Phase 7 WSM Development – Updates on Time-averaged and Dynamic Hydrology Model Linkage

Modeling Workgroup Quarterly Meeting – October 2021

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Presentation Outline

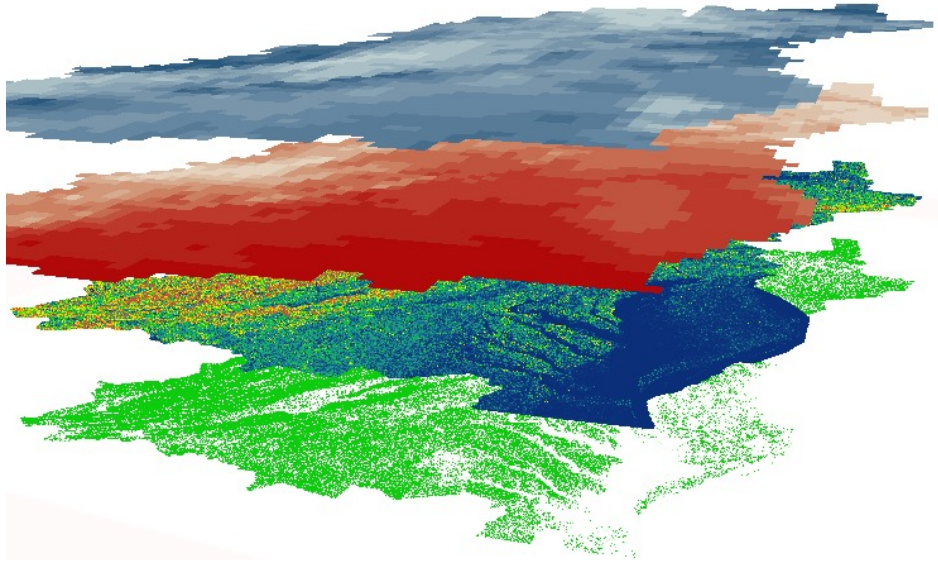
1. Time-averaged Hydrology Model – CalCAST
2. Dynamic Model (DM) of Hydrology (an initial, operational protype)
3. Prototype for CalCAST→DM Hydrology Linkage
4. Model Results – Linkage Prototype Verification

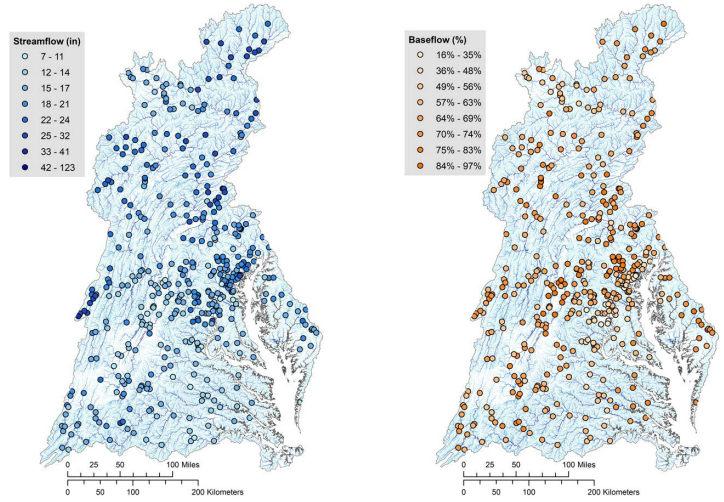
Spatial Data: Land use, input datasets, and other watershed characteristics

Hydrograph Indices of observed streamflow

CalCAST Hydrology

Average annual





CalCAST→DM linkage

Dynamic Hydrology Model

Hourly (event scale) simulation

- Simply put, Phase 6 hydrology was based on mass balance and assumed (empirical) hydrologic differences between land uses
- Where, potential evapotranspiration (PET) was calibrated *locally* for achieving mass balance *[Rainfall - Actual evapotranspiration (AET) = Runoff]*
- Model calibration was supported by observations but not linked to watershed properties
- In CalCAST we are trying to understand and statistically estimate the differences in runoff spatially and between land uses using *global* calibration
- It will improve our model results for land use and climate change scenarios

1. Time-averaged Hydrology Model – CalCAST

(NHD-100K scale simulation)

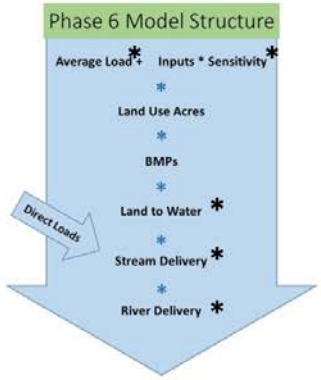
Prior presentations

[1] April 2021 – https://www.chesapeakebay.net/channel_files/42529/20210406_-_bhatt_-_phase_7_wsm_development_-_calcast_hydrology_-_cpp.pdf

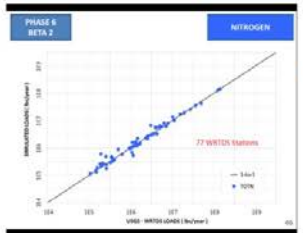
[2] July 2021 – https://www.chesapeakebay.net/channel_files/43361/bertani_mwg070621.pdf

CalCAST Hydrology Model Development

- Average annual streamflow *(Q)* is the difference of Rainfall and Actual Evapotranspiration *(AET)*, where *AET* can be estimated from Potential Evapotranspiration *(PET)* and/or other watershed properties.



Calibration of meta-parameters to spatial loads

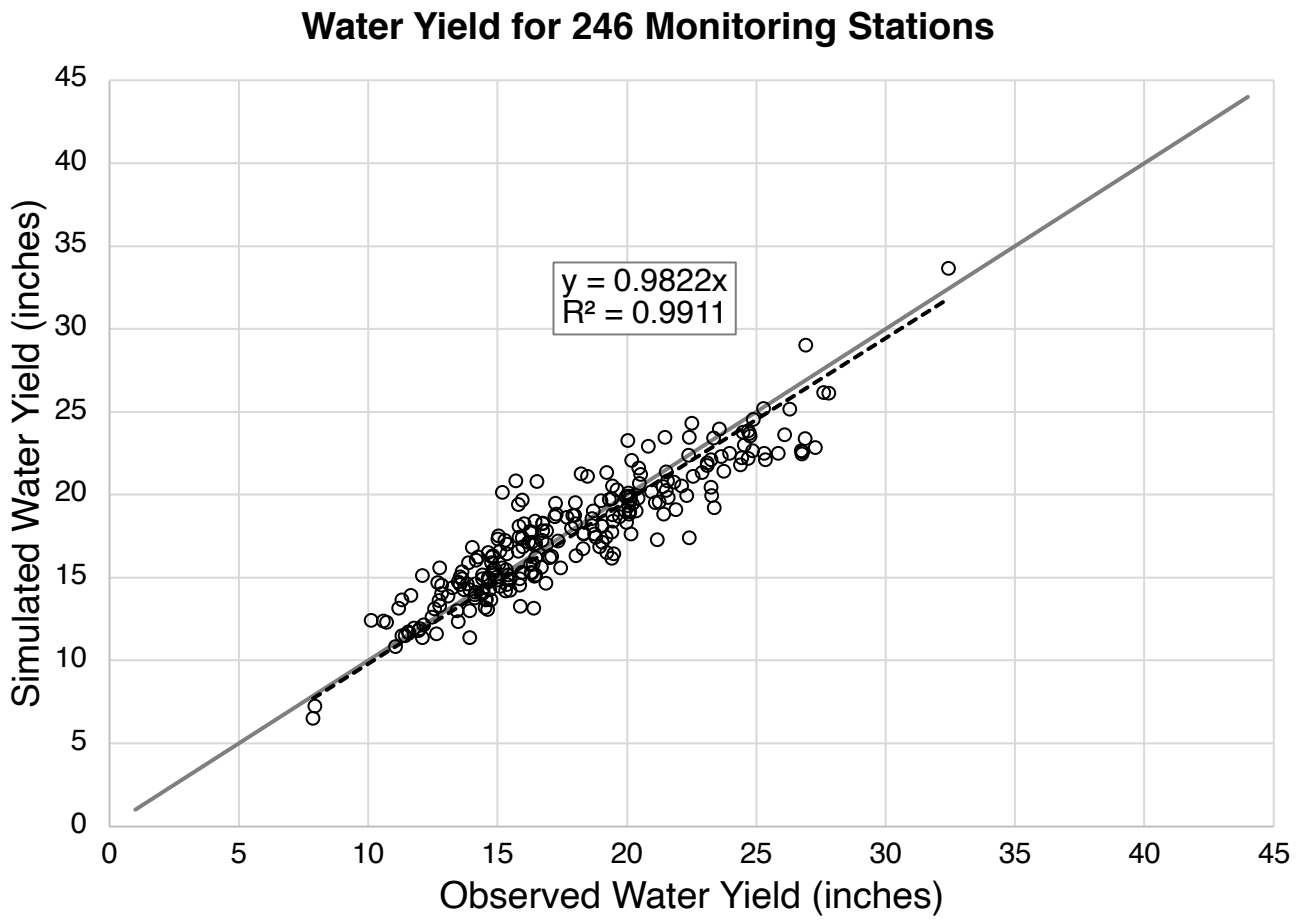


$$Q = \sum_{\substack{upstream \\ geography}} Precipitation - PET \times f_{LU} \sout{\times Fn(watershed\ properties)}$$

$$e.g., Fn(watershed\ properties) = a + f_w \times Wetness + f_s \times Slope$$

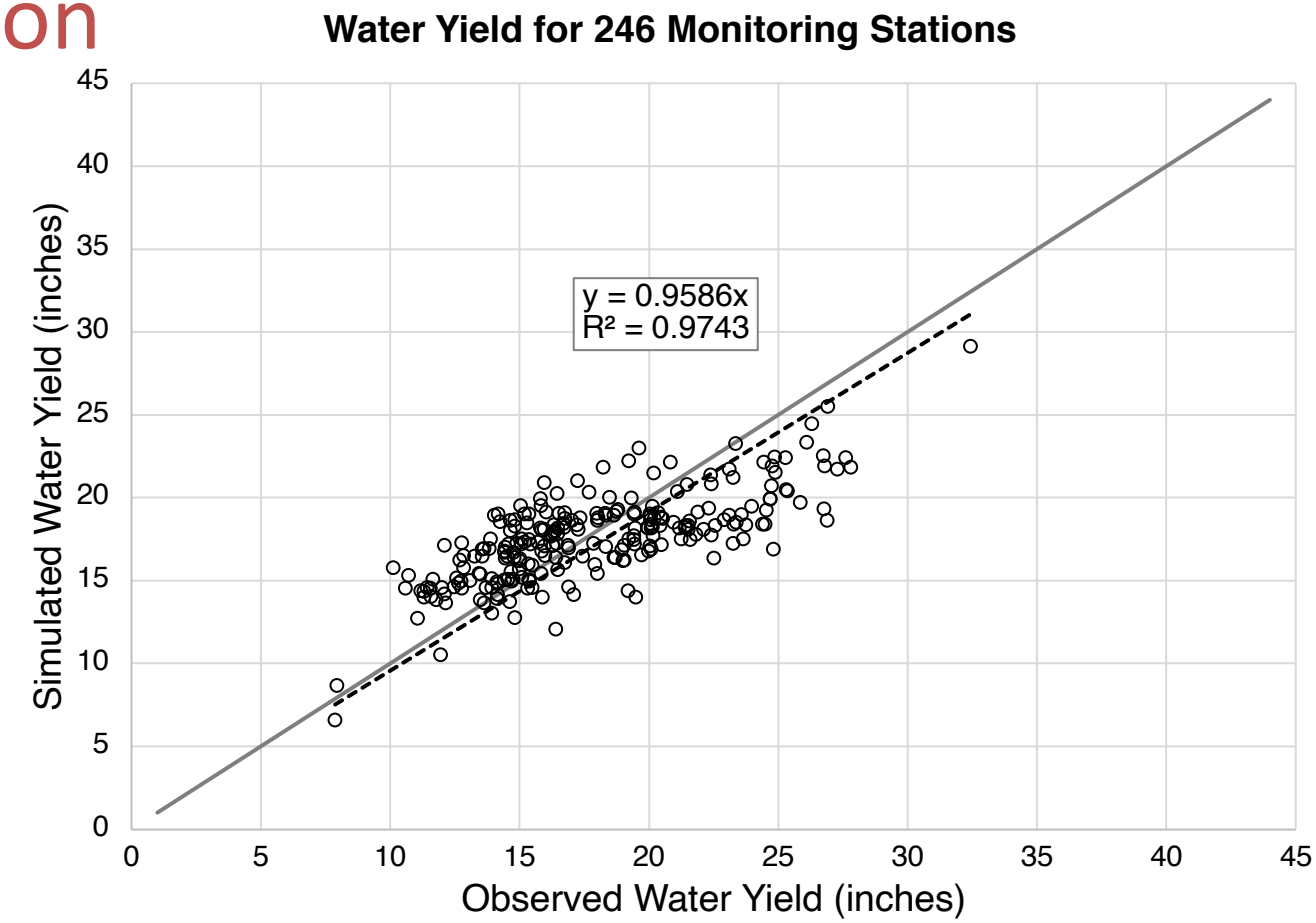
Results (CalCAST Hydrology – an initial, simplified prototype)

Phase 6 as a reference



Results (CalCAST Hydrology – an initial, simplified prototype)

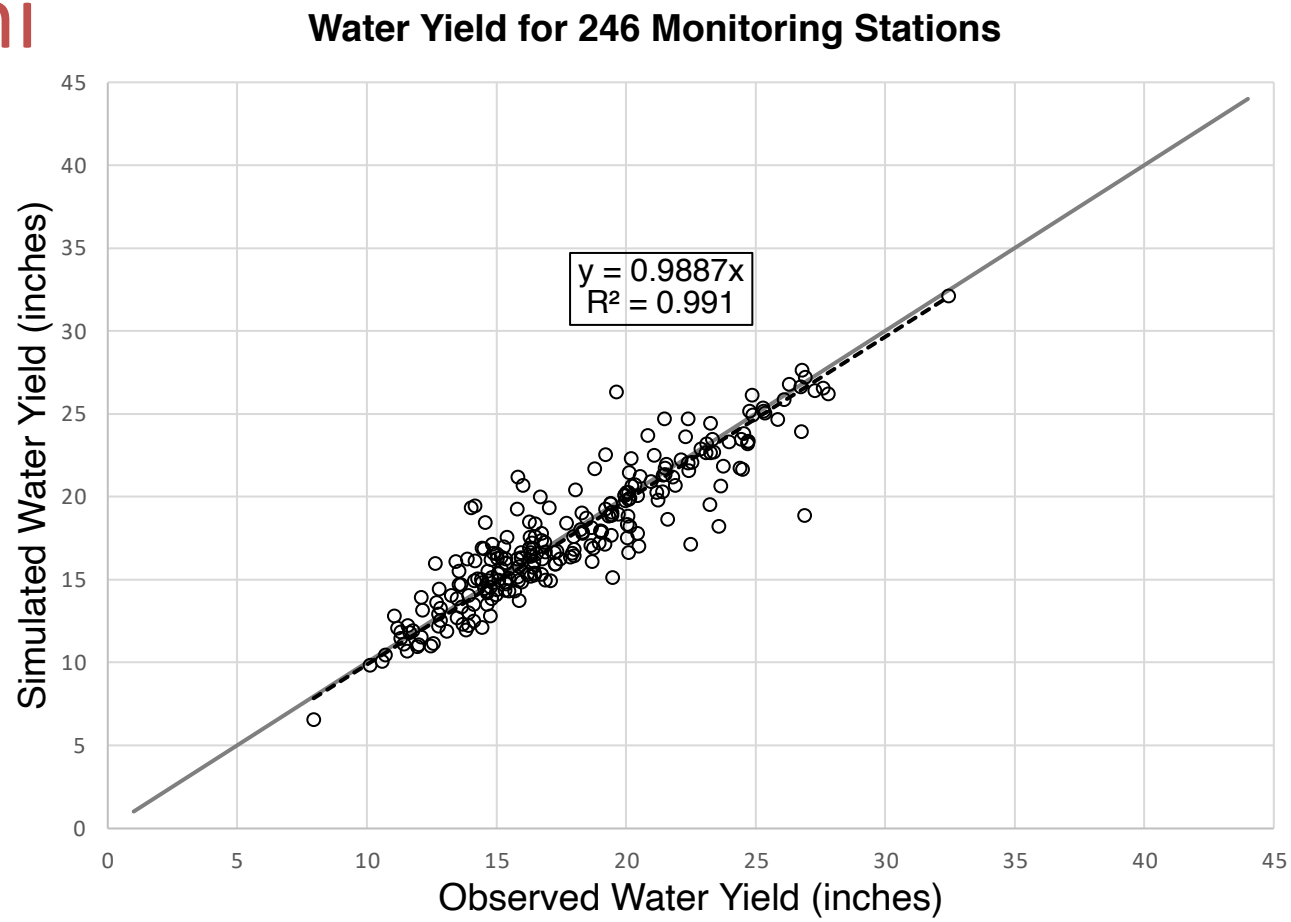
After Calibration



On the graph paper but it needed refinements for meeting the *as good or better* criterion.

Results (CalCAST Hydrology – refined prototype)

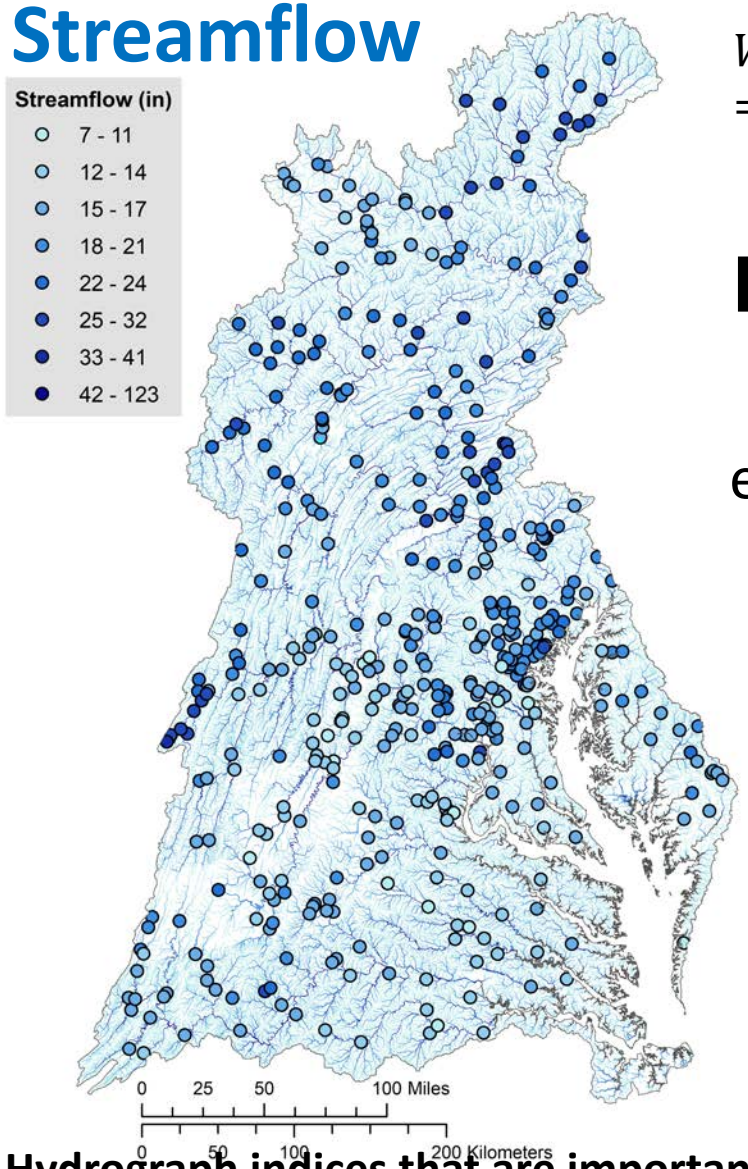
Isabella Bertani



[1] It includes refinements on various aspects including the incorporation of emergent watershed properties in the model.
[2] CalCAST is making reasonable predictions with global calibration rather than local calibration applied in Phase 6.

CalCAST Hydrology Model Development

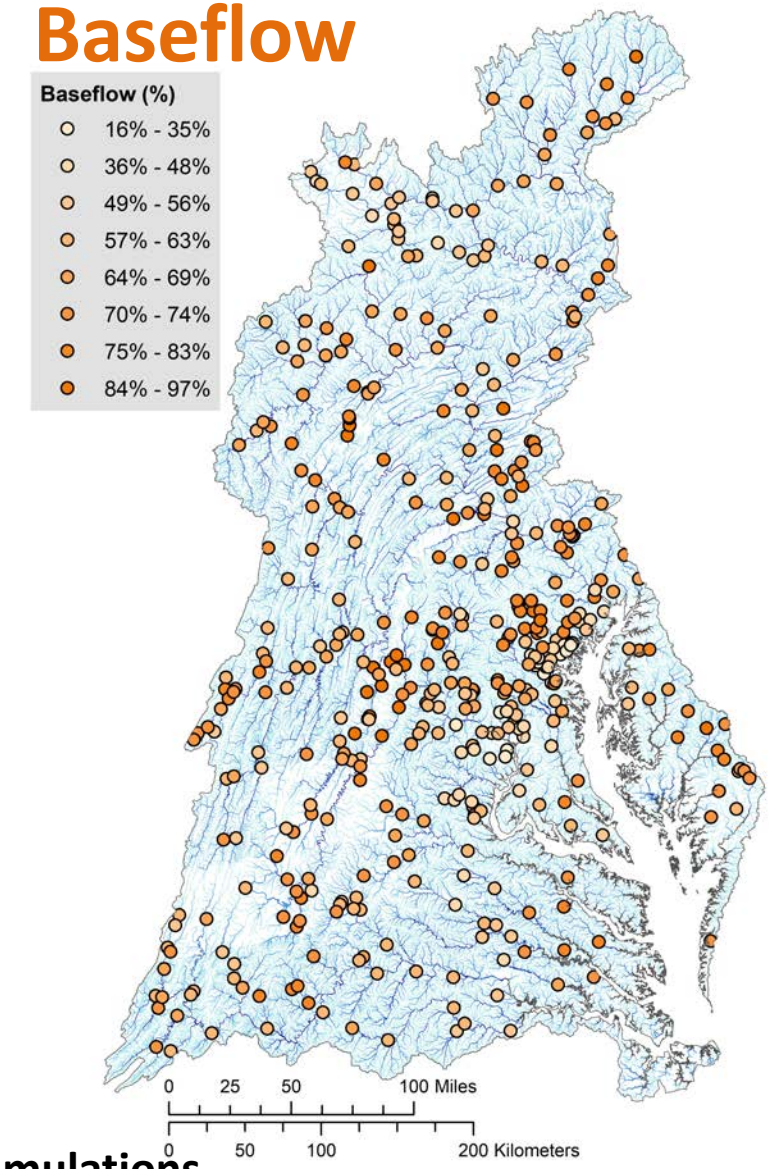
Streamflow



$$Watershed\ Response = Fn(Inputs, Watershed\ Properties)$$

This framework can be extended to other hydrology endpoints[1], e.g., baseflow response, peakiness etc.

Baseflow



[1] Hydrograph indices that are important for hydrology, sediment, and nutrient simulations.

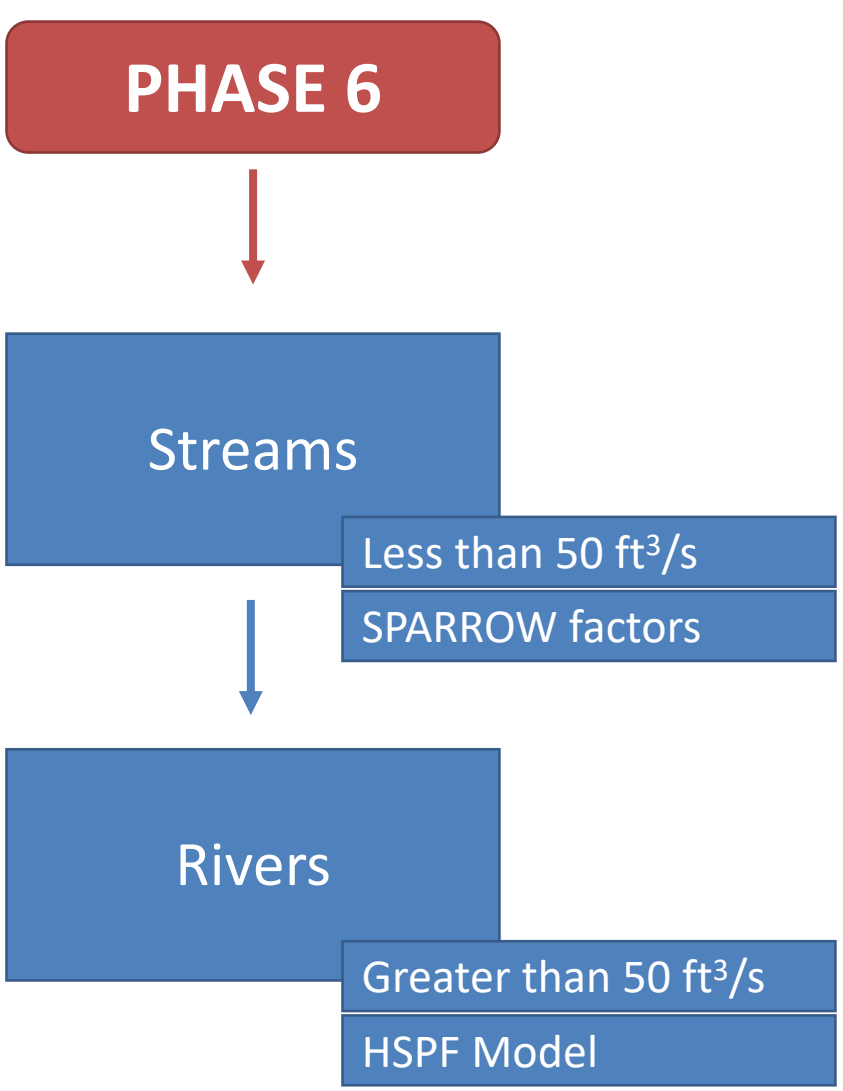
2. Dynamic Model (DM) of Hydrology

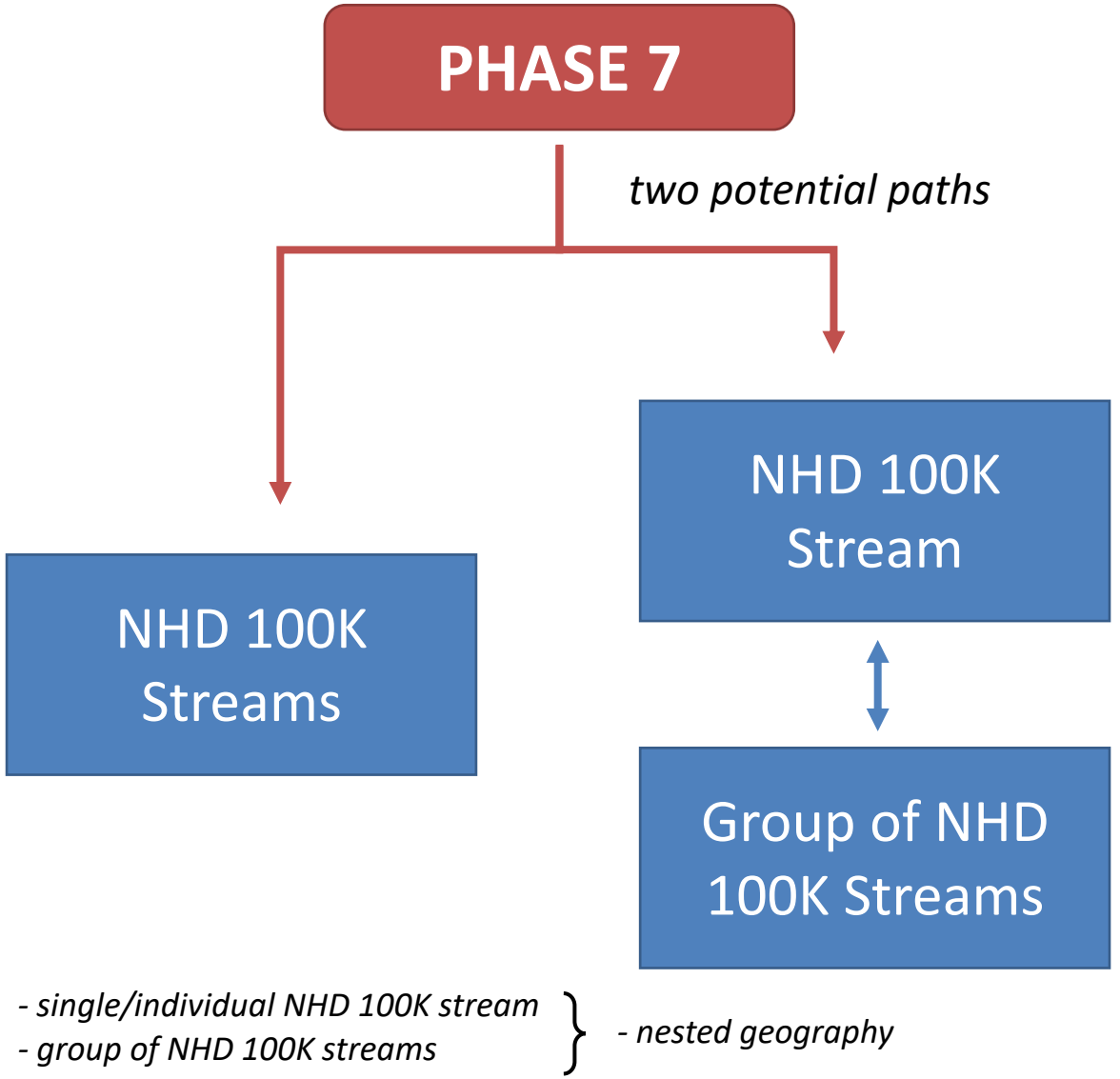
(an initial, operational prototype of NHD-100K scale simulation)

Prior presentations

[1] July 2021 – https://www.chesapeakebay.net/channel_files/43361/20210706_bhatt_phase_7_wsm_development_dynamic_hydrology.pdf

River Segmentation





River Simulation

HSPF

Complex model and requires estimation of several model parameters.

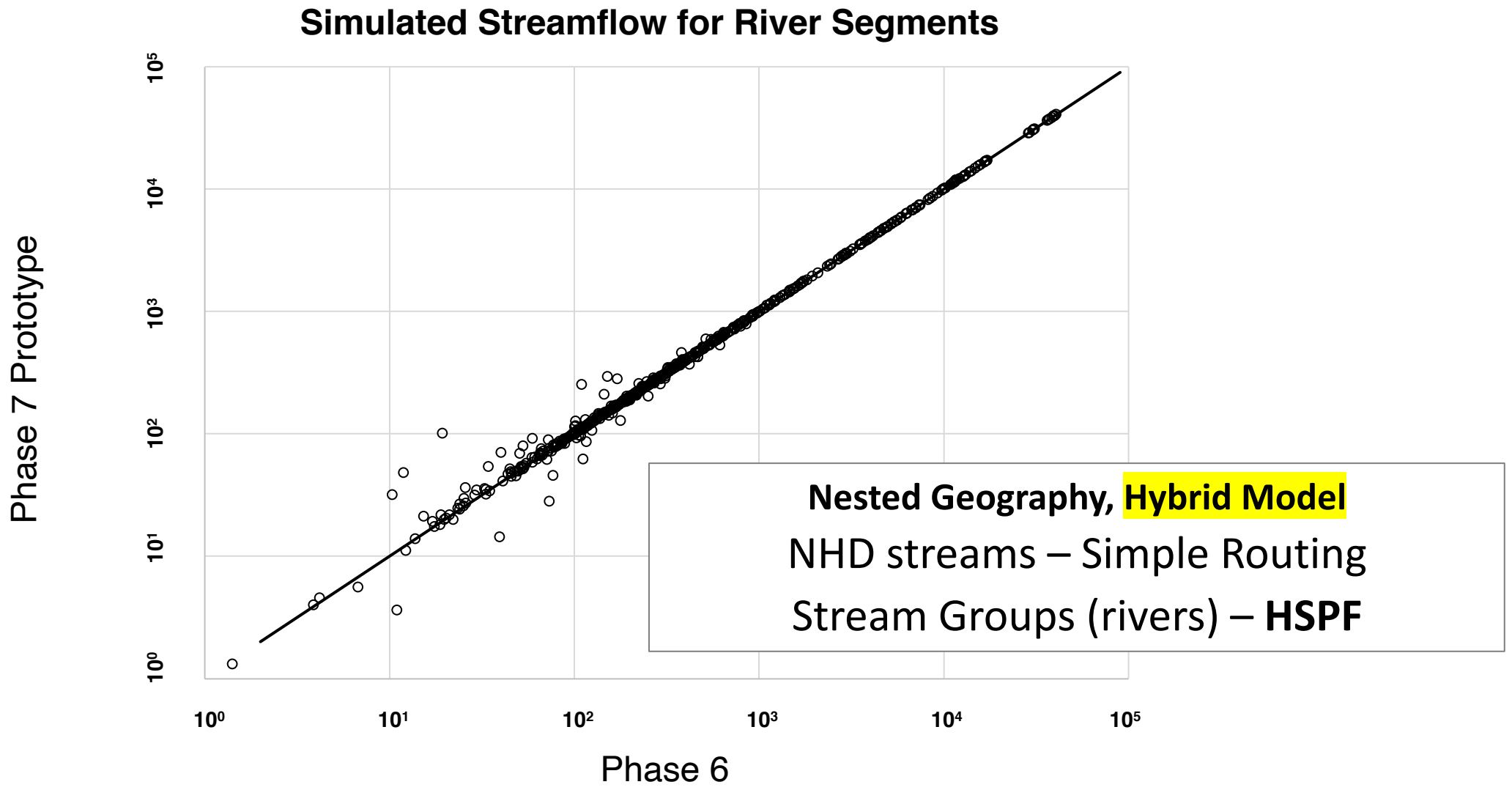
Simple Routing

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

Hybrid

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

Results (DM Hydrology – an initial, operational prototype)



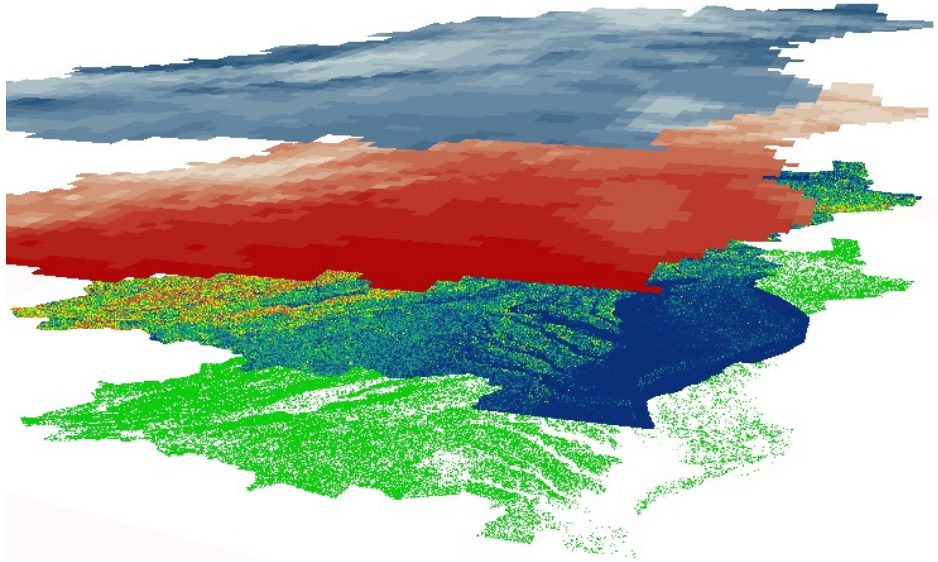
It showed that the model is well set up and HSPF river simulation (vs. Simple Routing) did better for the reservoirs.

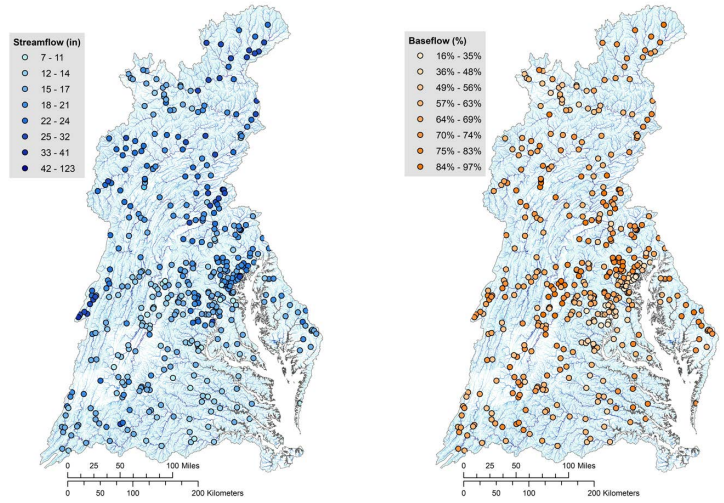
3. Prototype for CalCAST-DM Hydrology Linkage

CalCAST → DM
vs.
Phase 6 → DM

Spatial Data: Land use, input datasets, and other watershed characteristics

Indices of observed streamflow





CalCAST Hydrology

Average annual

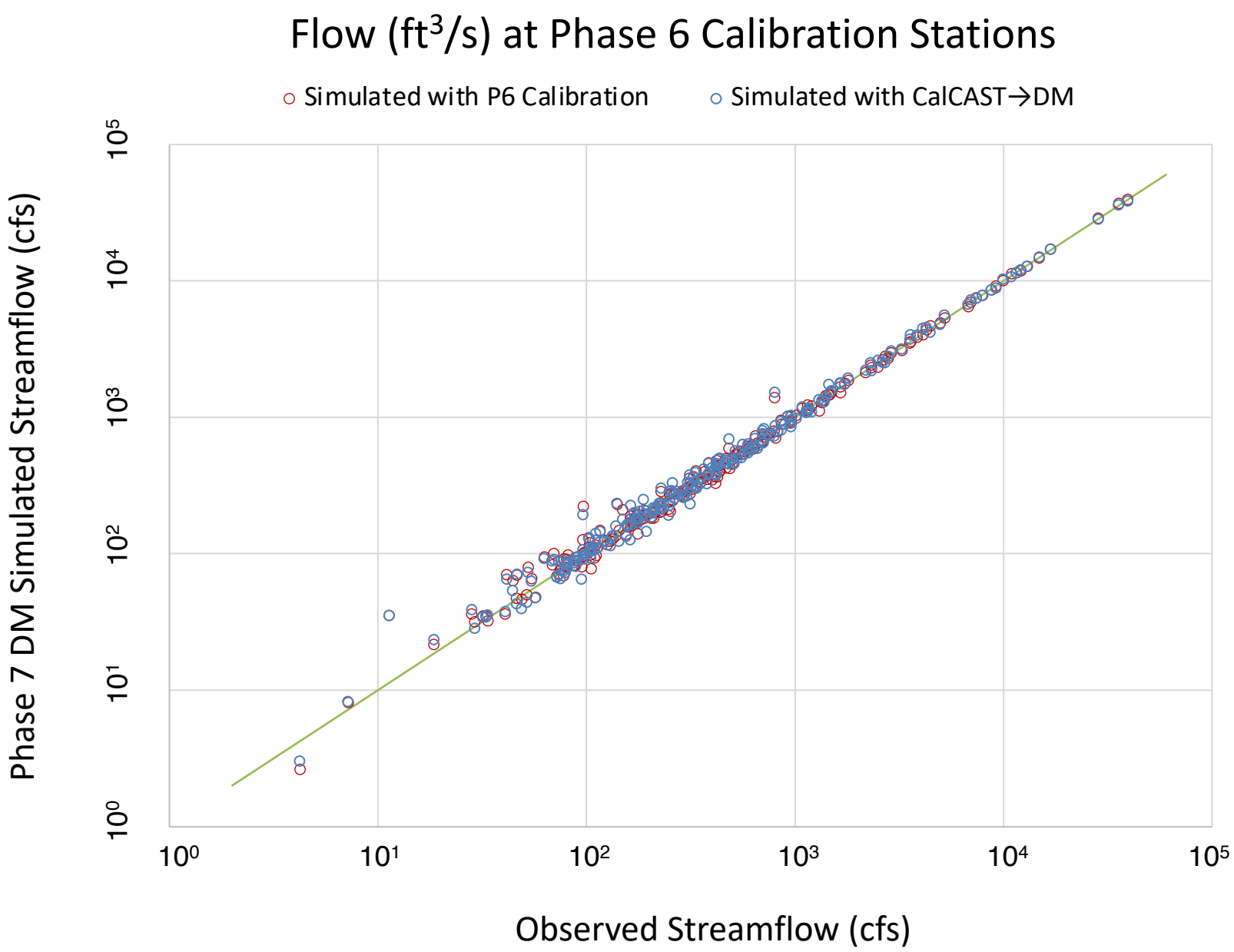
CalCAST→DM linkage

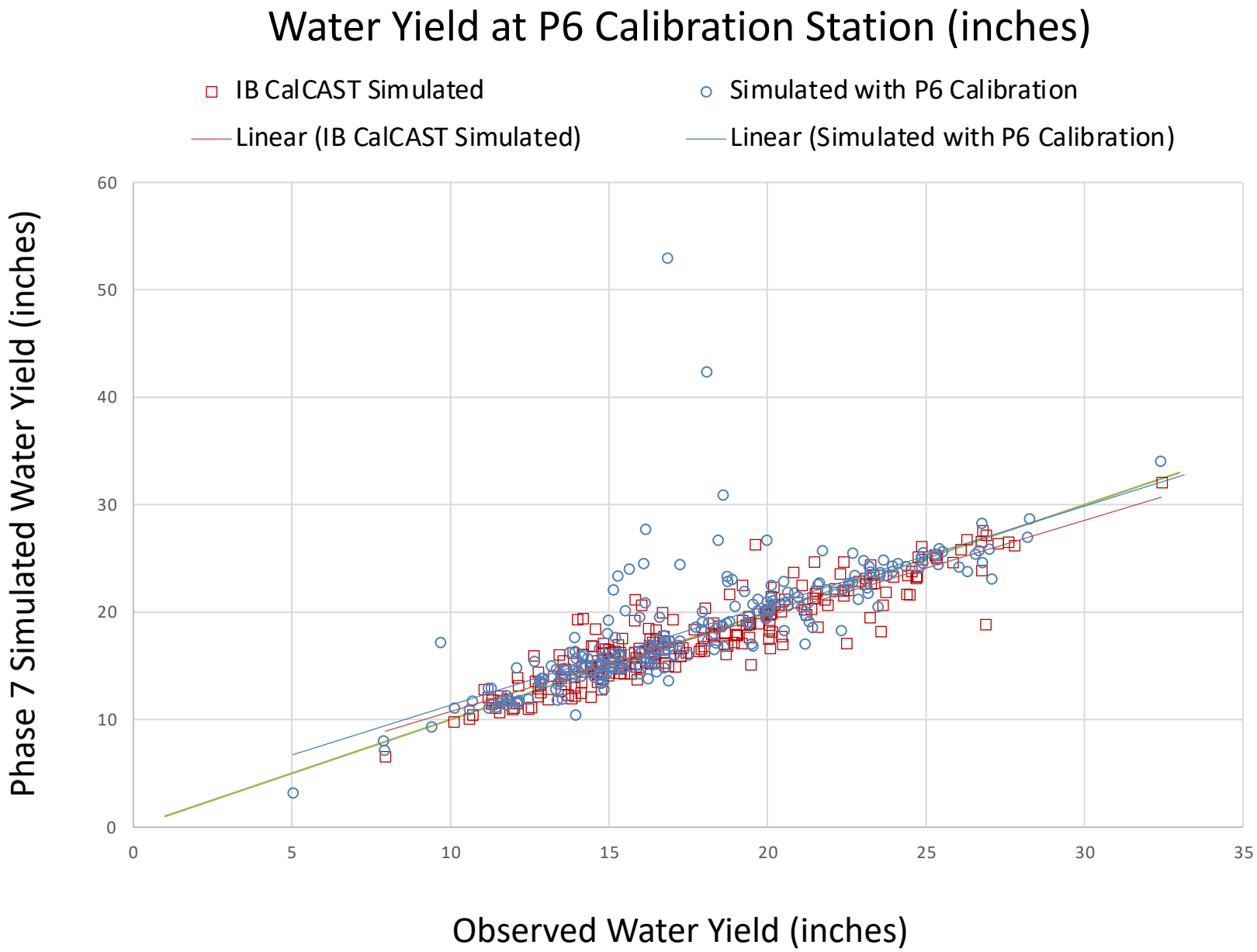
Dynamic Hydrology Model

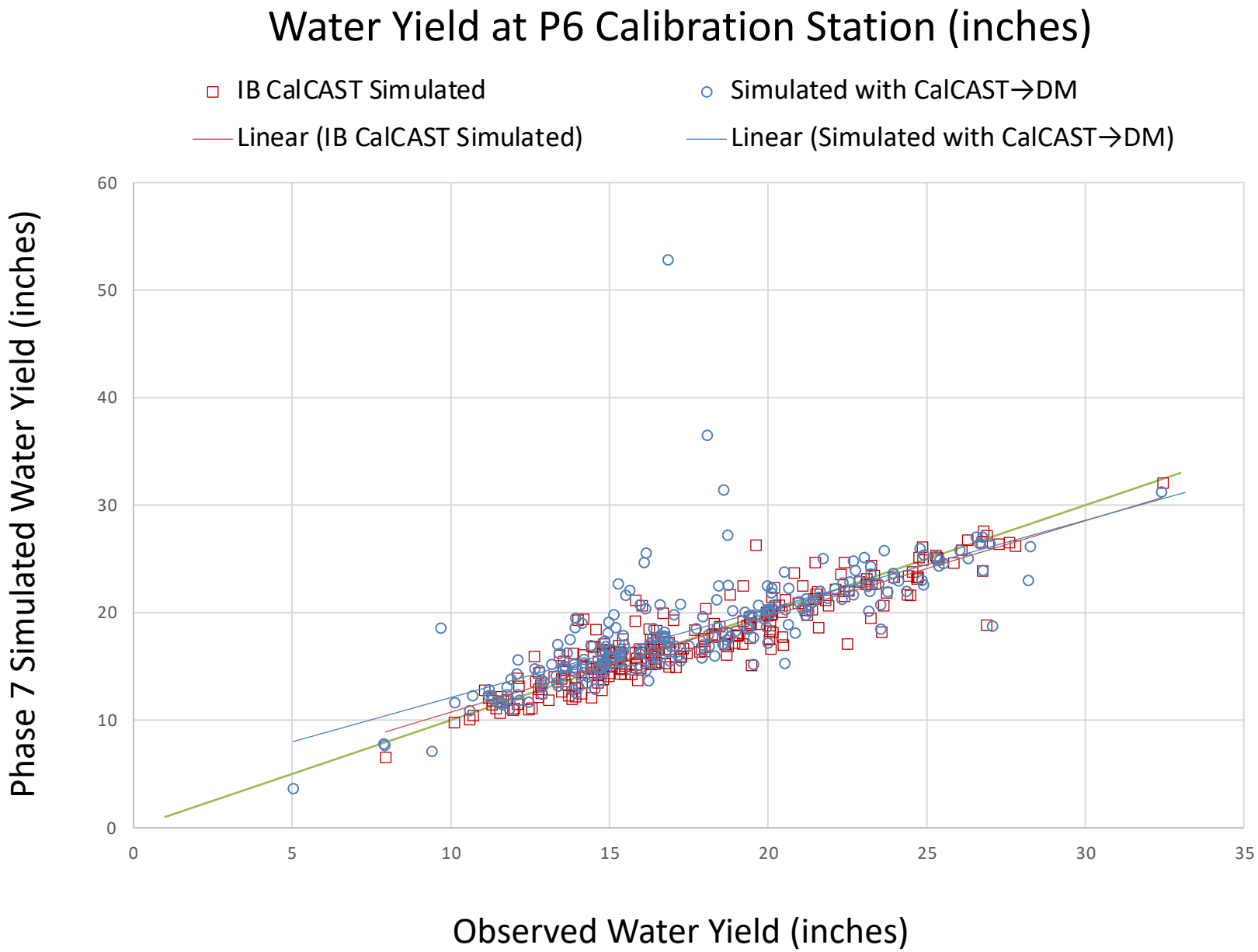
Hourly (event scale) simulation

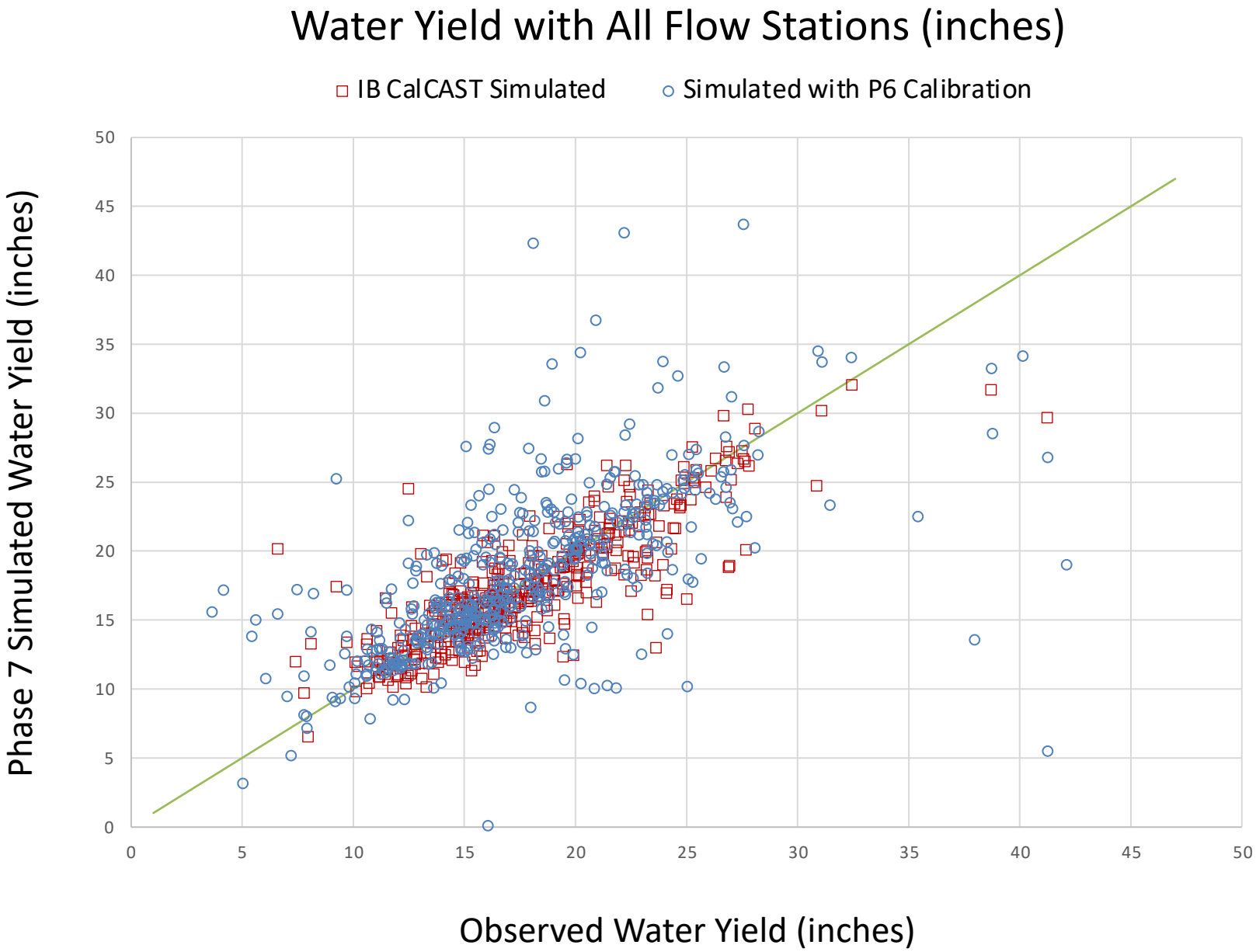
- Some of the details for the linkage are yet to be determined but significant changes to the hydrology calibration method may be needed.
- Currently annual correction factors are being applied in the [1]CalCAST→DM hydrology linkage prototype.

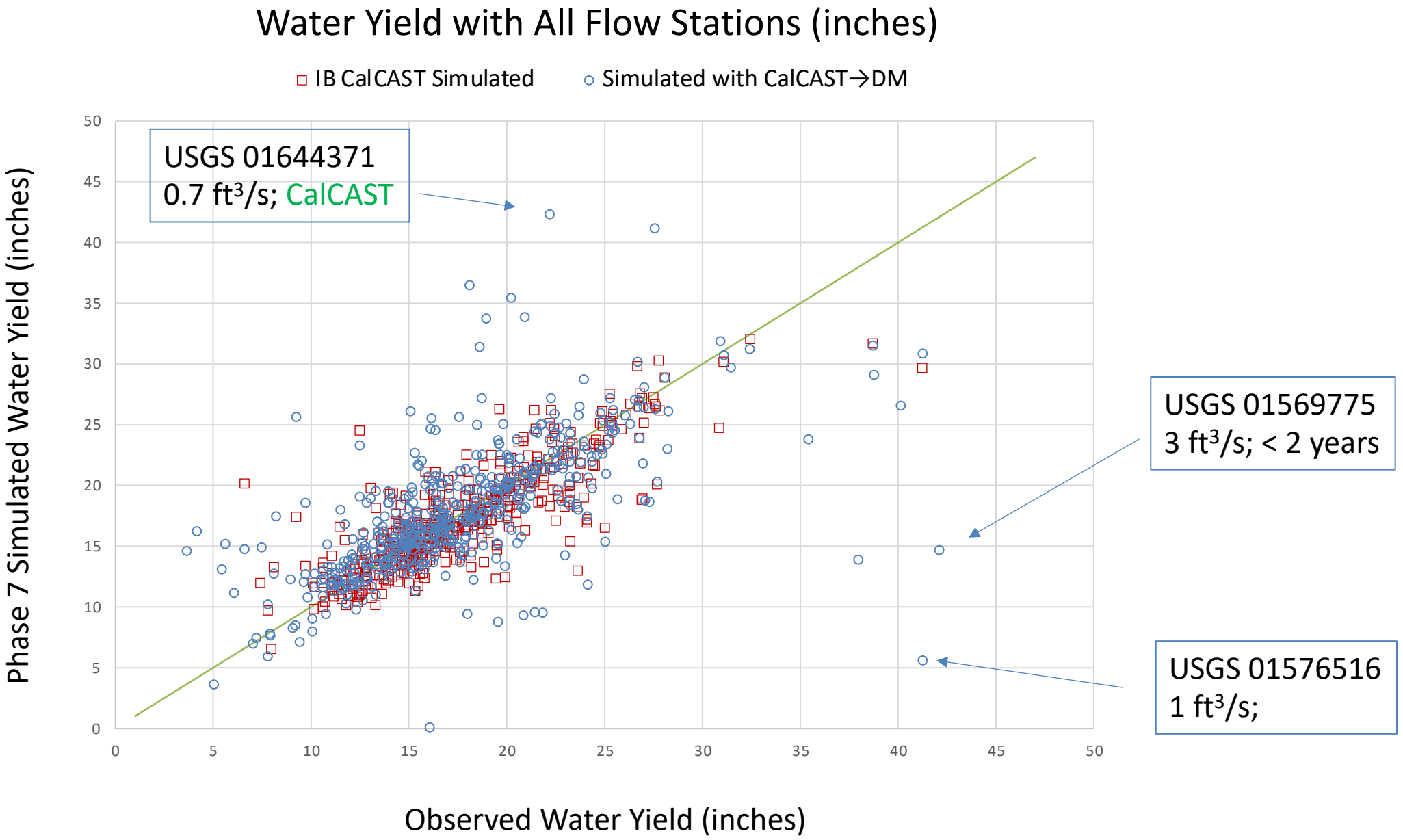
[1] Using CalCAST Hydrology (late September 2021) from Isabella Bertani


Flow (ft3/s) at Phase 6 Calibration Stations
Simulated with P6 Calibration
Simulated with CalCAST→DM
Phase 7 DM Simulated Streamflow (cfs)
Observed Streamflow (cfs)
10^0
10^1
10^2
10^3
10^4
10^5


Water Yield at P6 Calibration Station (inches)
IB CalCAST Simulated
Simulated with P6 Calibration
Linear (IB CalCAST Simulated)
Linear (Simulated with P6 Calibration)
Phase 7 Simulated Water Yield (inches)
Observed Water Yield (inches)
0
10
20
30
40
50
60
0
5
10
15
20
25
30
35

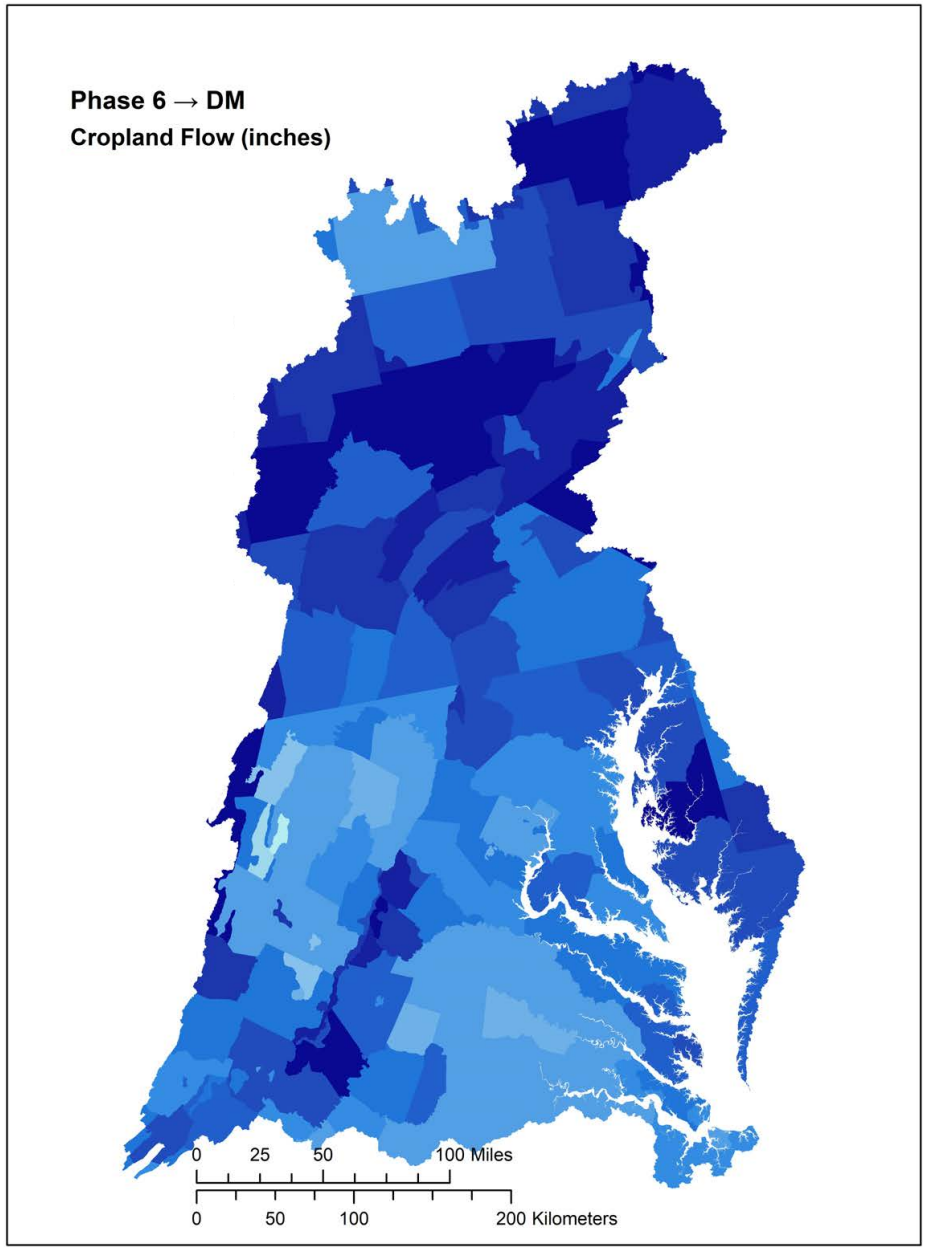

Water Yield at P6 Calibration Station (inches)
IB CalCAST Simulated
Simulated with CalCAST→DM
Linear (IB CalCAST Simulated)
Linear (Simulated with CalCAST→DM)
Phase 7 Simulated Water Yield (inches)
Observed Water Yield (inches)
0
10
20
30
40
50
60
0
5
10
15
20
25
30
35


Water Yield with All Flow Stations (inches)
IB CalCAST Simulated
Simulated with P6 Calibration
Phase 7 Simulated Water Yield (inches)
Observed Water Yield (inches)
0
5
10
15
20
25
30
35
40
45
50

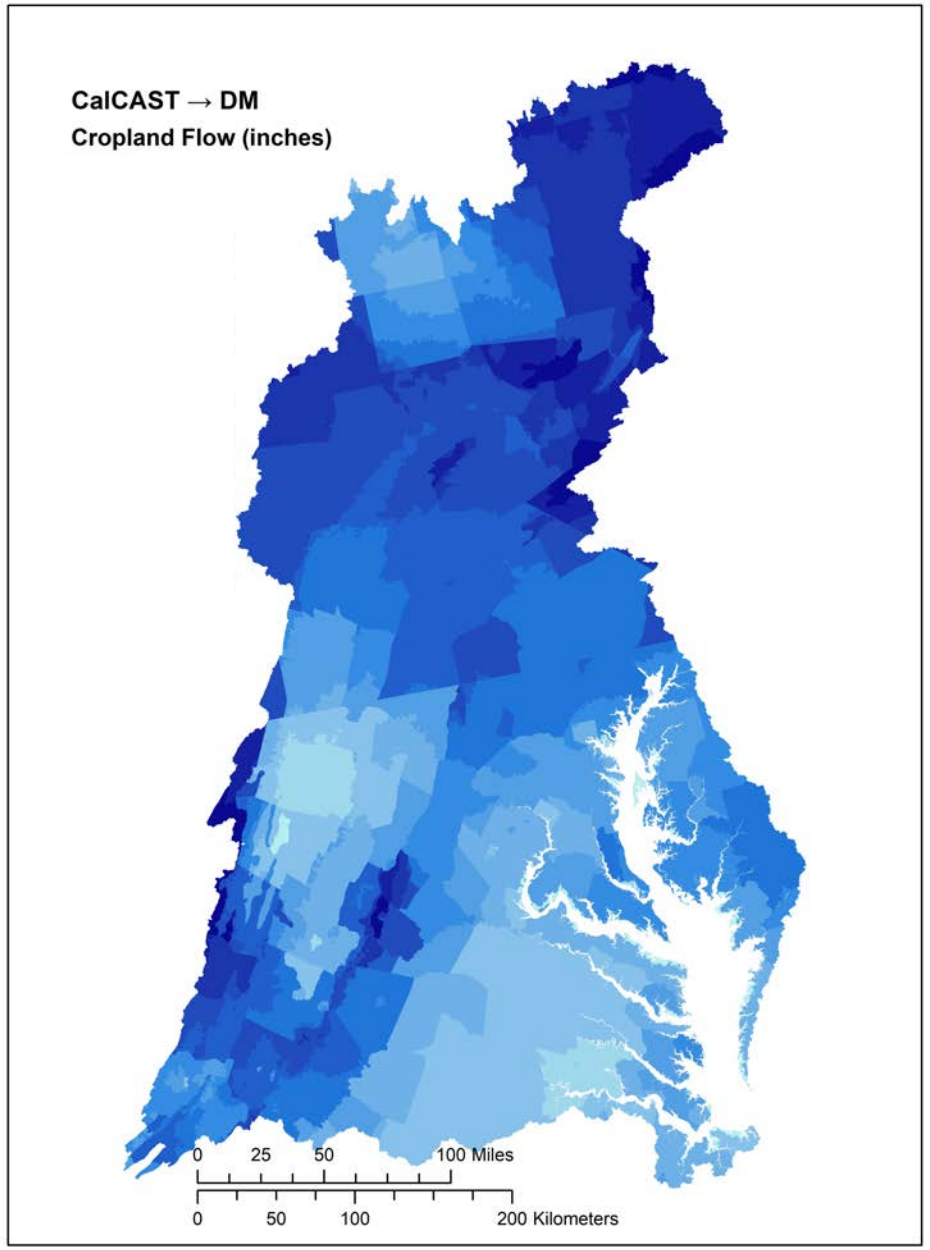

Water Yield with All Flow Stations (inches)
IB CalCAST Simulated
Simulated with CalCAST→DM
USGS 01644371
0.7 ft³/s; CalCAST
USGS 01569775
3 ft³/s; < 2 years
USGS 01576516
1 ft³/s;
Phase 7 Simulated Water Yield (inches)
Observed Water Yield (inches)
0
5
10
15
20
25
30
35
40
45
50

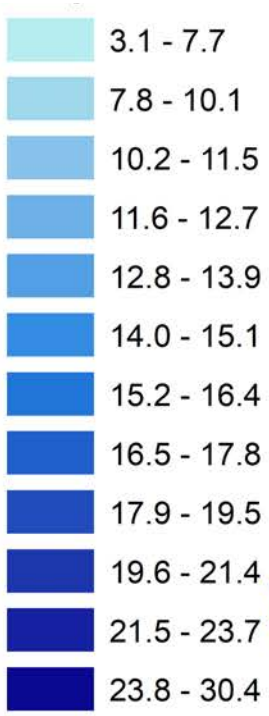
Cropland

NHD Scale DM informed by Phase 6



NHD Scale DM informed by CalCAST

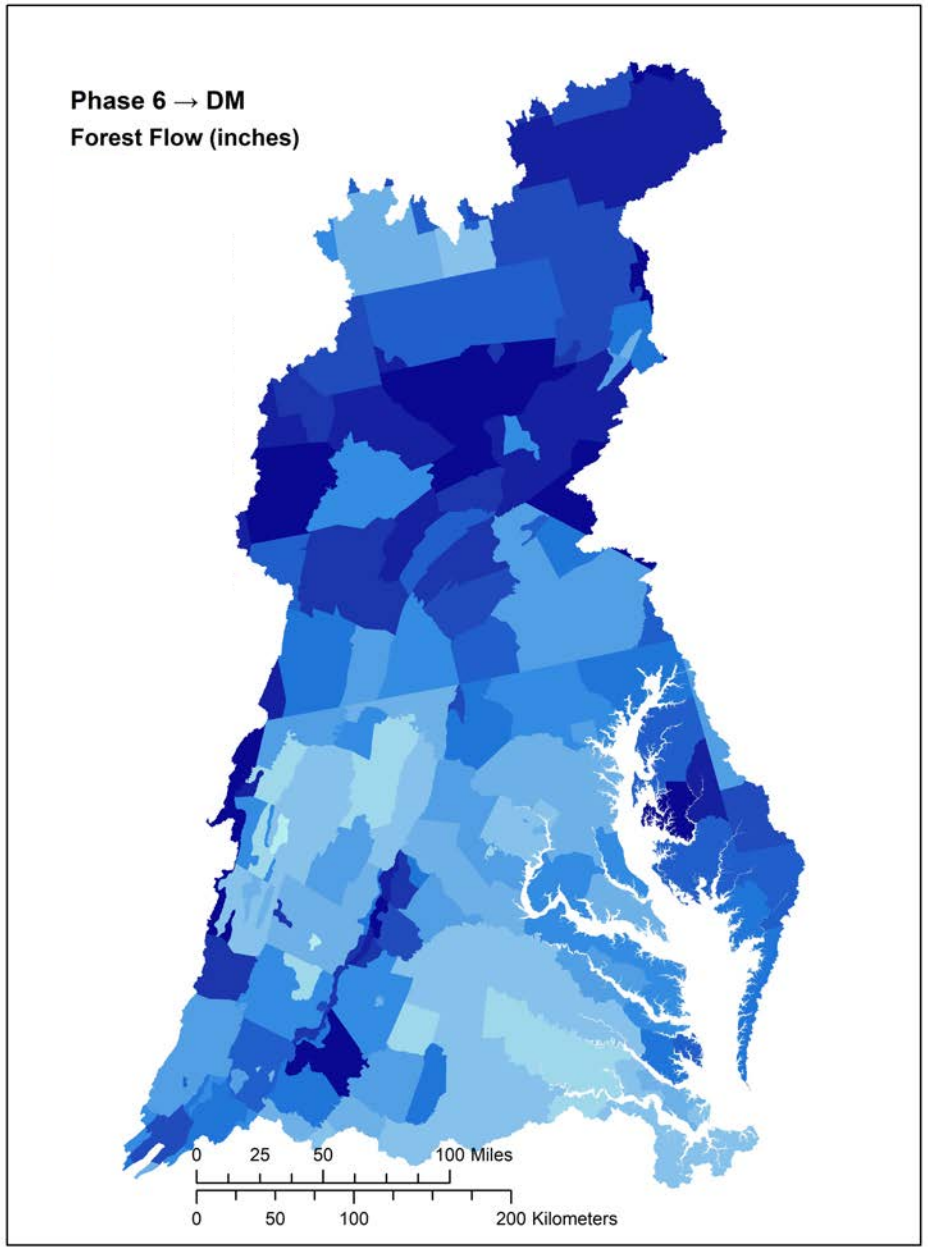




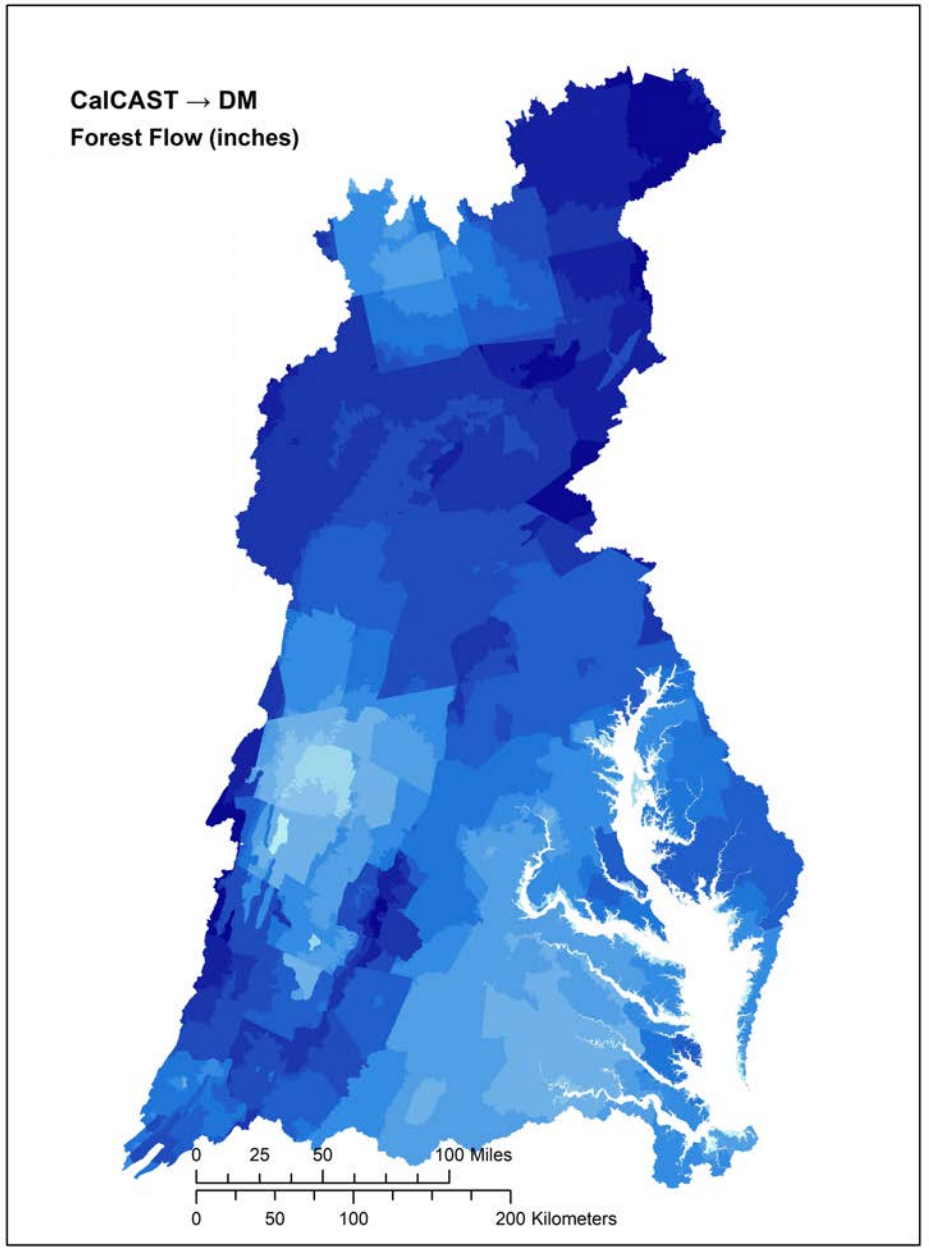
DM informed by CalCAST provide sub-county spatial variability in runoff (globally calibrated, Fn of watershed properties)

Forest

NHD Scale DM informed by Phase 6

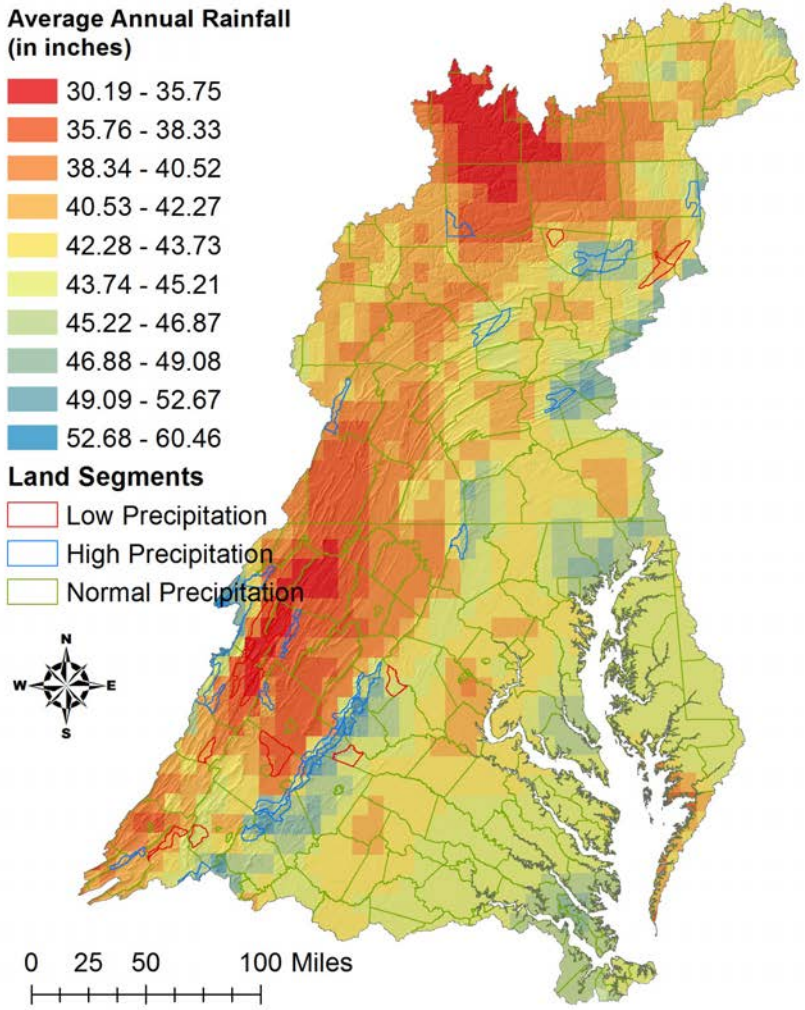


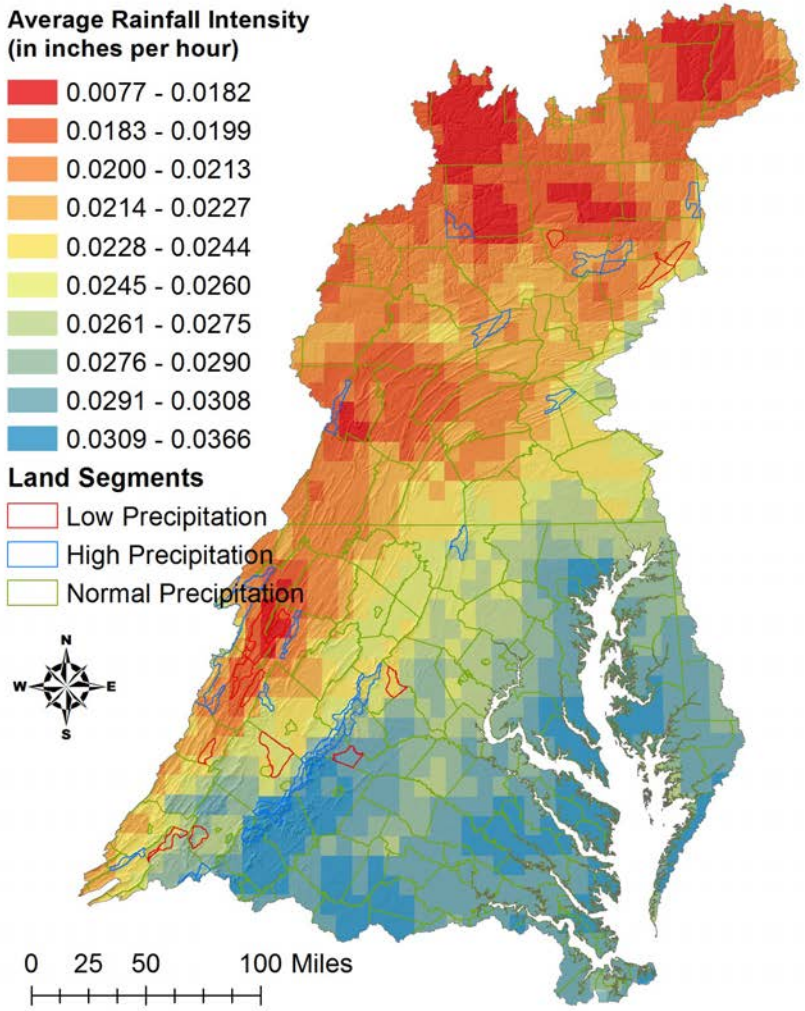
NHD Scale DM informed by CalCAST

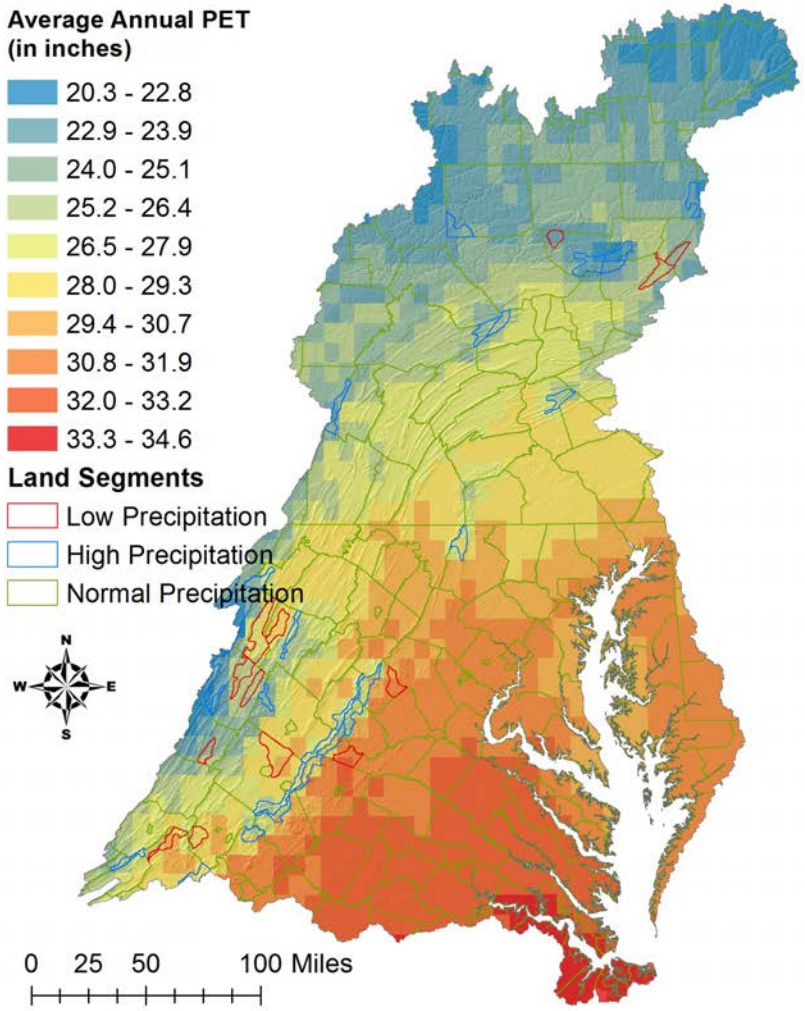


DM informed by CalCAST provide variability in runoff between land uses (e.g., forest vs. cropland on the previous slide)

- Spatial variability in rainfall and meteorology are not fully included and that is likely the reason for county boundaries showing up in the maps of hydrologic responses







Summary

- CalCAST→DM hydrology linkage holds potential for improving model prediction skill for land use and climate change scenarios.
- CalCAST is making reasonable predictions with global calibration rather than local calibration.
- The DM prototype has been set up and the analyzed results are looking good.

Next Steps / Issues

- Extend the simulation period up to 2020 (+6 years)
- Additional analyses of CalCAST→DM prototype to understand how it impacted other hydrograph indices
- Refine and expand CalCAST model for additional hydrologic indices
- Continue to further investigate CalCAST→DM linkage, refine data processing tools, and strategies for refining the linkage