10/04/2022

Phase 7 WSM Development – Dynamic Model for Hydrology & Sediment

Modeling Workgroup Quarterly Meeting – October 2022

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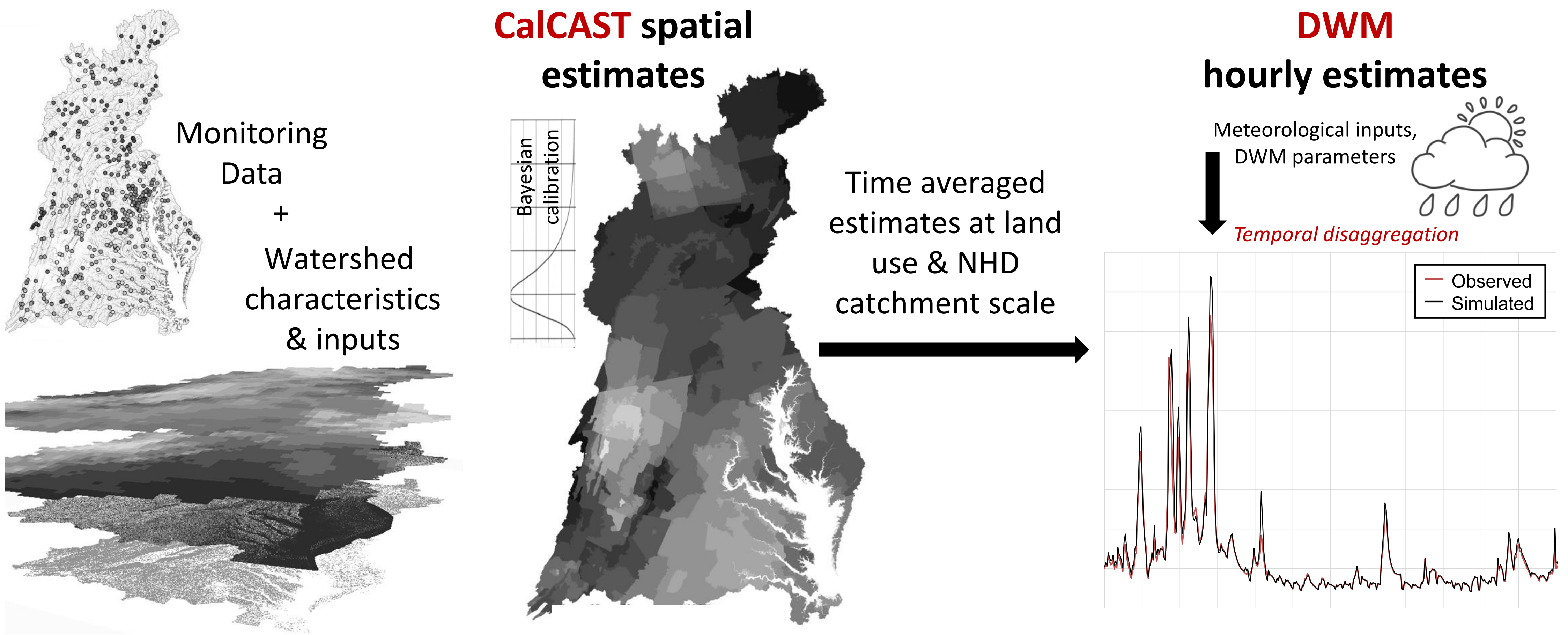
Framework: Spatial Model (CalCAST) → Dynamic Watershed Model (DWM)



- Data-driven CalCAST informs DWM parameters and responses.
- NHD-scale DWM prototype is now using CalCAST *average annual* (a) total flow, (b) stormflow, and (c) sediment erosion and delivery factors.

Purpose

NHD Scale Dynamic Watershed Model (DWM)

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

Presentation Outline

Dynamic Watershed Model (DWM) for Hydrology & Sediment

1. NHD Model for Stormflow (CalCAST→DWM Stormflow)

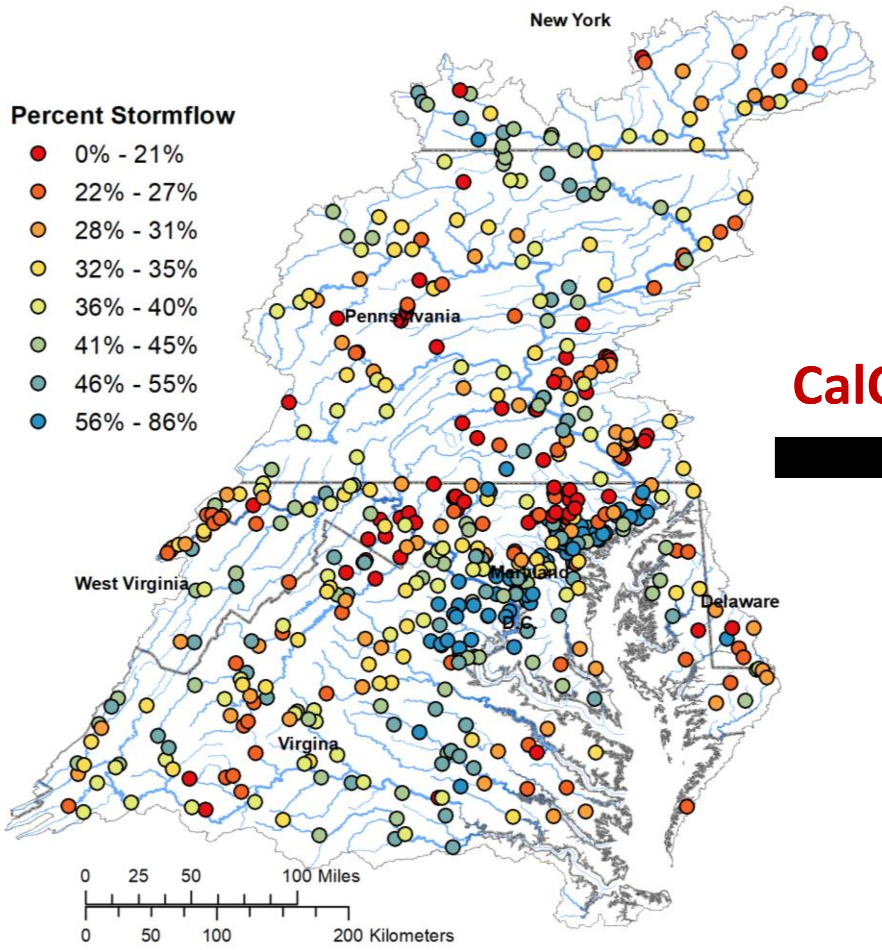
- Input: CalCAST stormflow at catchment land use scale
- Incorporation in DWM and proposed calibration method changes
- Calibration results and performance evaluations
- Potential issues

2. NHD Model for Sediment (CalCAST→DWM Stormflow)

- Sediment model structure
- Model performance (daily, annual, average annual, etc.)

Average Annual Stormflow Model

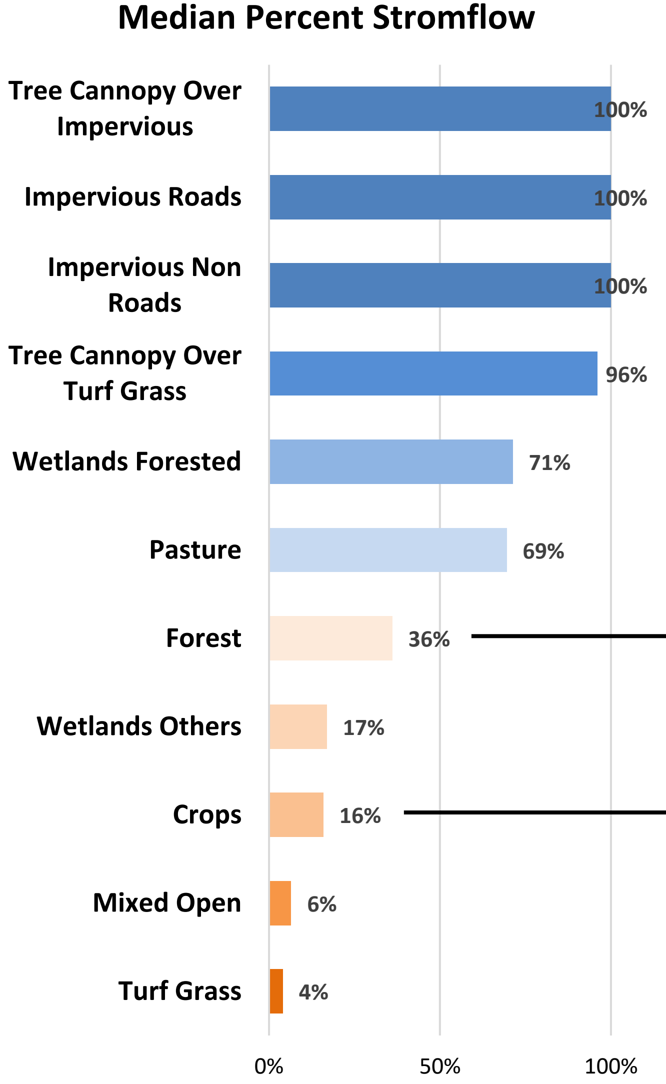
Monitoring

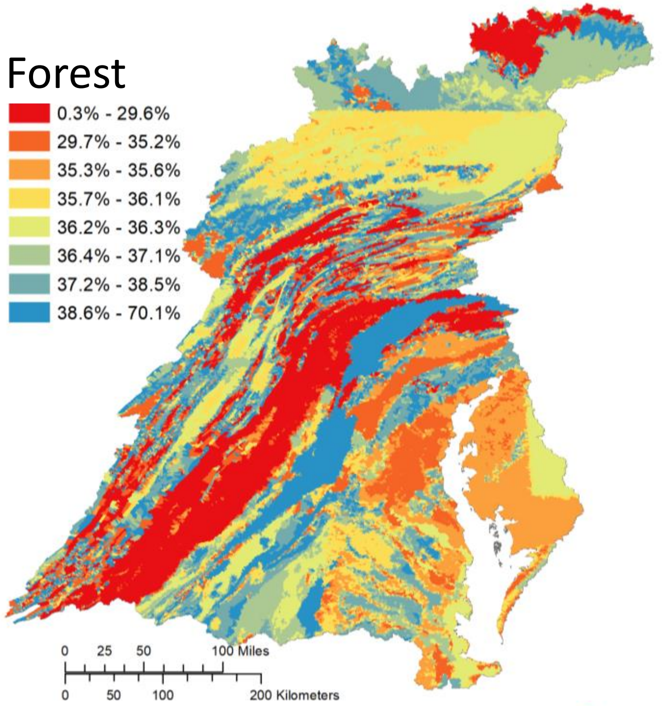


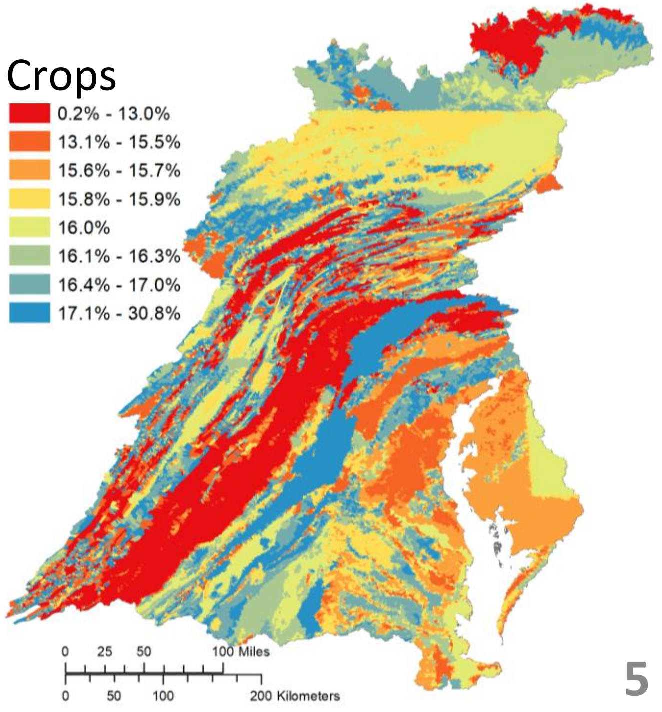
Average Annual Stormflow
Estimated using USGS PART

CalCAST

Spatial Prediction



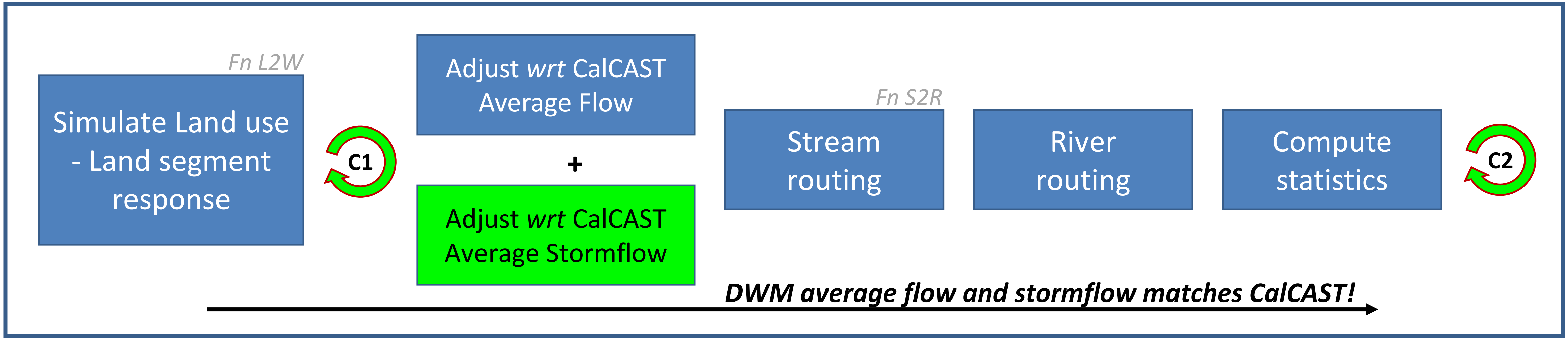




Hydrology Calibration Method

PHASE 6: HYDROLOGY CALIBRATION

PHASE 7: PROPOSED DWM HYDROLOGY CALIBRATION



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

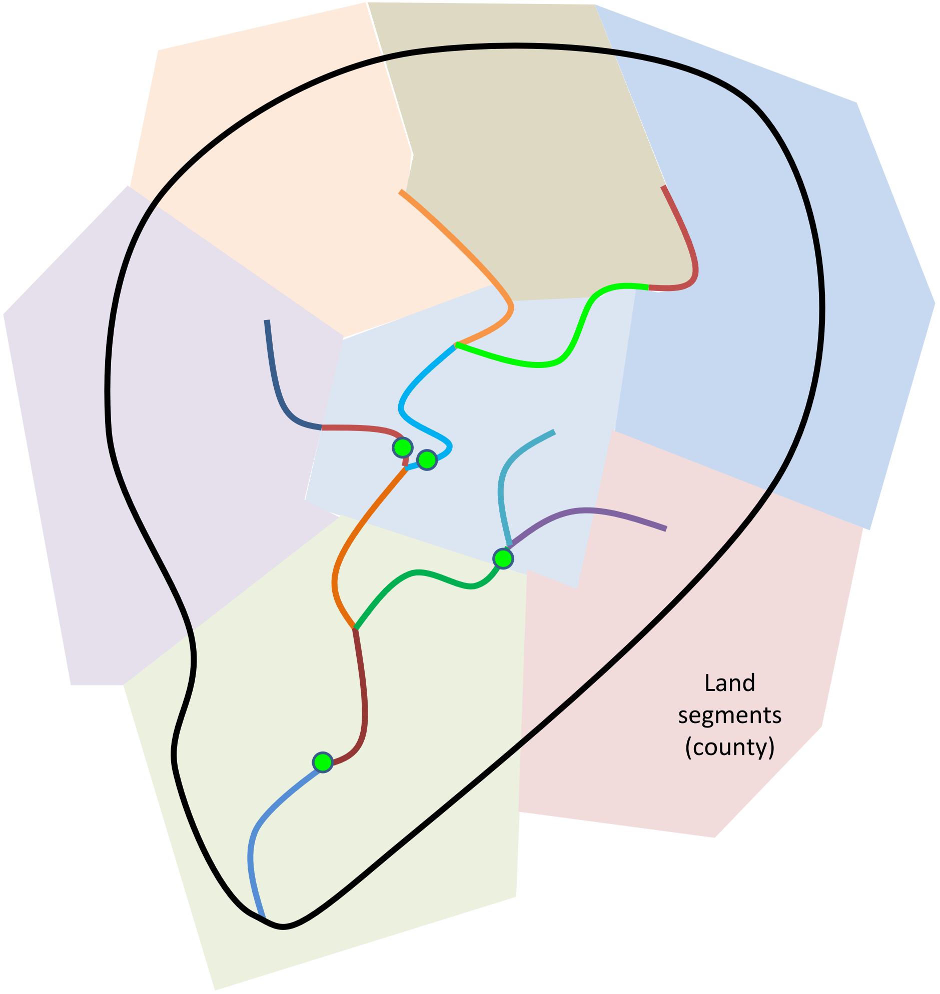
Hydrology Calibration Method: HSPF Land-use Parameters

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 — ✓ *Testing completed*

CalCAST landuse response — ***TODO***

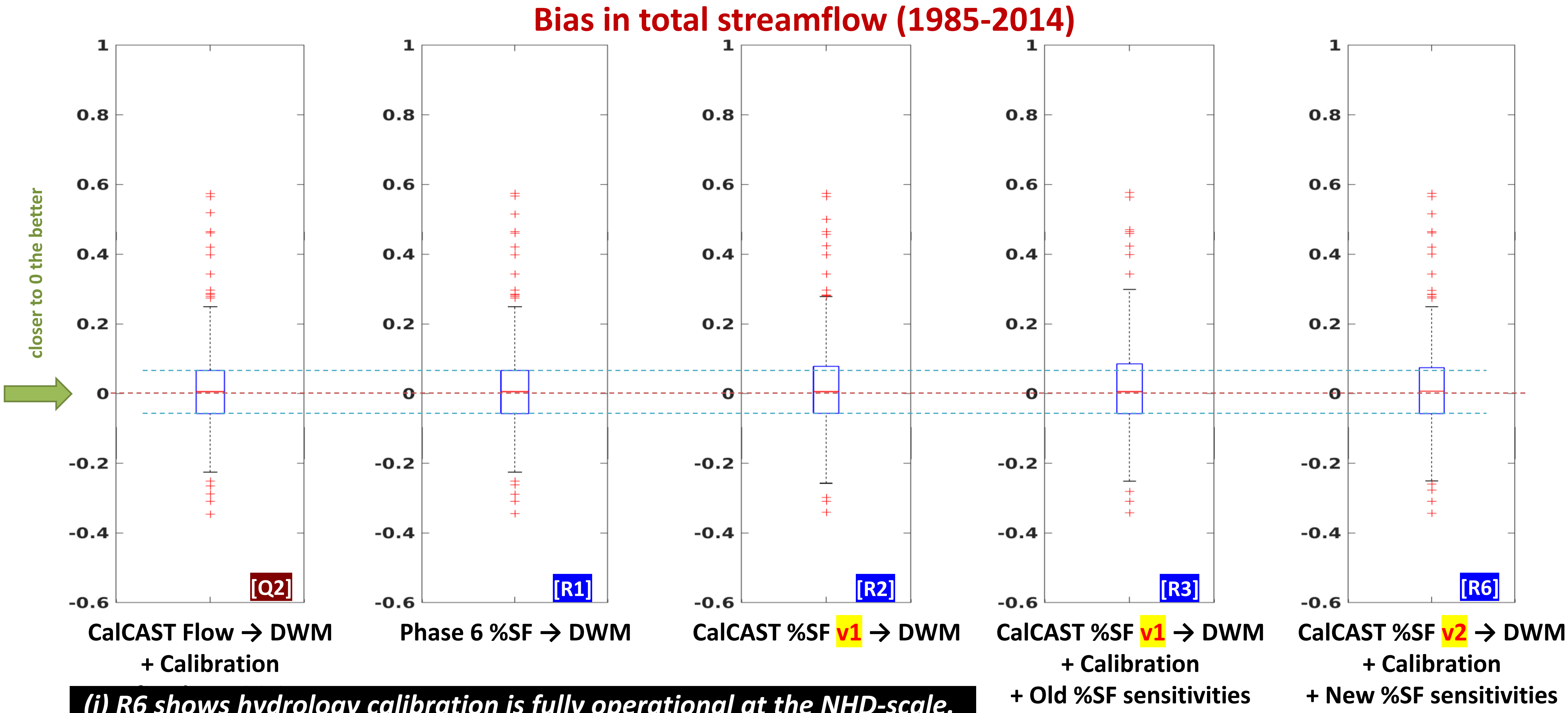


In Phase 6, all model parameters were calibrated to hydrograph statistics at the monitoring stations.
In Phase 7, we are proposing that some of these model parameters can be calibrated to CalCAST data.

Incremental Hydrology Calibration Runs

CalCAST flow (CalCAST→DWM)	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	[$Q2_1$]
NHD Model + CalCAST flow	Calibration + matching CalCAST average flow ✓		[$Q2_2$]
NHD Model + CalCAST flow & stormflow	**Calibration + matching CalCAST average flow & stormflow**		[R3]
NHD Model + CalCAST flow + HSPF parameters	Calibrating HSPF parameters to CalCAST average flow ✓		[Q2]
NHD Model + CalCAST flow & stormflow + HSPF parameters	**Calibrating HSPF parameters to CalCAST average flow & stormflow**	Runtime: Model ~ 4.5 hours Calibration ~ 66 hours	[R6]

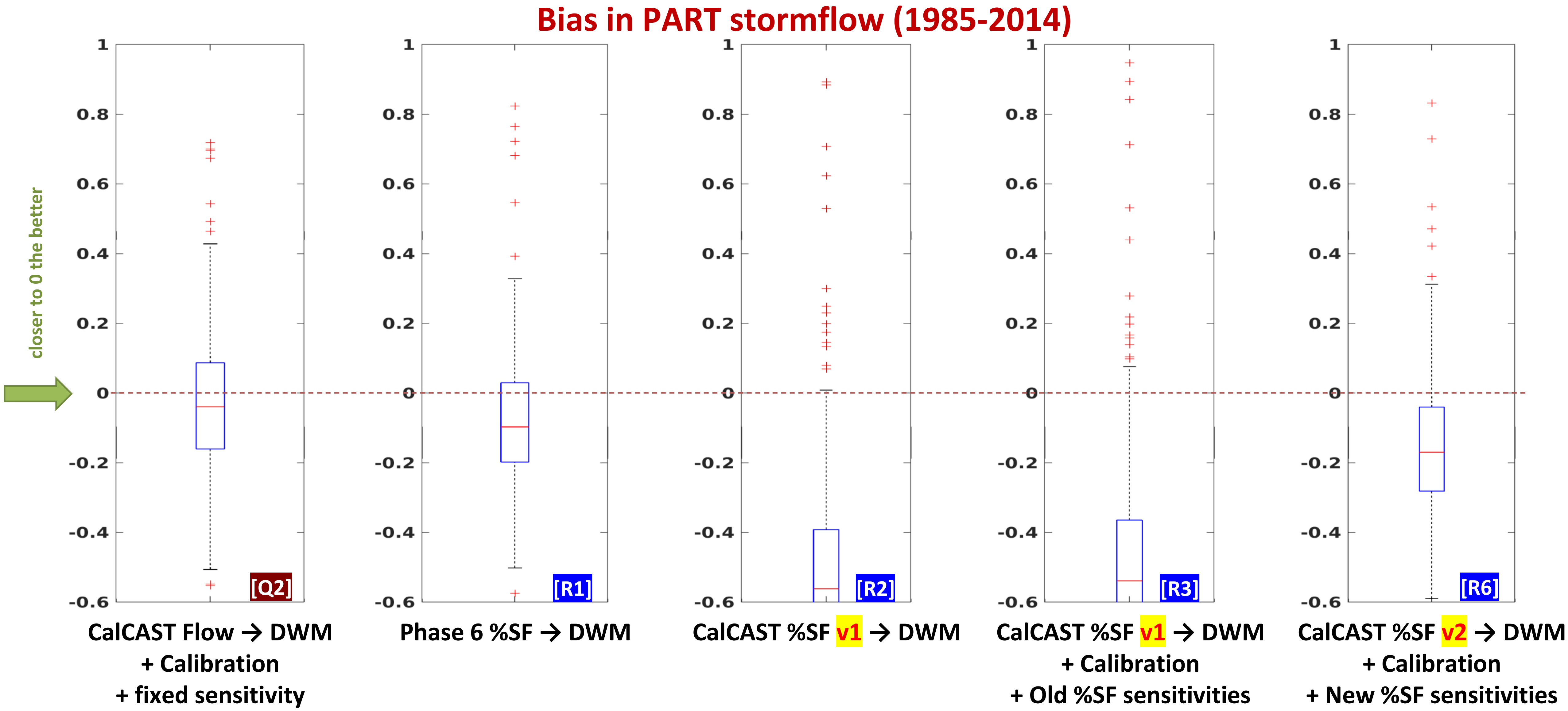
Results: Incremental Hydrology Calibration Runs



(i) R6 shows hydrology calibration is fully operational at the NHD-scale.

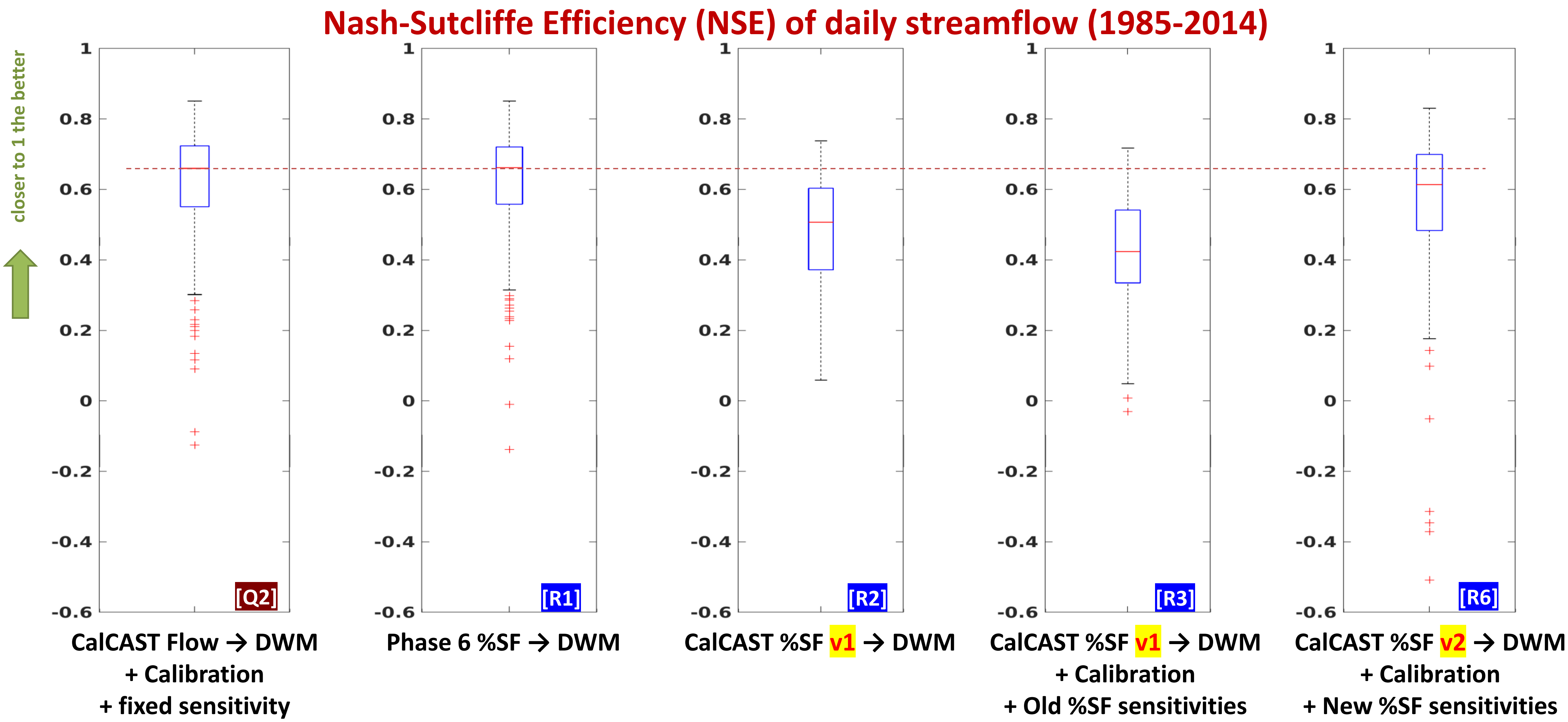
(ii) R1, R2, R3, R6 stormflow runs show DWM match CalCAST average flow.

Results: Incremental Hydrology Calibration Runs



Q2 and R6 show DWM performance decreased with inclusion of CalCAST stormflow but expect future improvements

Results: Incremental Hydrology Calibration Runs



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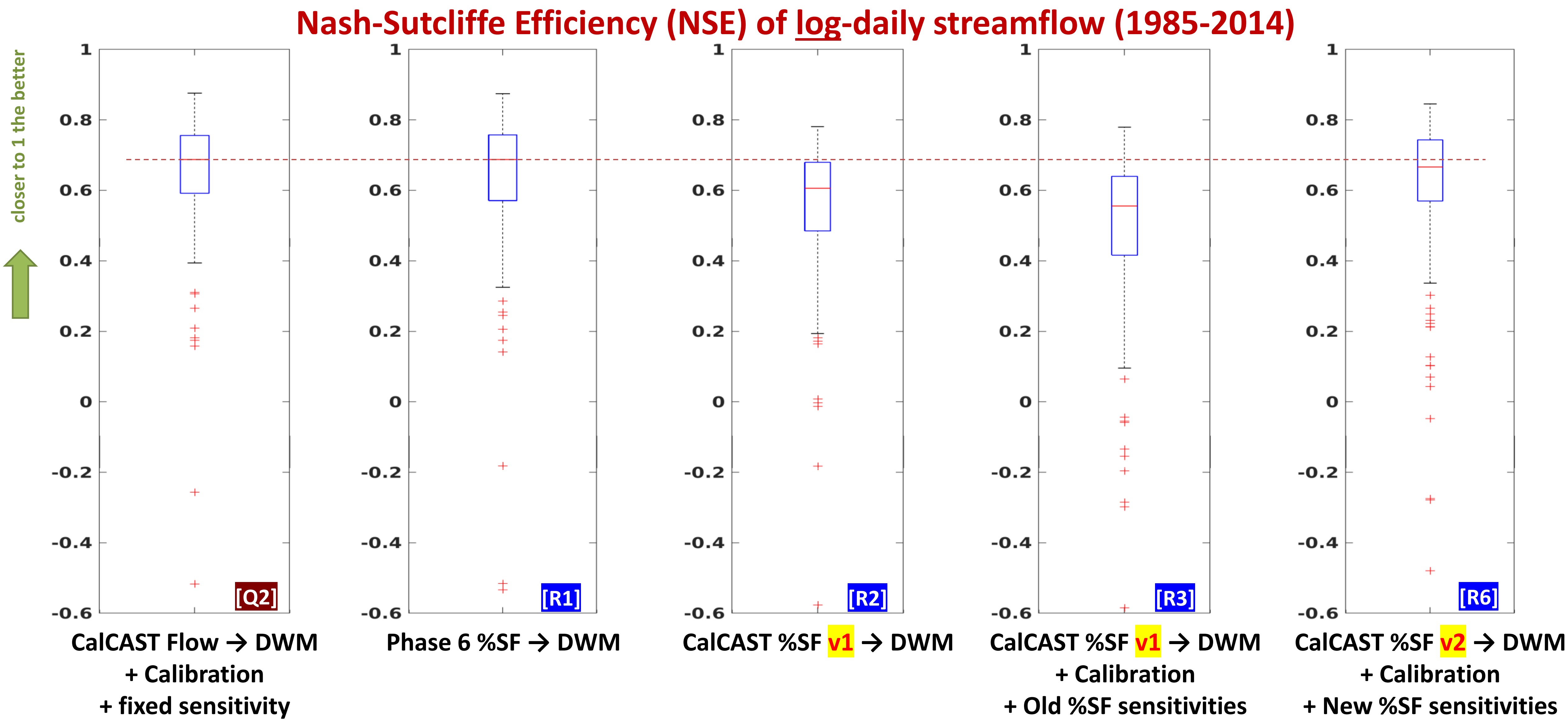

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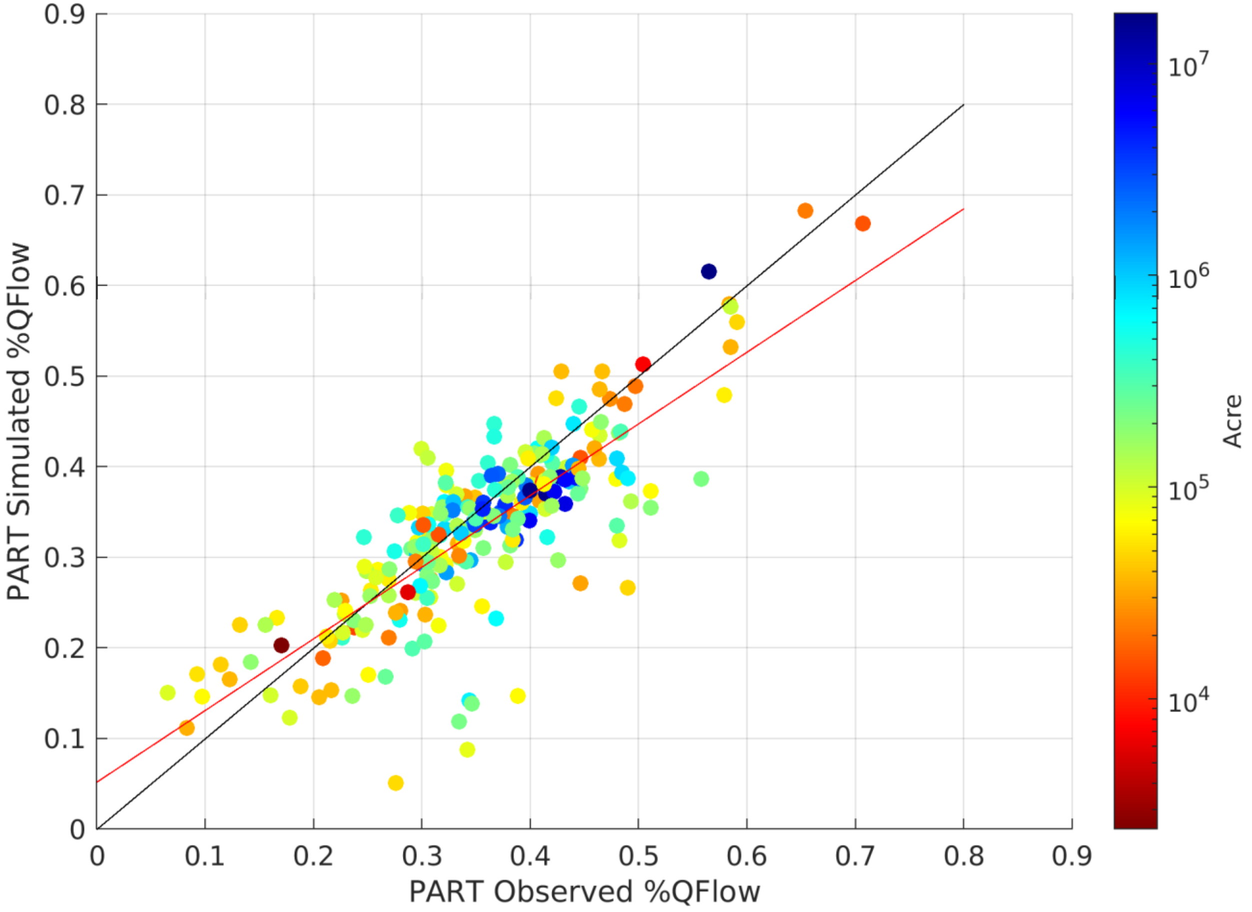
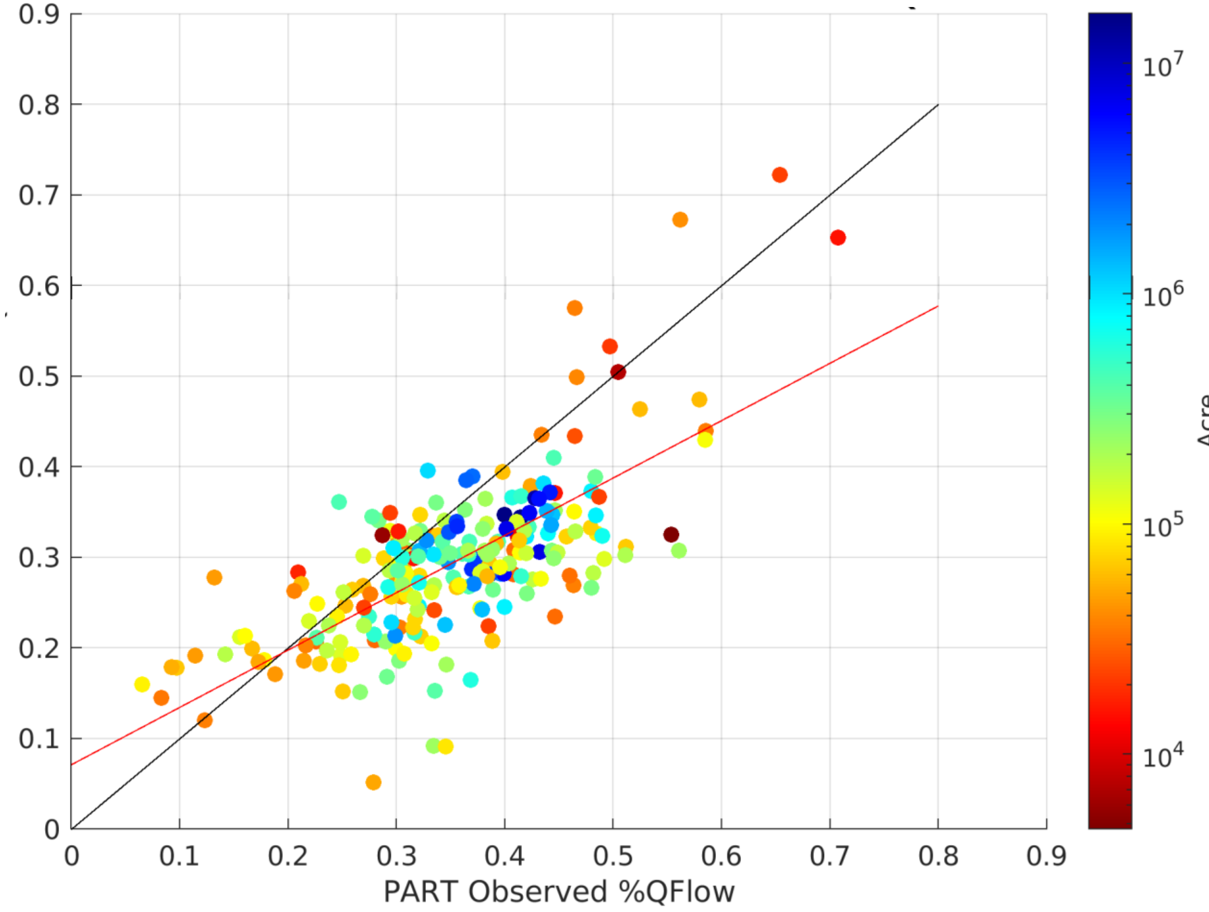
Potential Issues

Stormflow in Phase 6

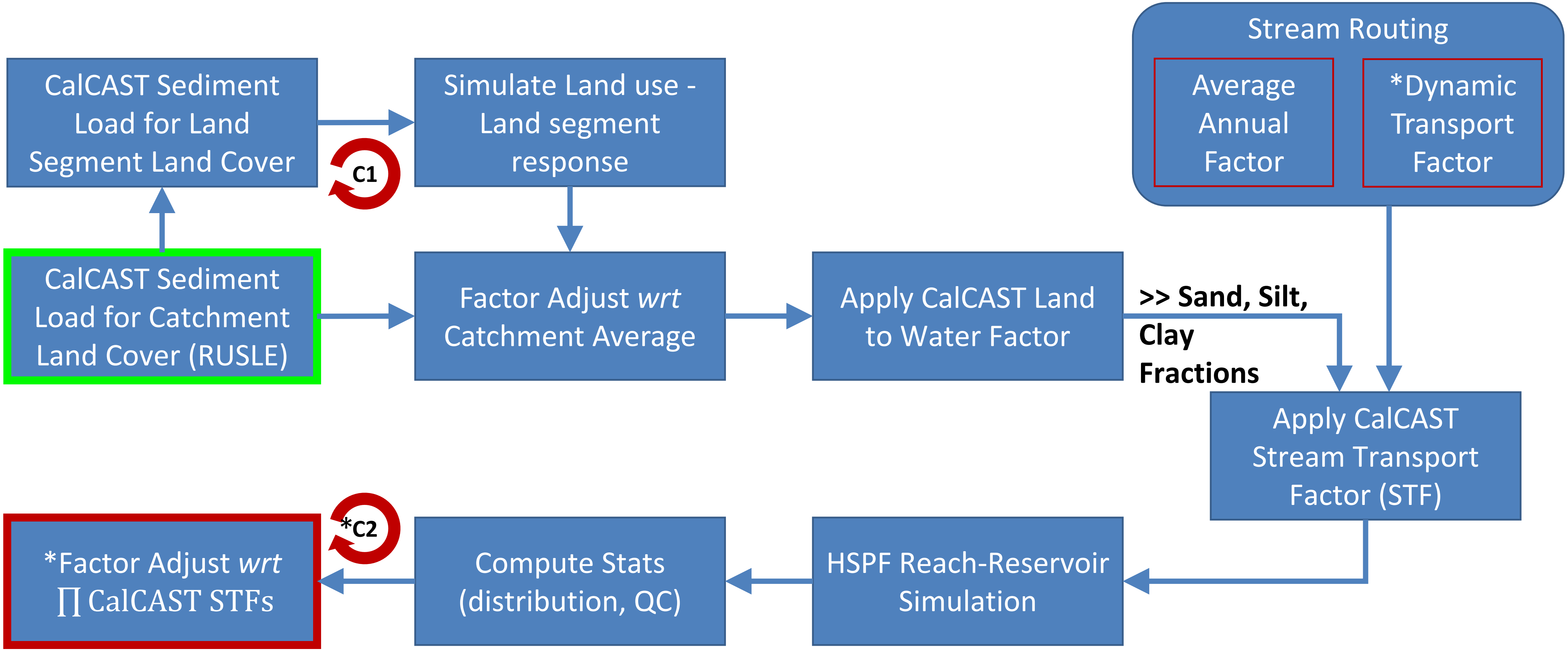


Stormflow in NHD Model



(i) We haven't been able to fully verify DWM stormflow against CalCAST at the gage stations.
(ii) Standard model poses challenges in such verification. We will work on verification in 4Q through simplified runs.

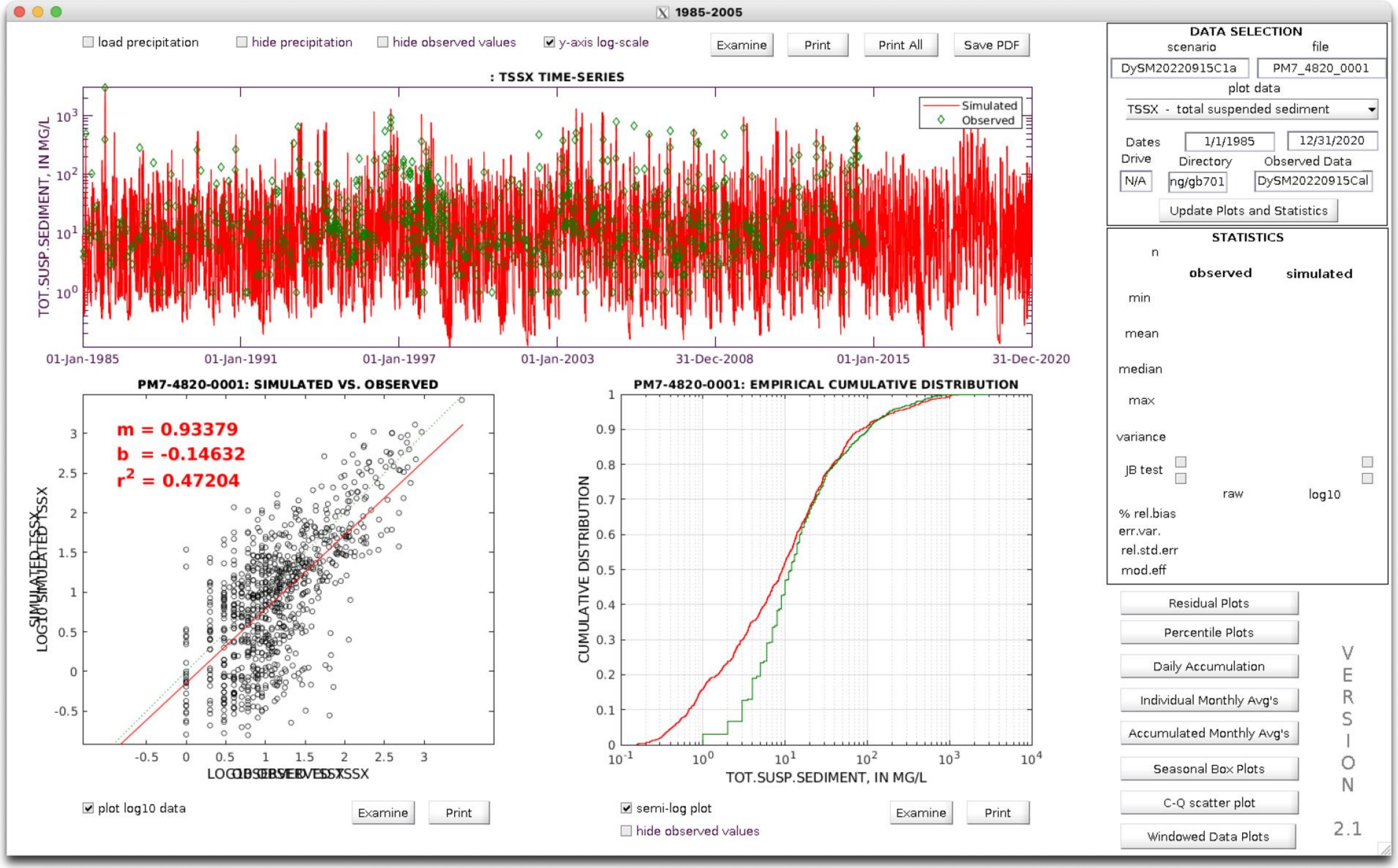
NHD Scale Sediment Model Structure



Modules marked with * are not yet implemented or applied in the prototype we are discussing today.

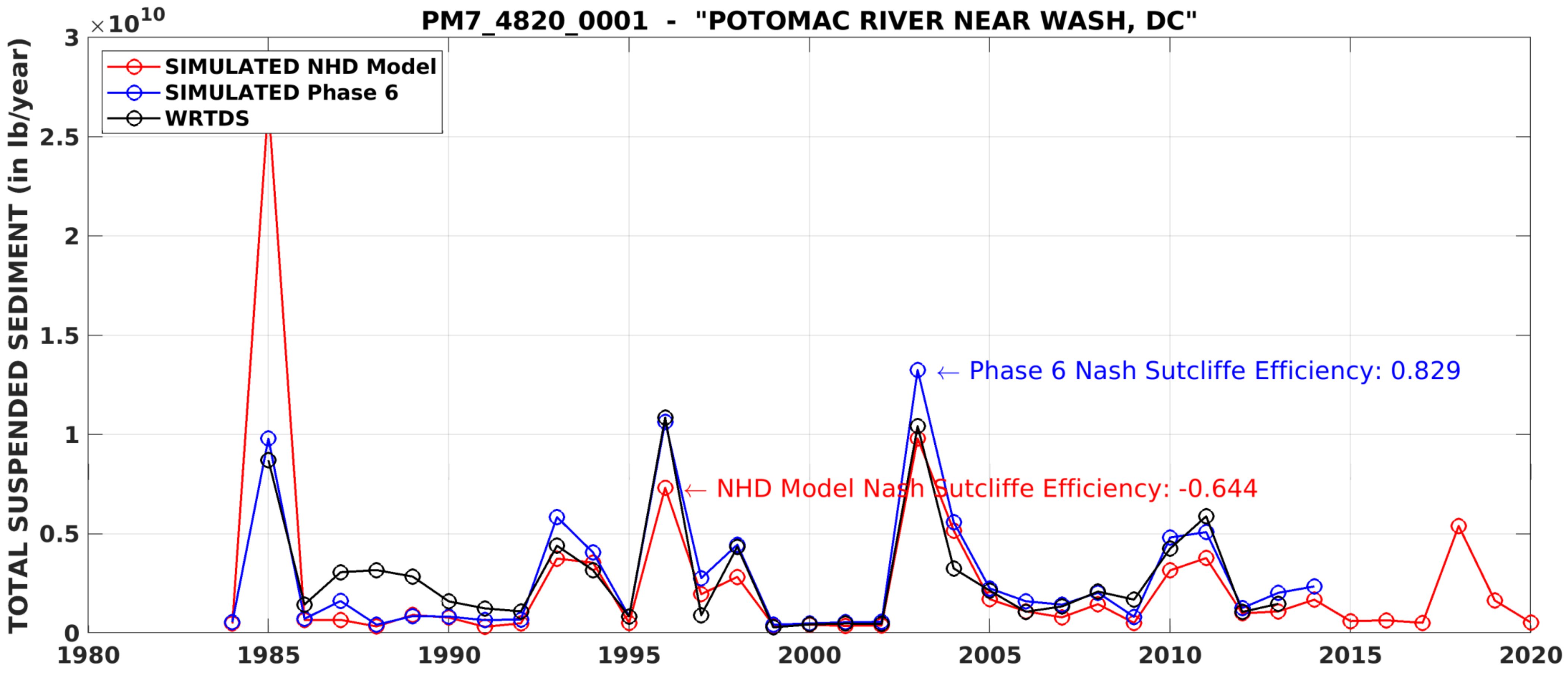
Results: Daily Suspended Sediment

POTOMAC RIVER AT CHAIN BRIDGE, AT WASHINGTON, DC



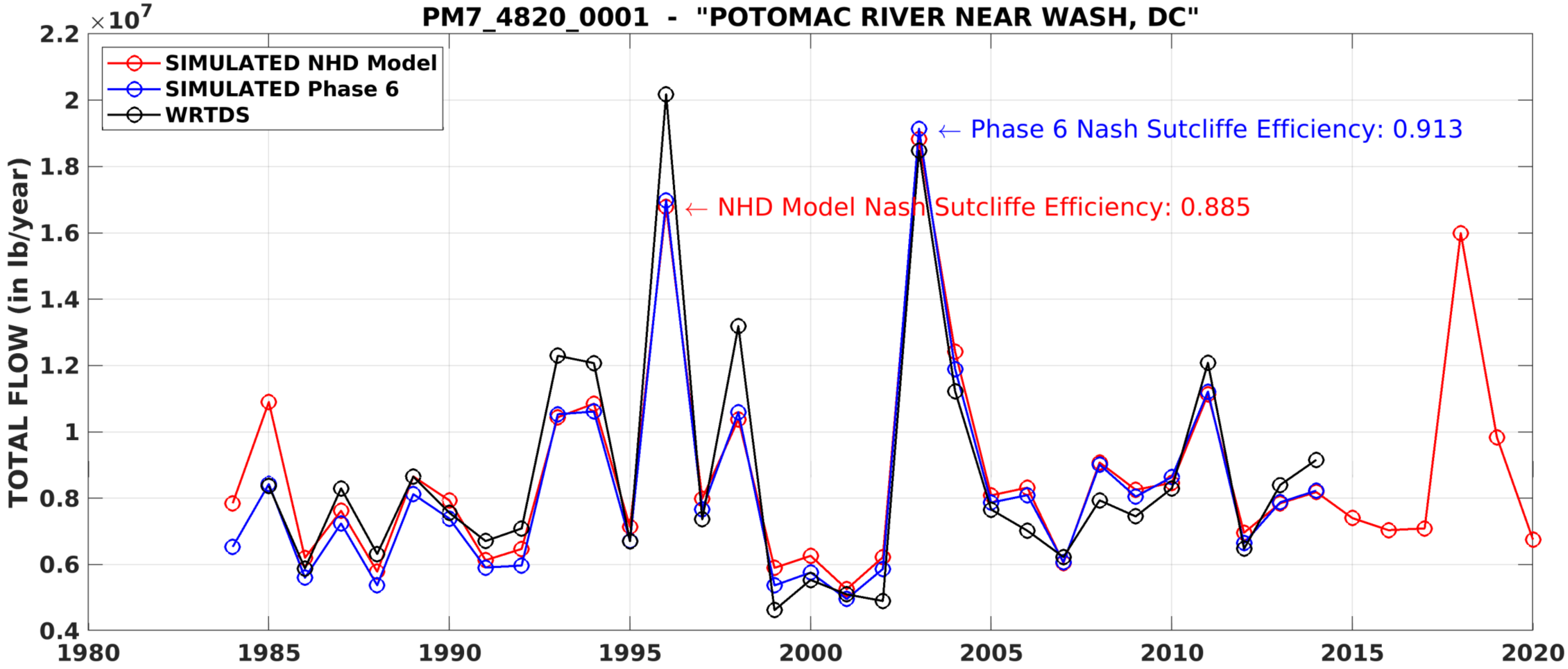
NHD Model has similar simulated daily concentration showing the model is working as expected.

Results: Annual Loads for Suspended Sediment



(i) Annual loads seem to perform well. NHD Model has generally lower annual load than that of Phase 6.
(ii) However, NHD Model has significantly higher load in 1985. What happened? We briefly investigated …

Results: Annual River Flow



(i) Annual flows seem to have performed reasonably well.
(ii) NHD Model has significantly higher flow in 1985 as well, which can certainly impact sediment load.

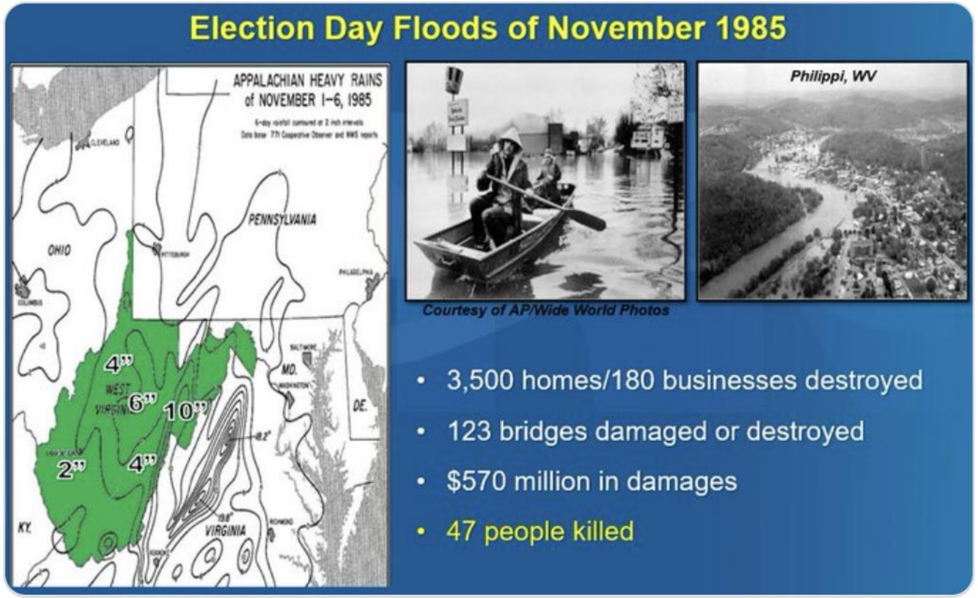
1985 Election Day Floods

Aubrey Urbanowicz @WHSVaubs · Follow

The 1985 election day floods across our area was one of the worst in history.
Magnitude of an event is relative to your location- for some the worst was 1996 or 2003.
But 1985 hit VA and especially WV very hard
📸 from SVEC

NWS Charleston, WV @NWSCharlestonWV · Follow

On this date in weather history, 4-8 inches of rain fell in 1985, setting the stage for catastrophic flooding on the Potomac, Greenbrier, Little Kanawha, West Fork, Tygart Valley, Cheat and Monongahelia Rivers. The 1985 Election Day Floods would kill 47 West Virginians. #wvwx

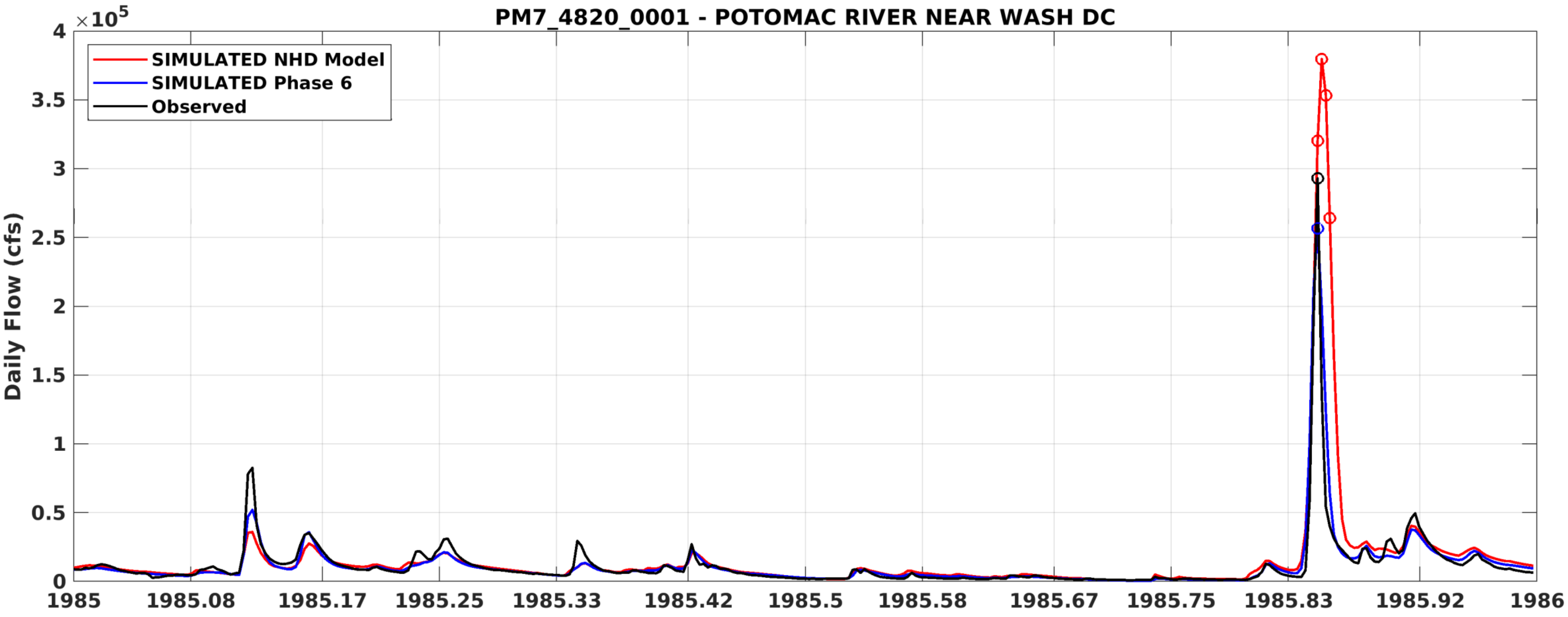


Late October Hurricane Juan + Rain on Nov 4 from a low-pressure system = 4-18" of rain

"On November 4 and 5, 1985, heavy rain fell across the area and caused historic flooding devastated parts of West Virginia and the Shenandoah Valley"[1]

[1] https://www.whsv.com/2020/11/05/remembering-the-1985-election-day-floods/
[2] https://www.washingtonpost.com/archive/politics/1985/11/06/floods-cause-26-deaths-heavy-damage-in-region/ea7cf865-d41e-4617-975d-c3b60ec720a0/

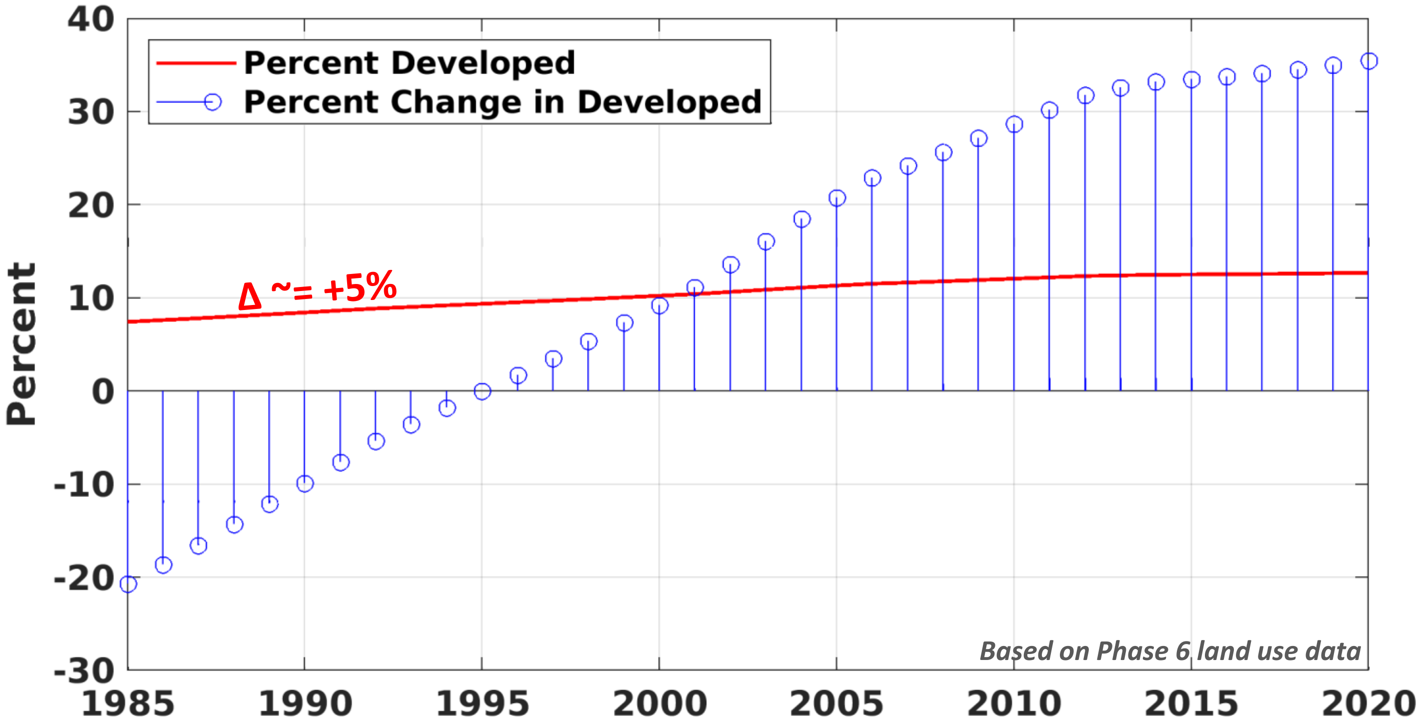
1985 Daily River Flow

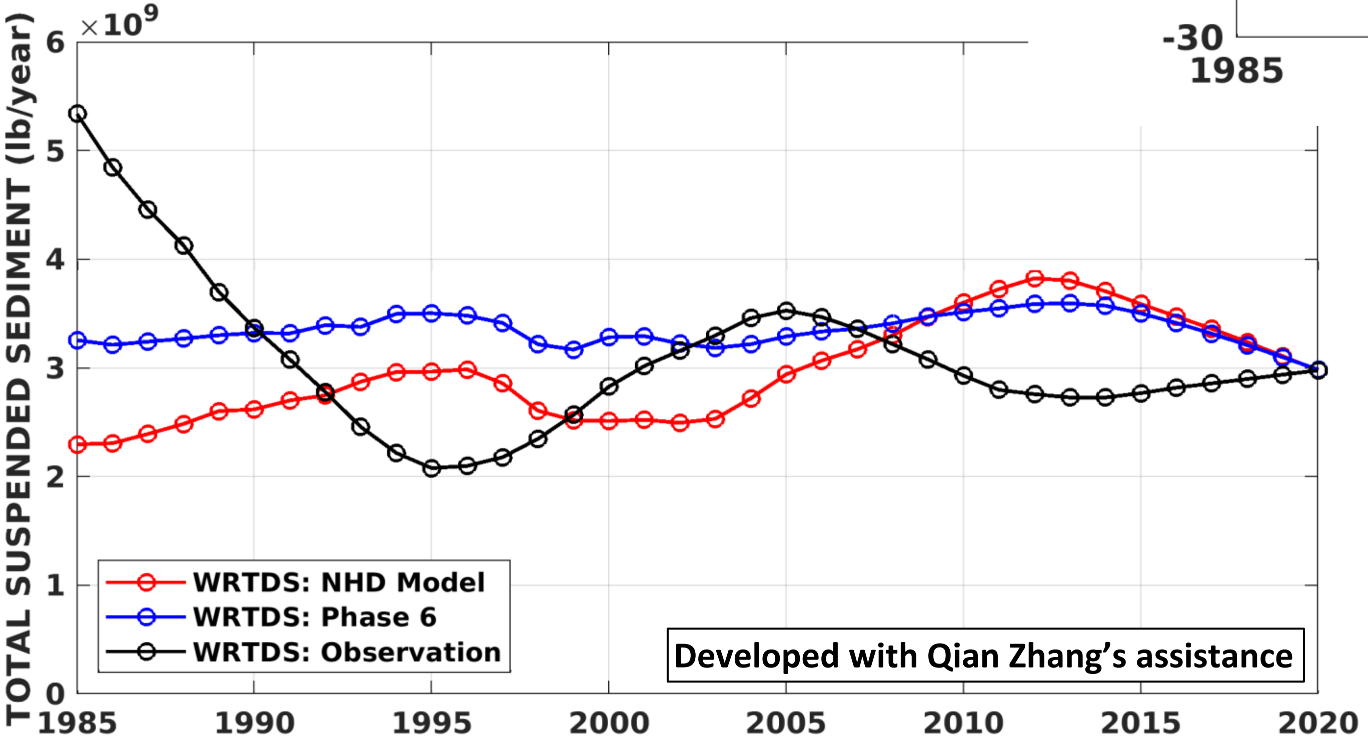


(i) In November 1985, Phase 6 Model had one daily event with flow larger than 250,000 cfs.
(ii) NHD Model currently has a total of four daily events with flow larger than 250,000 cfs for the same period.

Likely explanations

(i) NHD Model is currently using constant land cover data for the entire simulation period. 2013 land cover data has ~1.7x developed land cover that of 1985, which means NHD Model has ~1.7x more developed in 1985.



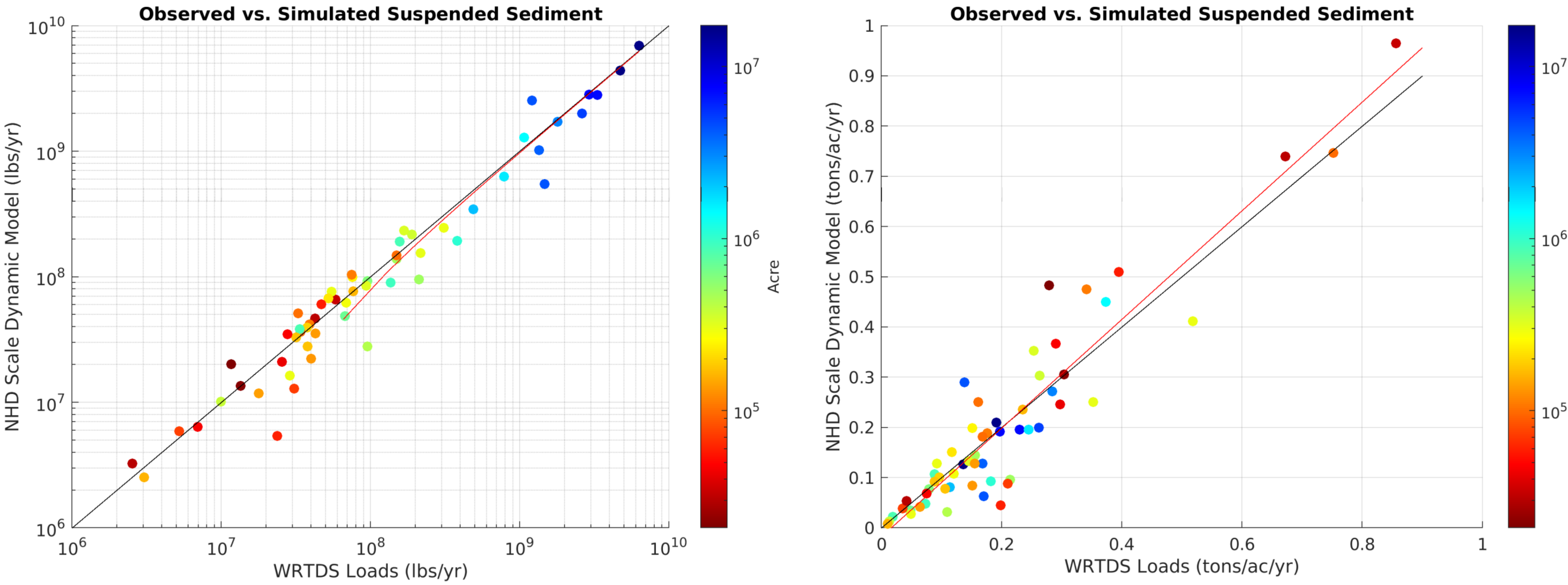


(ii) WRTDS Flow Normalized (FN) loads show both (a) NHD Model and (b) Phase 6 are performing similarly. Although it appears that FN loads for NHD Model is lower, it is likely due to higher developed footprint.

(iii) Model hydro parameters are suspect too.

Results: NHD Model for Sediment

Average Annual Loads at the Calibration Stations



(i) Riverine calibration wasn't performed. We are currently using Phase 6 river parameters.
(ii) Although incomplete, initial results show that NHD Model for sediment is performing as expected.

Model Run Time

Runs are made of AWS Cloud HPC with 144 compute cores

	Model Run	Calibration
Hydrology (CalCAST Flow)	4 Hours	55 Hours
Hydrology (CalCAST Flow and Stormflow)	4.5 Hours	66 Hours
Hydrology & Sediment	11 Hours	?

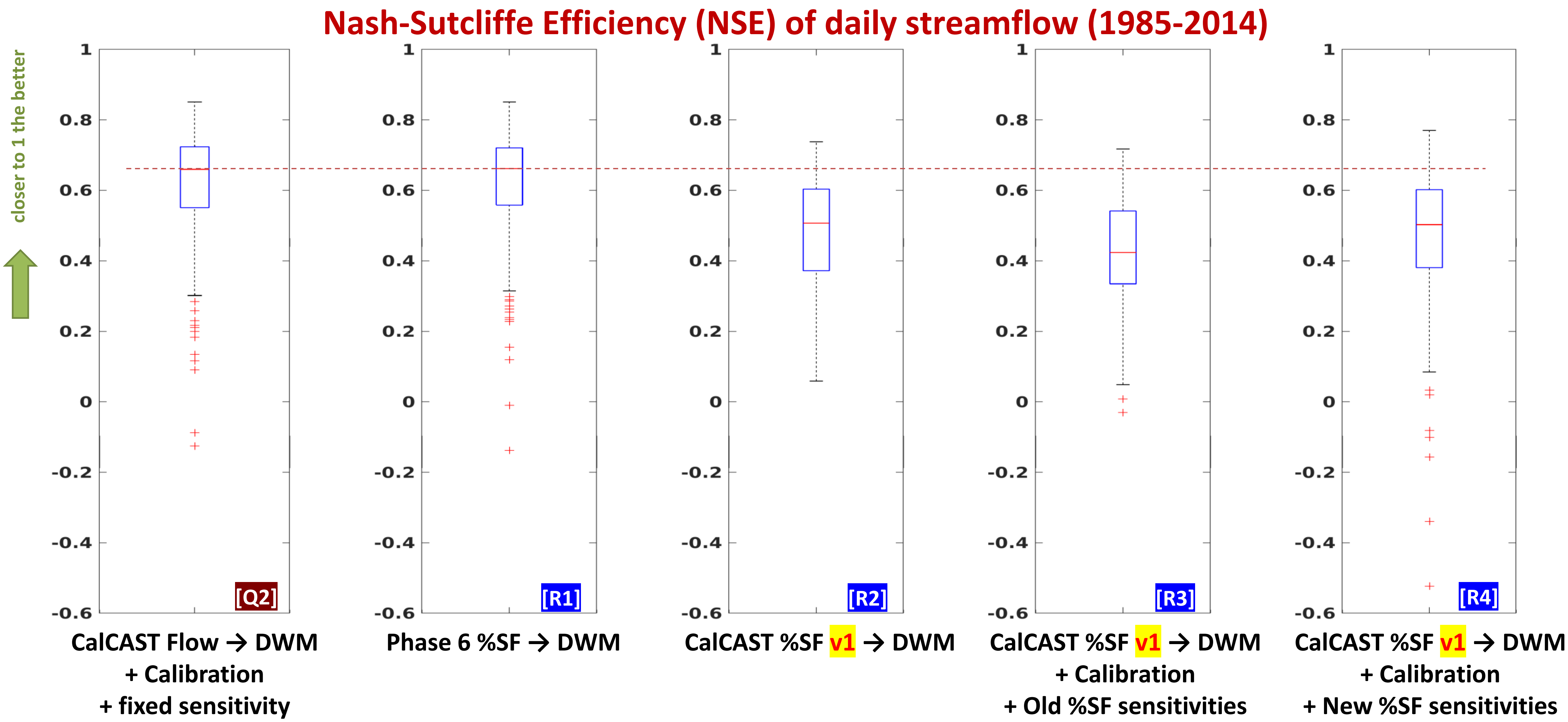
Aggregation of loads from land-uses took the most time, ~ 8 hours.

We expect land use will change from 12 to something else.
Sediment added 3 model variables (i.e., sand, silt, clay). Nutrients will add even more.

Summary and Next Steps

- We reviewed the progress made in the hydrology and sediment calibration of the NHD 100K scale Dynamic Watershed Model (DWM).
- We are proposing some calibration method changes, and they appear to be working as the initial results are as expected.
- Although results of the sediment model prototype are encouraging, it needs further development and testing.
- We will continue to pay attention to run time as we add additional processes in the model.
- In addition, DWM development will shift towards nutrients during the fourth quarter.

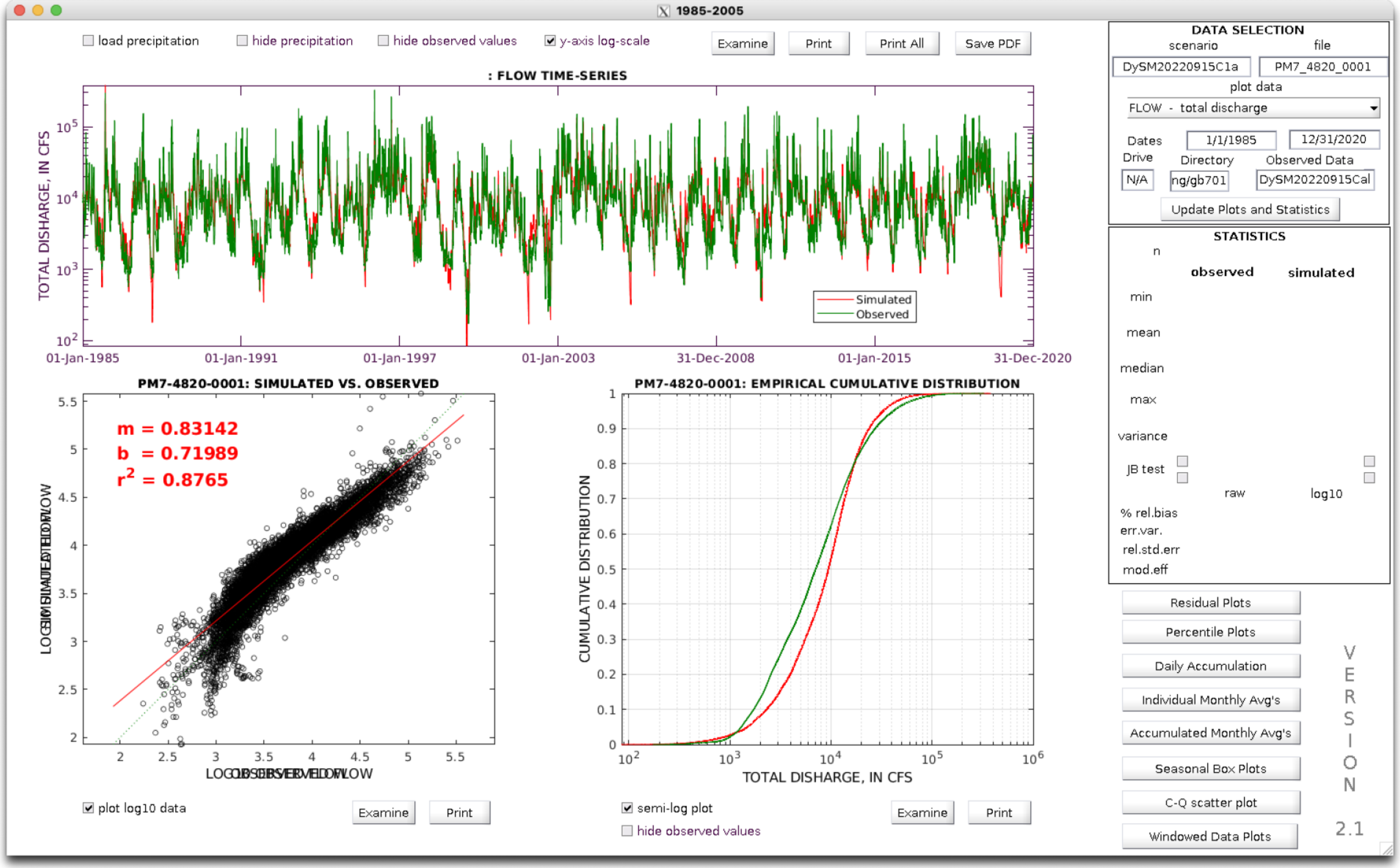
Results: Incremental Hydrology Calibration Runs

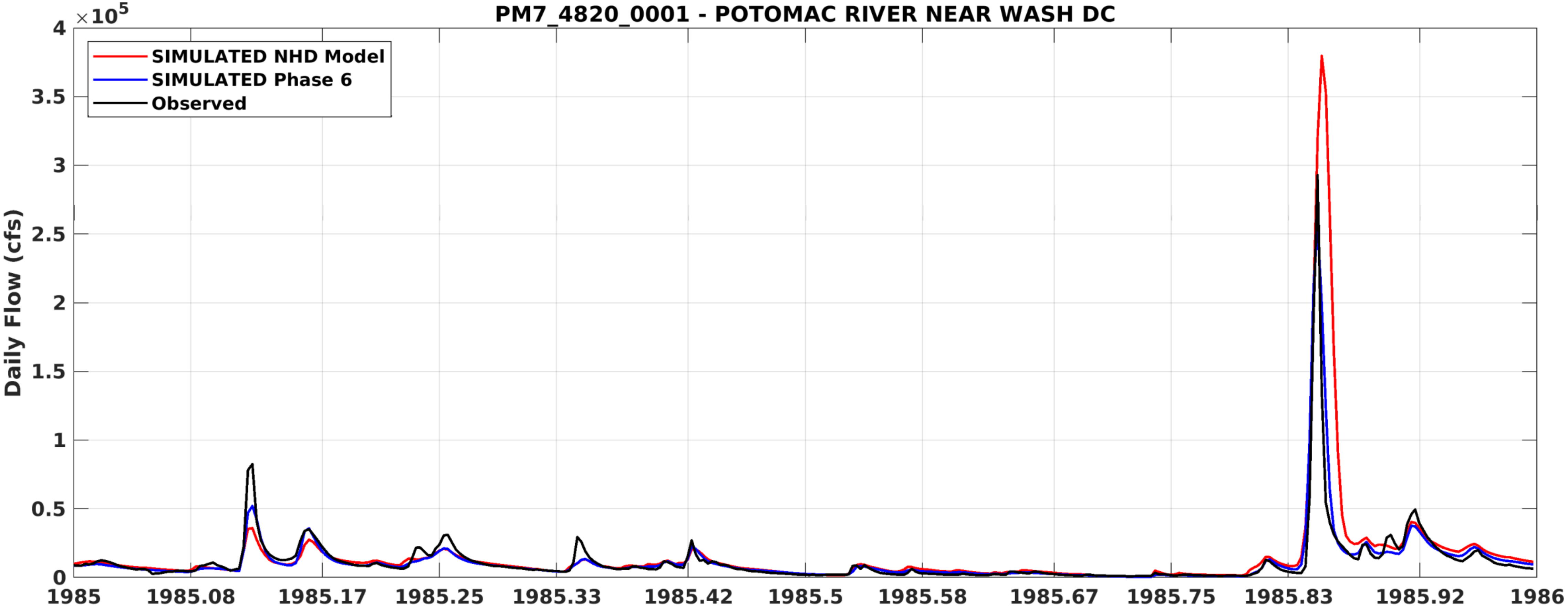


R3 and R4 show improvements in model performance with calibration in addition to CalCAST data

Results: Daily River Flow

POTOMAC RIVER AT CHAIN BRIDGE, AT WASHINGTON, DC





PM7_4820_0001 - POTOMAC RIVER NEAR WASH DC
×10^5
4
3.5
3
2.5
2
1.5
1
0.5
0
Daily Flow (cfs)
SIMULATED NHD Model
SIMULATED Phase 6
Observed
1985
1985.08
1985.17
1985.25
1985.33
1985.42
1985.5
1985.58
1985.67
1985.75
1985.83
1985.92
1986