However, a lack of long-term streamflow records makes watershed model parameter estimation in low data environments (LDE) challenging for hydrologists. To reliably estimate parameters in LDE, a new calibration technique, simultaneous multi-basin calibration (SMC), was developed to estimate the parameters of several SWAT model initializations for newly instrumented USGS gages in the Lake Champlain Basin of Vermont, USA (Little Otter Creek-Monkton, West Branch Dead Creek, and East Branch Dead Creek). In SMC, SWAT models of each watershed were initialized following standard methods. Then, in order to increase information content, the simulated flow from each model and the corresponding measured flow were combined, and calibrated as one model using a differential evolution algorithm DEoptim. We compared the results obtained from the new technique with one of the most commonly used approaches for calibration in LDE: the similarity-based regionalization (SBR) based on a calibration of a nearby watershed with similar characteristics. In the SBR method, the calibrated parameters from a watershed with a more extended period of recorded data (donor watershed, Little Otter Creek-Ferrisburg) transfer to the LDE watersheds (receptor watersheds). We show that in SBR the uncertainty of the donor watershed model propagates through the receptor watershed model, this propagation does not occur in SMC. We demonstrated that the agreement between simulated and observed streamflow, via the Nash-Sutcliffe efficiency (NSE) improved model performance from 1-20% using the SMC technique. Moreover, the calibrated soil storage parameters, including soil depth, available water capacity, and soil saturated hydraulic conductivity obtained from individual SMC and SBR models, were compared to the SSURGO soil database, where the SMC method provided parameter estimates that more closely matched SSURGO. This study demonstrated that a SMC method can outperform SBR in low data environments.

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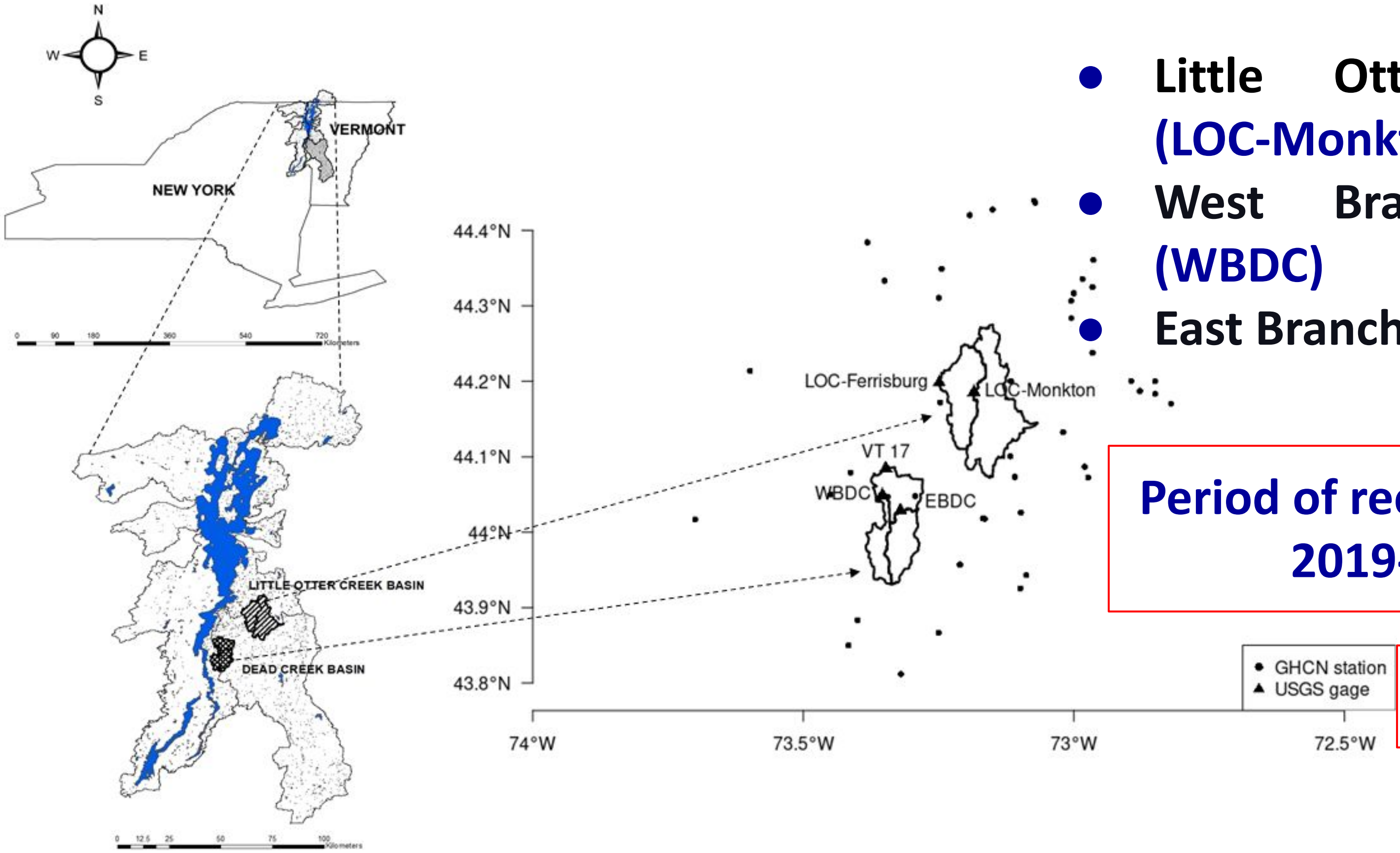
Overview



- **Little Otter Creek-Monkton (LOC-Monkton)**
- **West Branch Dead Creek (WBDC)**
- **East Branch Dead Creek (EBDC)**

Period of record for streamflow: 2019-09 to2021-11

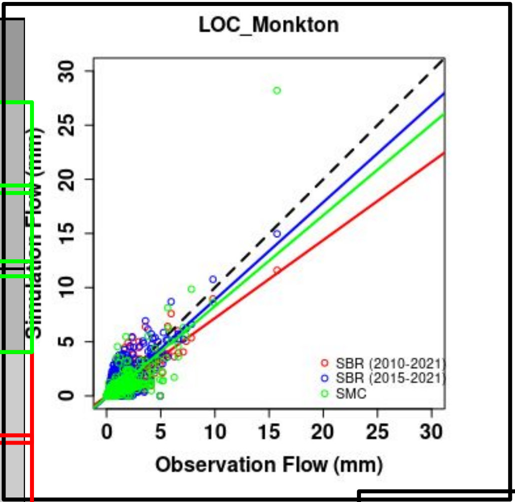
Model Calibration?

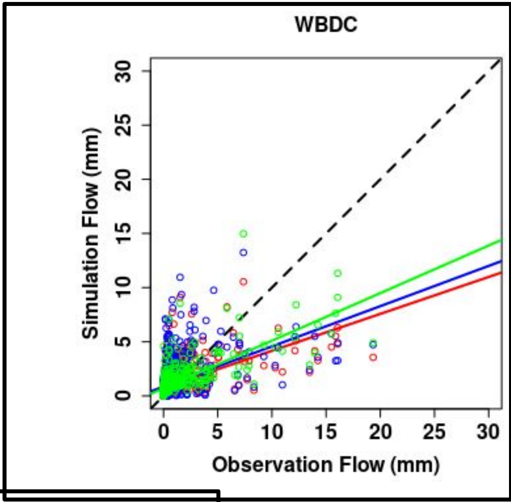
Calibration Results

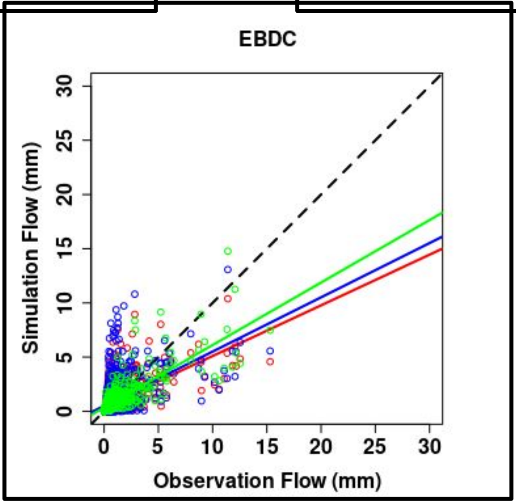
Source	Depth (mm)	AW (mm/mm)	Ksat (mm/hr)
SBR (2010-2021)	892-1270	0.19-0.31	20-38
SBR (2015-2021)	765-1089	0.19-0.30	19-35
SMC	2490-3545	0.22-0.30	5-9
Field measurements	Mostly down to 3000mm+	0.24	Very low

SMC outperforms the SBR (traditional regionalization) method.

	Watershed	NSE
SMC	LOC_Monkton	0.52
	WBDC	0.49
	EBDC	0.60
SBR 2010-2021	LOC_Monkton	0.57
	WBDC	0.25
	EBDC	0.29
SBR 2015-2021	LOC_Monkton	0.60
	WBDC	0.04
	EBDC	0.01







Discussion

- SMC → better capturing of characteristics and parameter estimation of the regions
- Higher NSE values (2 out of 3) than regionalization method
- No need for the Donor watershed
- Applicable?
  - Most watersheds are not monitored, so this allows a quick install of several basins with much less history needed

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