07/12/2022

Phase 7 WSM Development – Dynamic Model for Hydrology

Modeling Workgroup Quarterly Meeting – July 2022

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Purpose

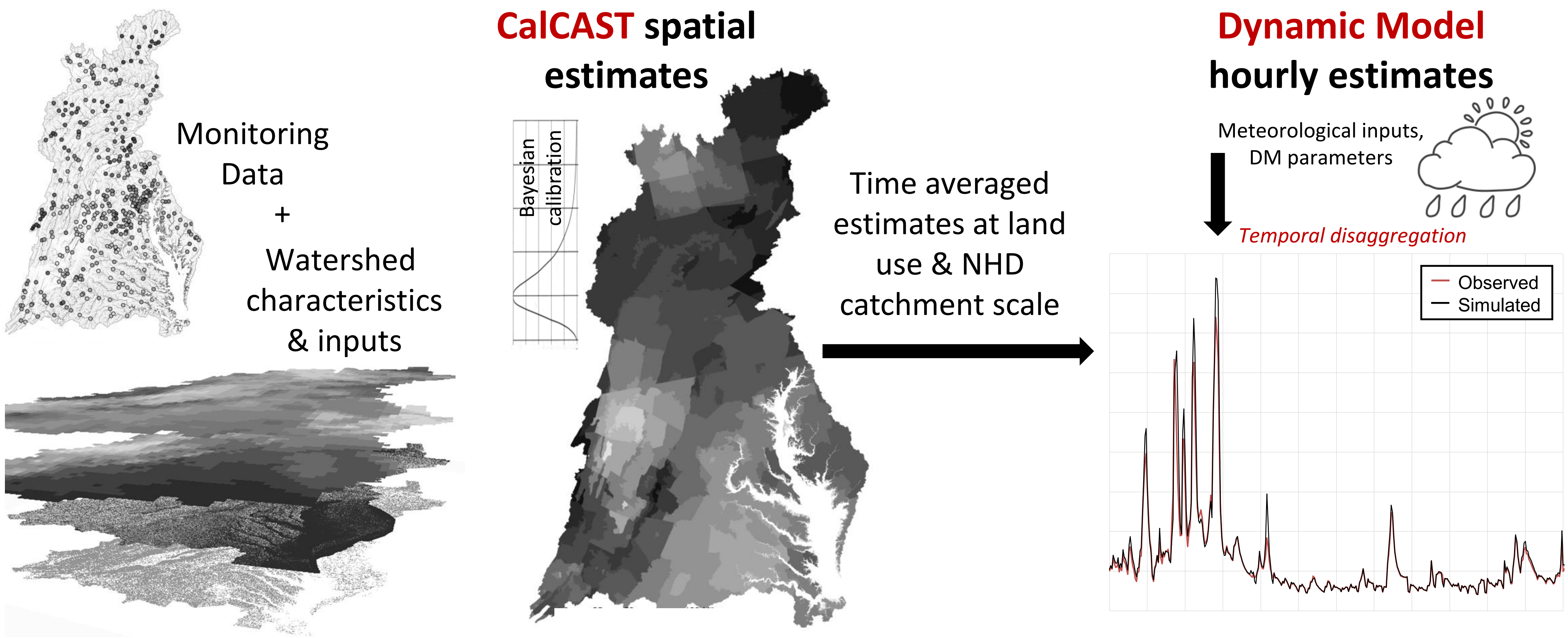
Dynamic Watershed Model

- Inputs for the estuarine models (MBM/MTMs)
- Watershed model calibration and scenario applications
- Support various research and collaboration activities

Presentation Outline

- CalCAST→DM Hydrology Framework
- NHD-100K Scale Dynamic Model
- Nested Geography for Streams and Rivers Simulations
- Hybrid of Simple (fast) and Advanced Routing (1985-2020)
- Hydrology Calibration Methods
- Performance Evaluation of Calibrated Methods/Experiments

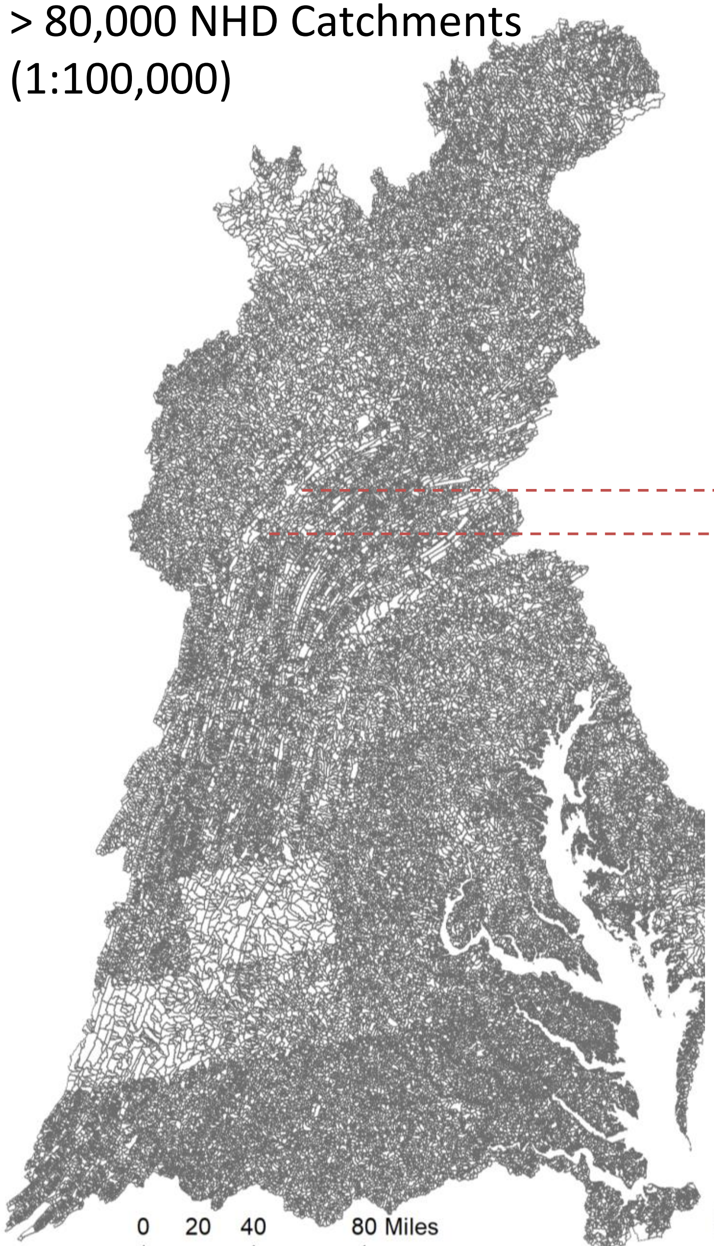
Framework: Spatial Model (CalCAST) → Dynamic Model (DM)

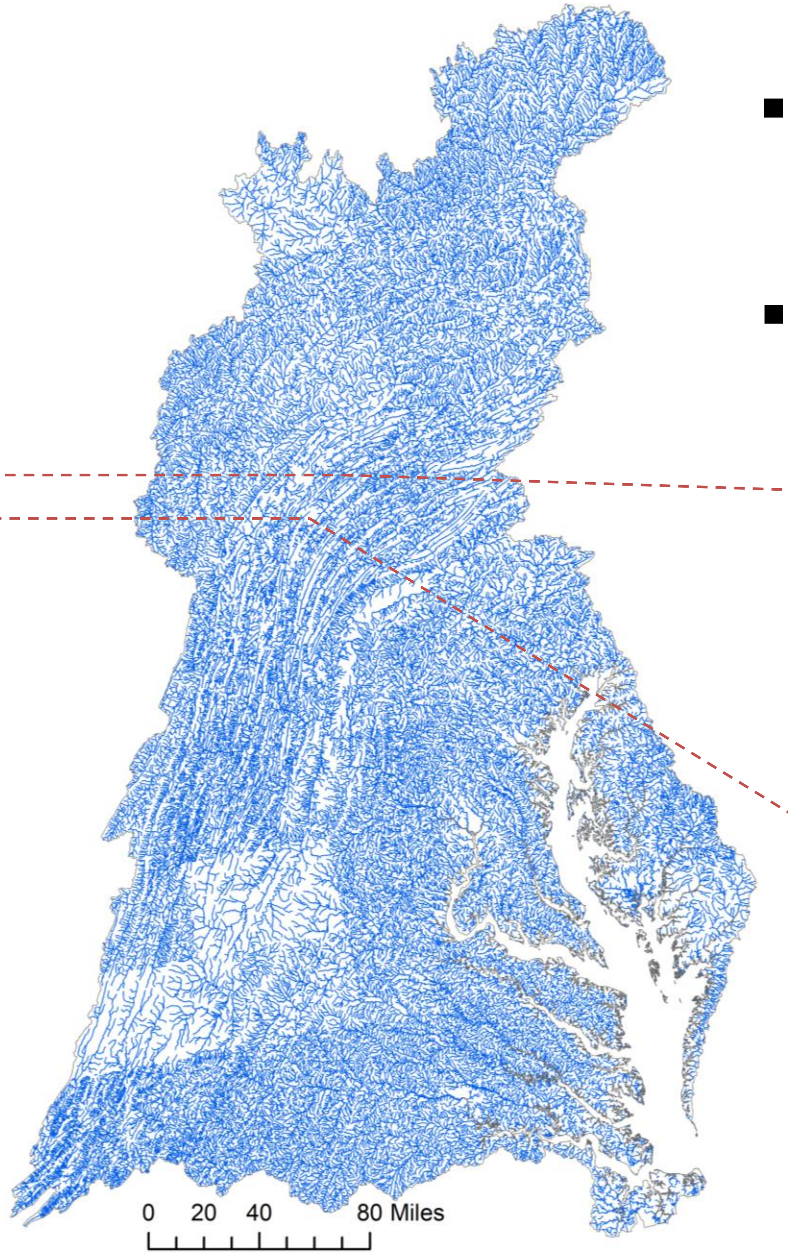


- Data-driven CalCAST informs DM parameters and responses.
- NHD-scale DM hydrology prototype is using CalCAST *average annual* flow.

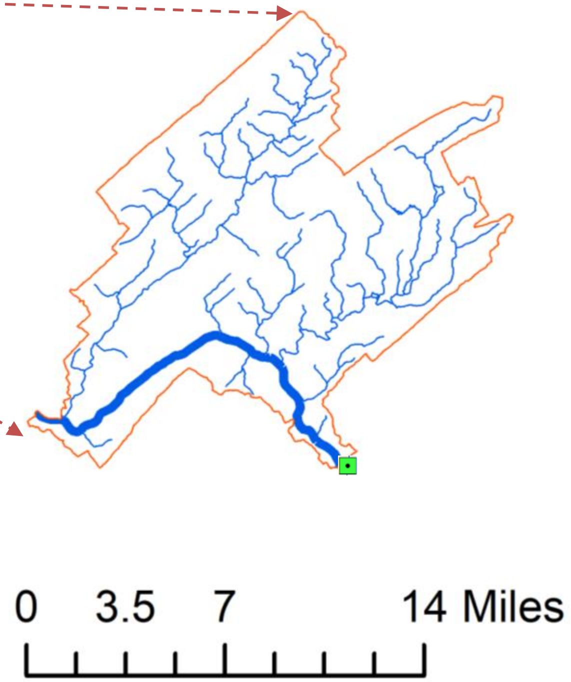
NHD-100K Scale Dynamic Model

> 80,000 NHD Catchments
(1:100,000)

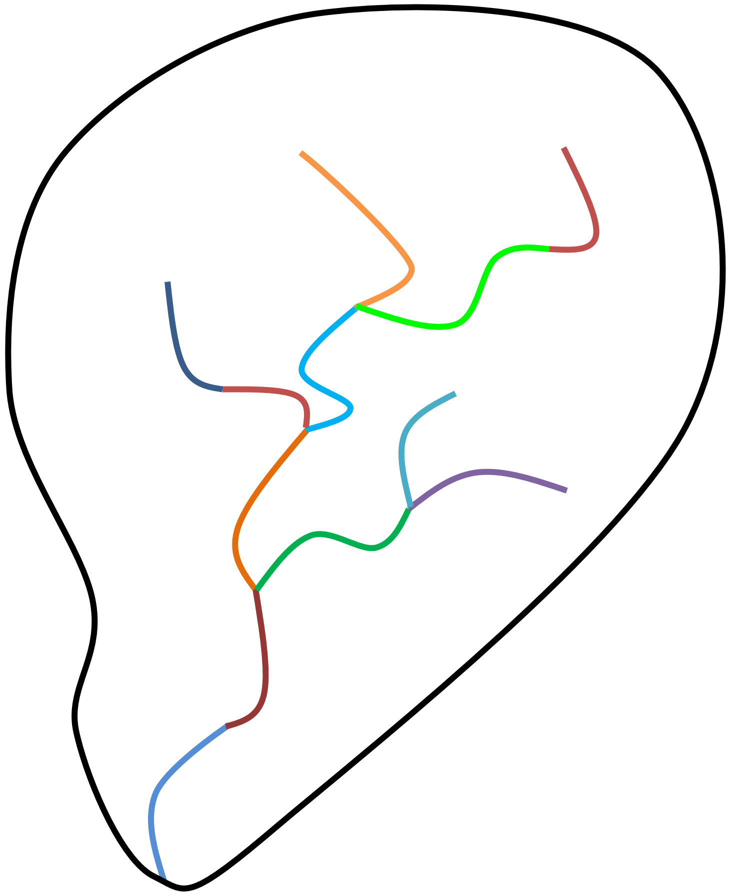




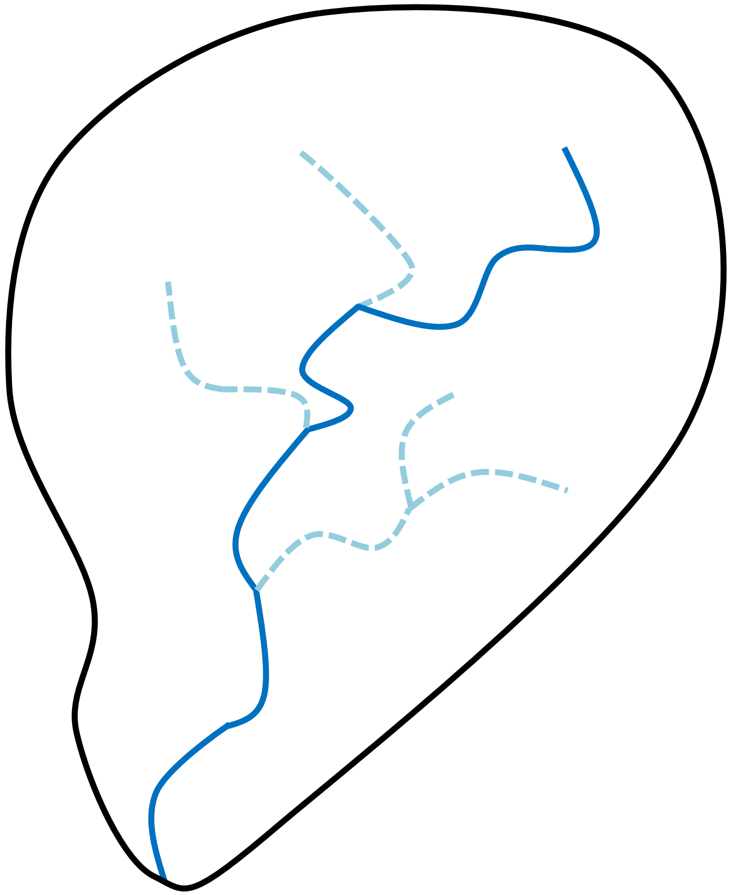
- Hourly timeseries of loads for land use NHD catchments.
- Hourly timeseries of loads for NHD streams and river segments.



Dynamic Model: Nested geography, Hybrid simulation

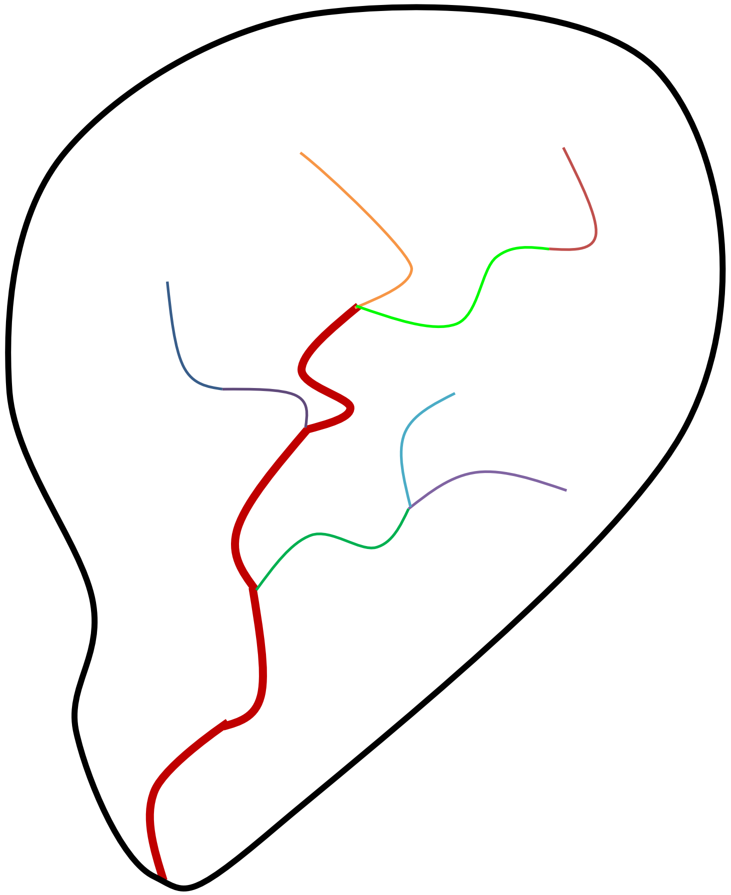


NHD streams



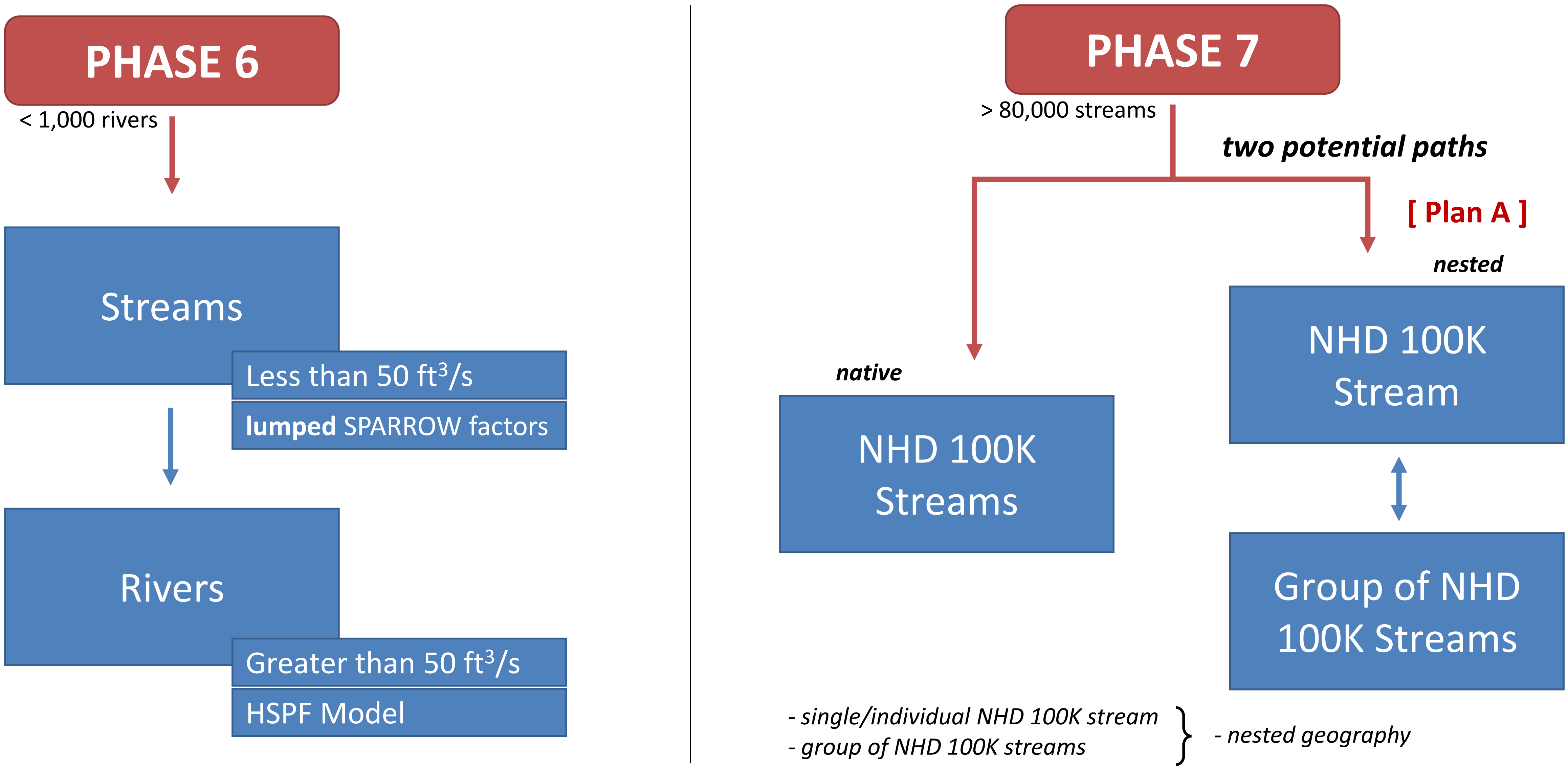
Phase 6

+ lumped factor for streams
+ HSPF river simulation



Nested geography, Hybrid DM simulation

River Segmentation



Streams/River Simulation

HSPF

Complex model and requires estimation of several model parameters.

Simple Routing

Potential for providing better agreement with the time-averaged model, CalCAST.

Hybrid

A combination of Simple Routing and HSPF (and a better understanding of trade-offs).

Streams – Simple Routing

Temporal Disaggregation → *Simpler* Model Formulation + Numerical Solution
vs. parameter estimation and computation of a process-based numerically accurate method

Streamflow

Objective: a robust yet simplified non-iterative solution (approximation) for computation efficiency

Currently, $Q_{out} = Q_{in}$ (for non-HSPF stream segments)

Storage-Discharge Relationship (Tabular or Function)

$$\frac{\Delta V}{\Delta t} = \Sigma Q_{in} - Q_{out}(V)$$

(a) $$Q_{out}(t) = Fn\{Storage, Q_{in}(t-1), Q_{out}(t-1)\}$$

Mass-balance

(b) $$S(t+\Delta t) = S(t) + \Delta t S'(t)$$

Euler method

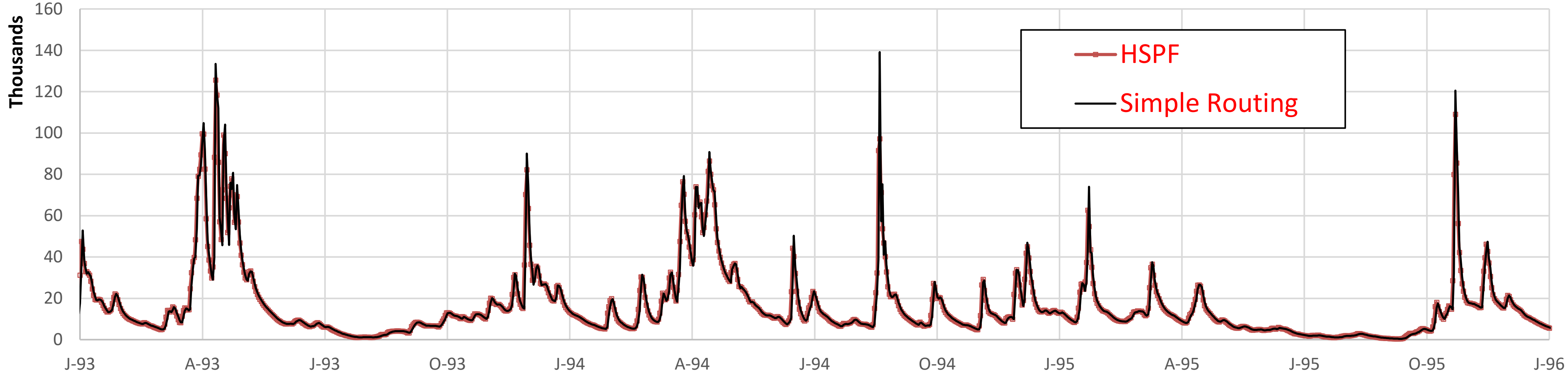
$$= S(t) + \Delta t\big(Q_{in}(t) - Q_{out}(t)\big)$$
$$where\ Q_{out}\ is\ Manning\ Eq.$$

HSPF, others

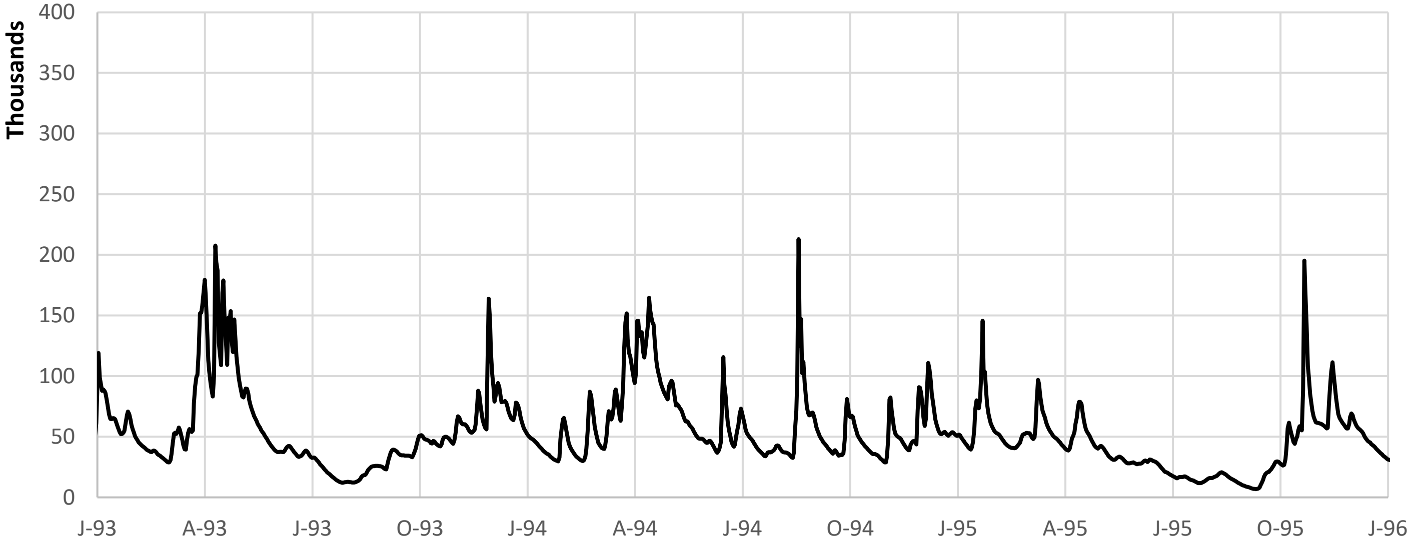
Streams – Simple Routing

! Preliminary !
Has not been fully tested

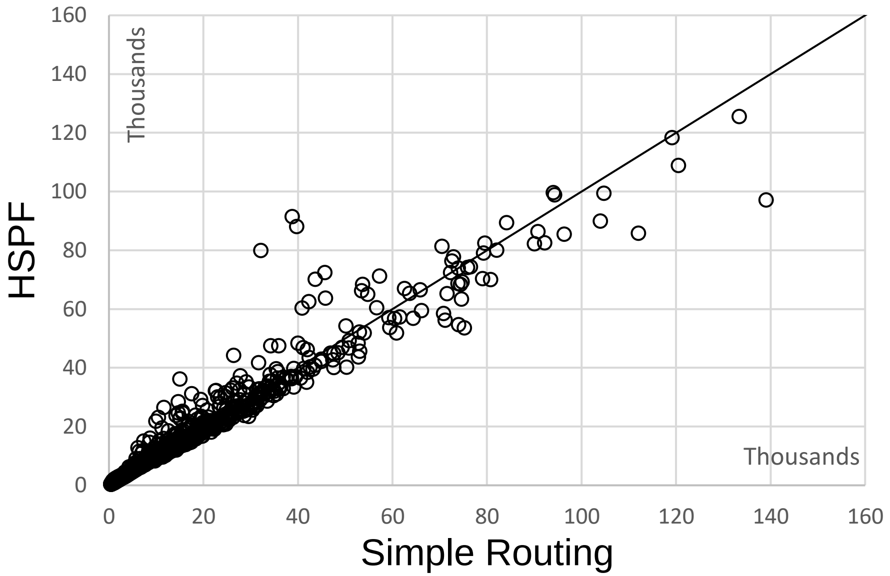
Estimated **Daily** Streamflow (ft^3/s) for 1993-1995



Estimated **Storage** (acre-feet) for the river reach during 1993-1995

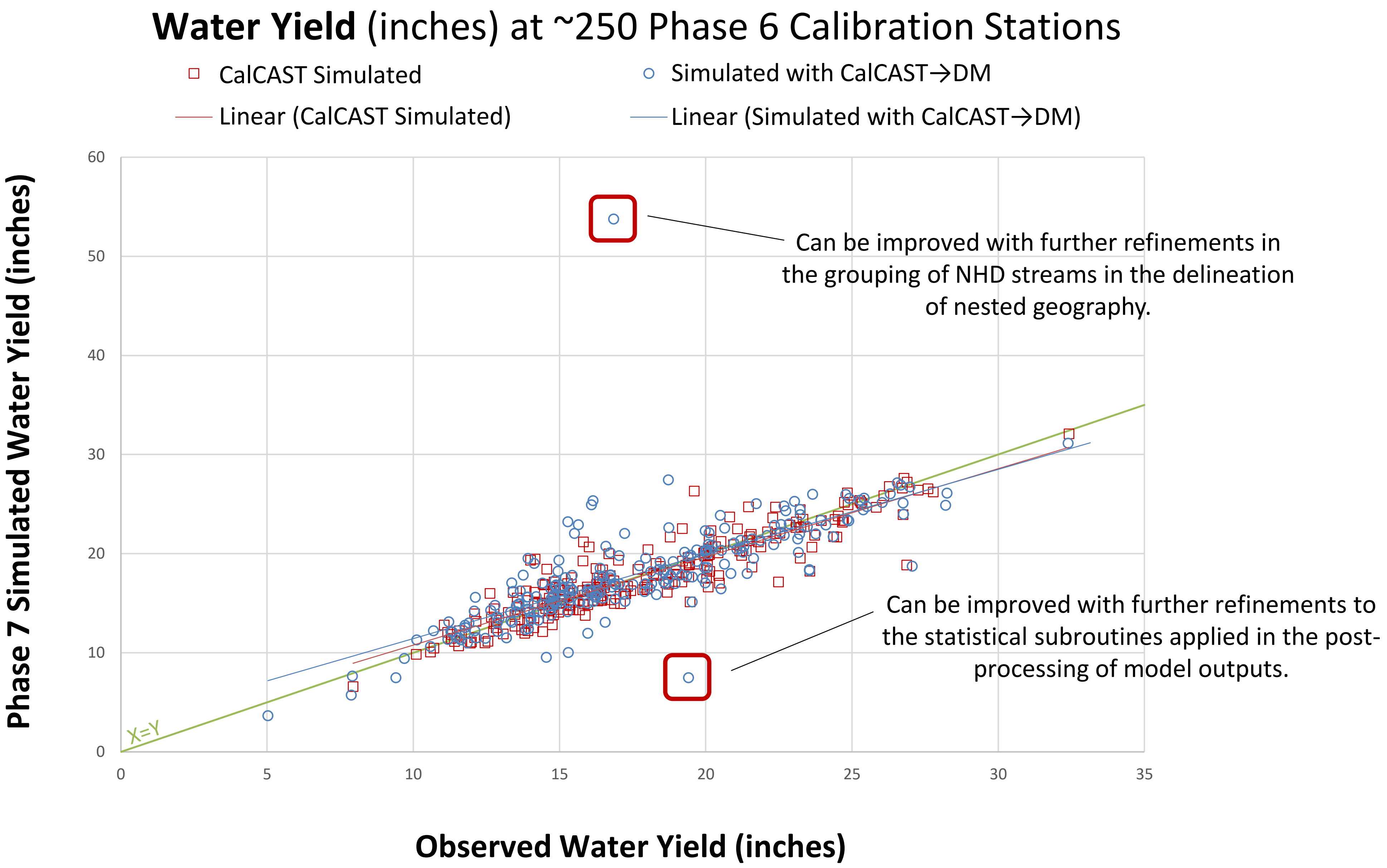


NSE = 0.933 (Years 1993-1995)



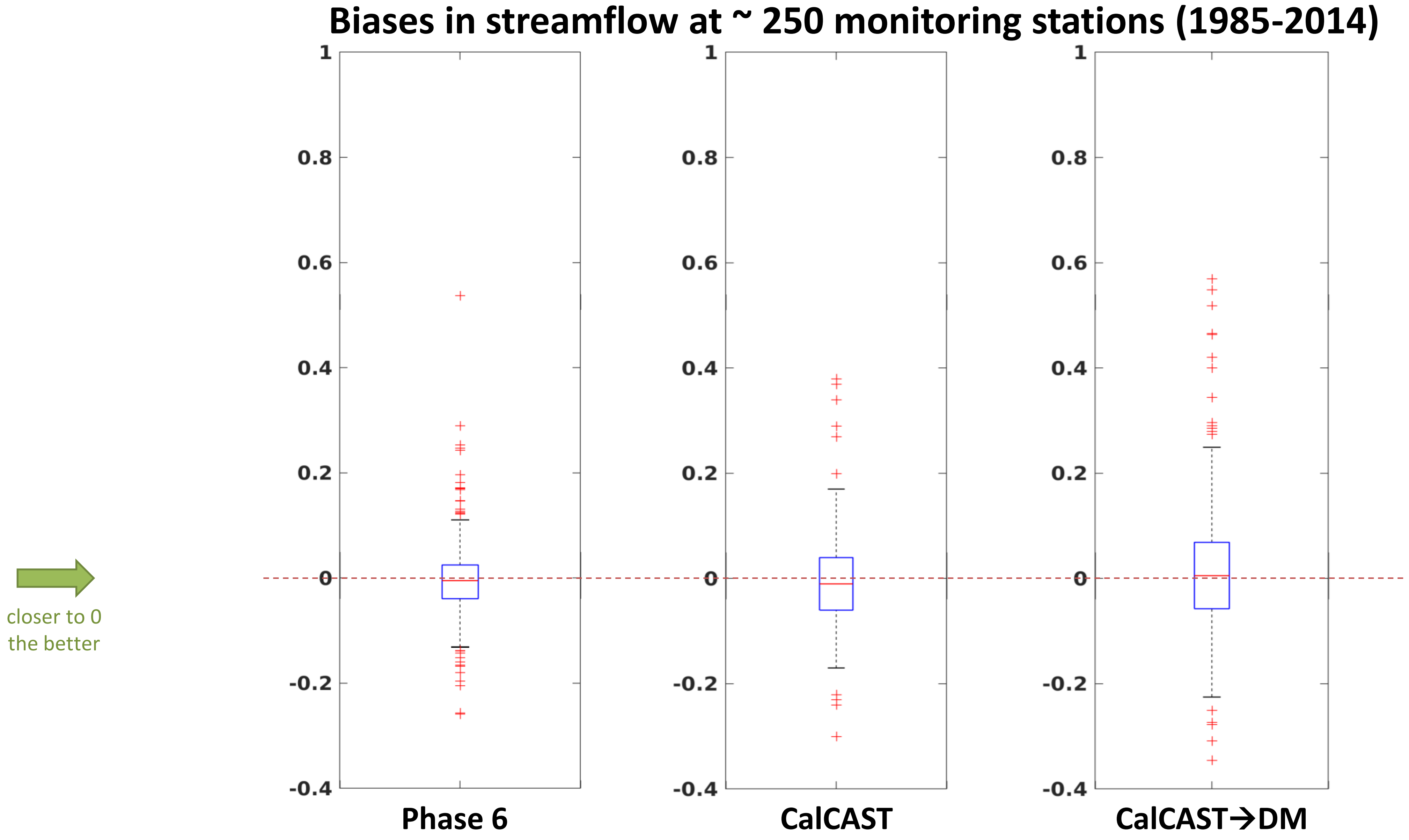
Results: CalCAST→DM Average Annual Water Yield

Preliminary, only for tracking development progress



Results: Daily Flow

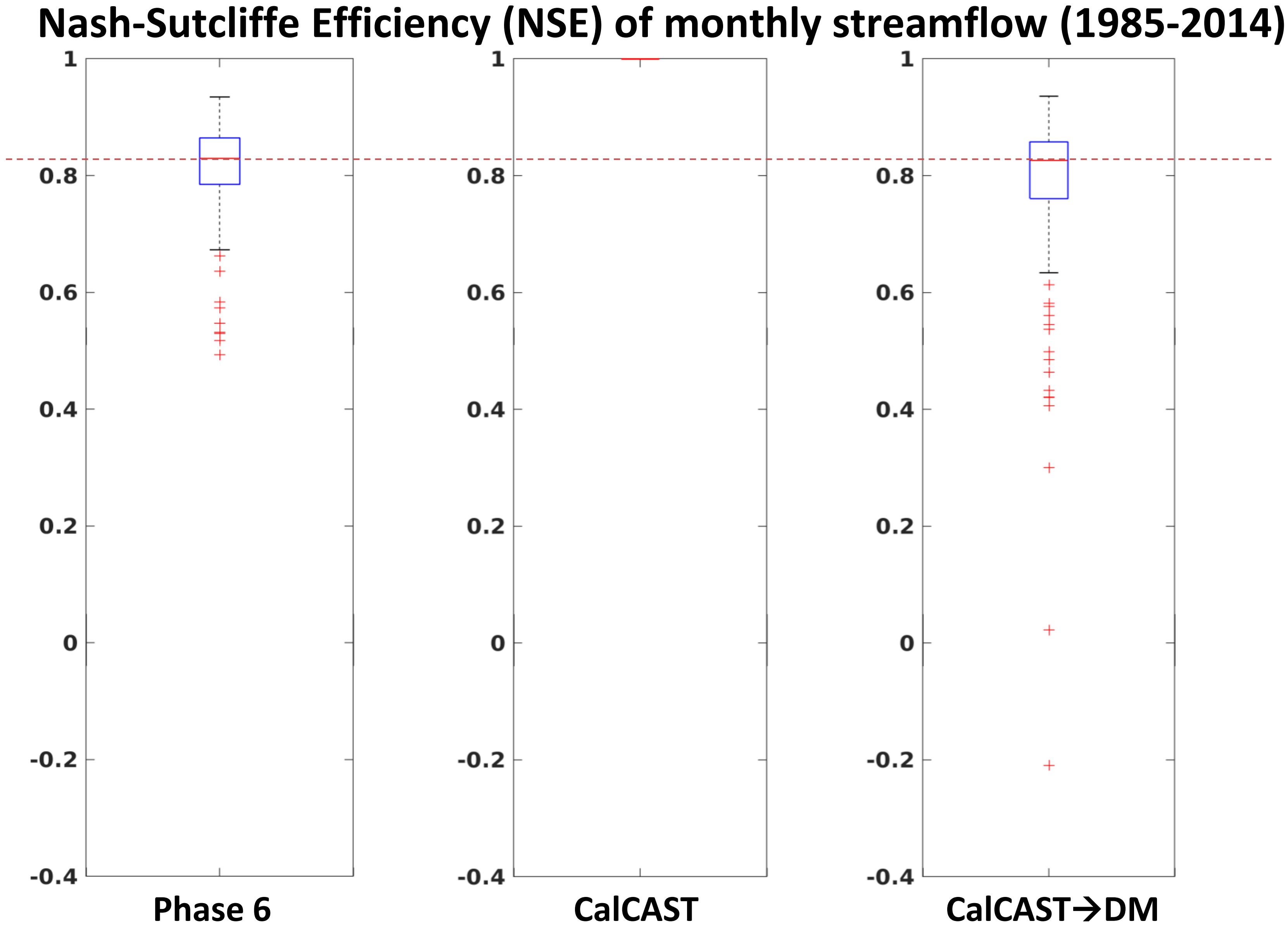
Preliminary, only for tracking development progress



Results: Monthly Flow

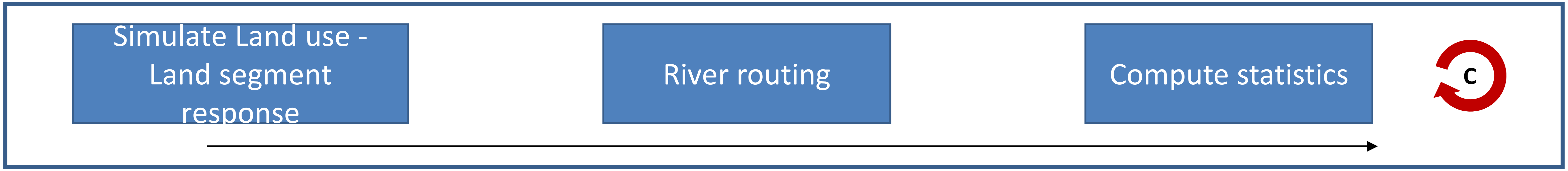
Preliminary, only for tracking development progress

closer to 1
the better

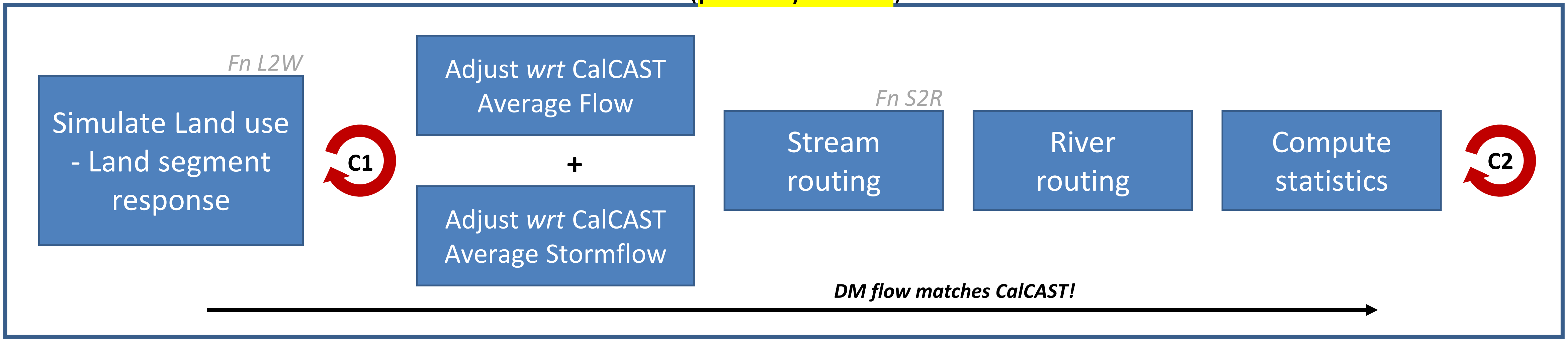


Hydrology Calibration Method

PHASE 6: HYDROLOGY CALIBRATION



PHASE 7: PROPOSED DM HYDROLOGY CALIBRATION (partially tested)



Can we improve DM hydrology in addition to new data from CalCAST?

Calibration of HSPF Land-use Hydrology Parameters

Hydrograph Statistics	HSPF Model Land-use Parameters
Total flow	*LANDEVAP*
Summer vs. winter flow	LZSN
Stormflow recession	IRC
Baseflow	INFILT
Baseflow recession	AGWR
Peak flow	INTFW
Summer flow	*AGWETP*
Low flow	KVARY

C1 CalCAST average flow — ***Testing completed***

C1 CalCAST stormflow — ***TODO***

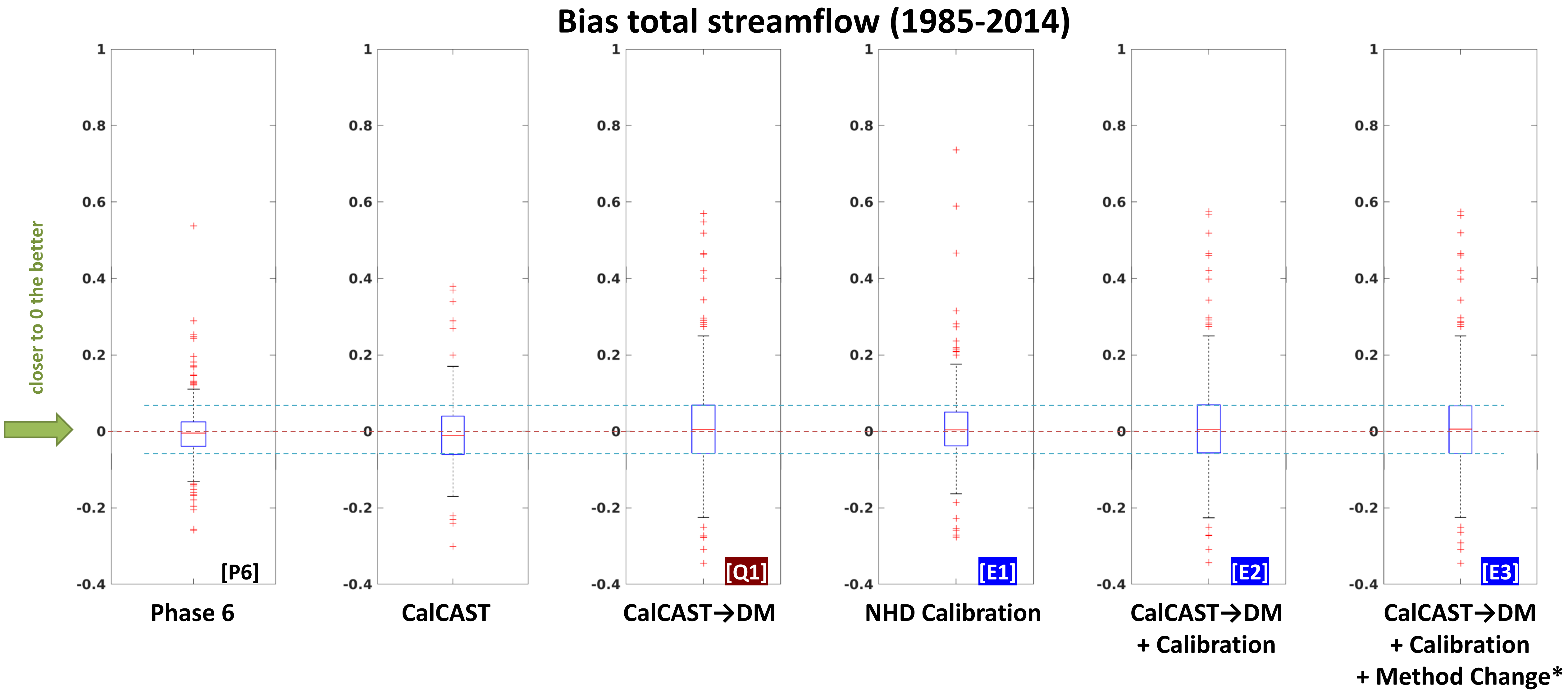
CalCAST landuse response — ***TODO***

All model parameters were calibrated to hydrograph statistics at the monitoring stations in Phase 6.
In Phase 7, we think some of these model parameters can be calibrated to CalCAST data.

Hydrology Calibration Method (Experiments)

Experiment	Description	Runtime	ID
CalCAST flow (CalCAST→DM)	i.e., Phase 6 calibration + CalCAST average flow (land use NHD)		[Q1]
NHD catchment scale hydrology model calibration	**Operational calibration for the NHD scale model**	**Runtime:** **Model ~ 4 hours** **Calibration ~ 55 hours**	[E1]
NHD Model + CalCAST flow	**Calibration + matching CalCAST average flow**		[E2]
NHD Model + CalCAST flow & stormflow	Calibration + matching CalCAST flow & stormflow		
NHD Model + CalCAST flow + HSPF parameters	**Calibrating HSPF parameters to CalCAST average flow**		[E3]
NHD Model + CalCAST flow & stormflow + HSPF parameters	Calibrating HSPF parameters to CalCAST flow & stormflow		

Hydrology Calibration Experiments

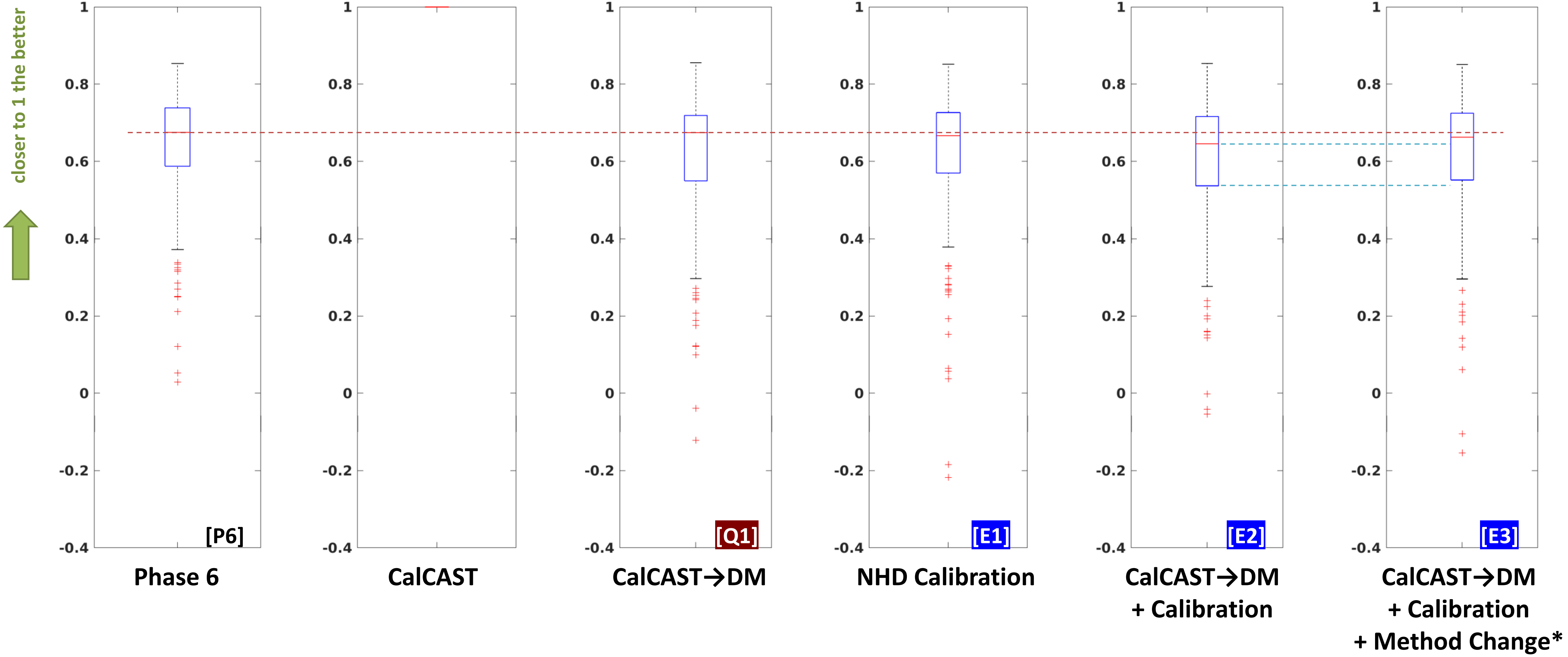


(i) E1 shows calibration is working at NHD-scale and we should expect improvements going from other sources.

(ii) Q1, E2, and E3 shows DM matches CalCAST average flow.

Hydrology Calibration Experiments

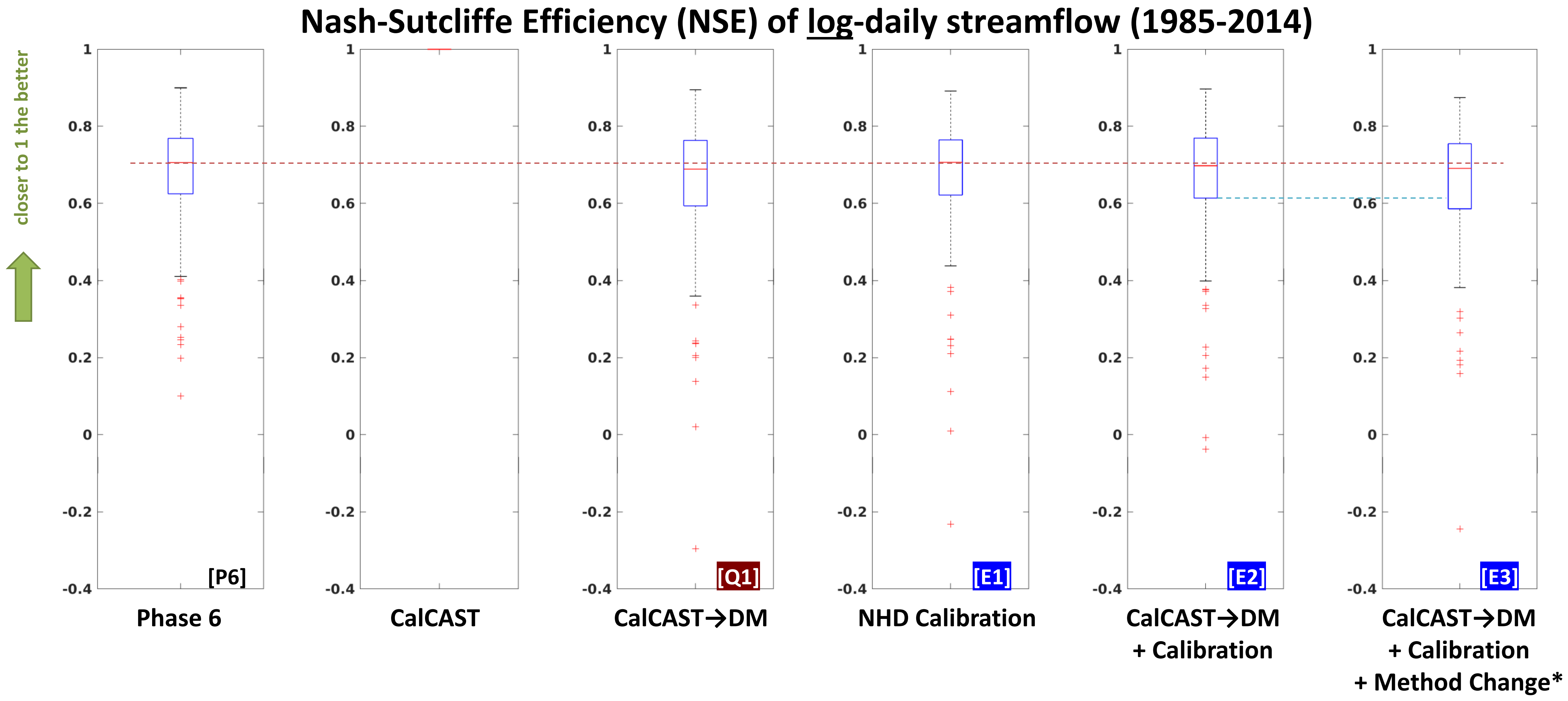
Nash-Sutcliffe Efficiency (NSE) of daily streamflow (1985-2014)



~~(i) [Q1] vs. [E3] show that calibration improved model performance in addition to CalCAST flow.~~

(ii) [E2] vs. [E3] show that calibration method change is helping improve the model performance

Hydrology Calibration Experiments



(i) Incorporation of CalCAST stormflow, and (ii) calibration of impervious land use should improve calibration.

Summary and Next Steps

- We reviewed the progress made in the hydrology calibration of the NHD 100K scale Dynamic Model.
- We are proposing and testing some calibration method changes, and the initial results are encouraging (but additional analysis is needed).
- Better hydrology simulation (scale and data explaining spatial variability) will improve simulations of sediment and nutrients.
- We have evaluated trade-offs of advanced vs. simple routing.
  - How can we improve the efficiency of a numerically accurate iterative solver
  - A non-iterative explicit numerical approximation for even greater efficiency