Unwrapping the discharge algorithm intercomparison study

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Hydraulic models

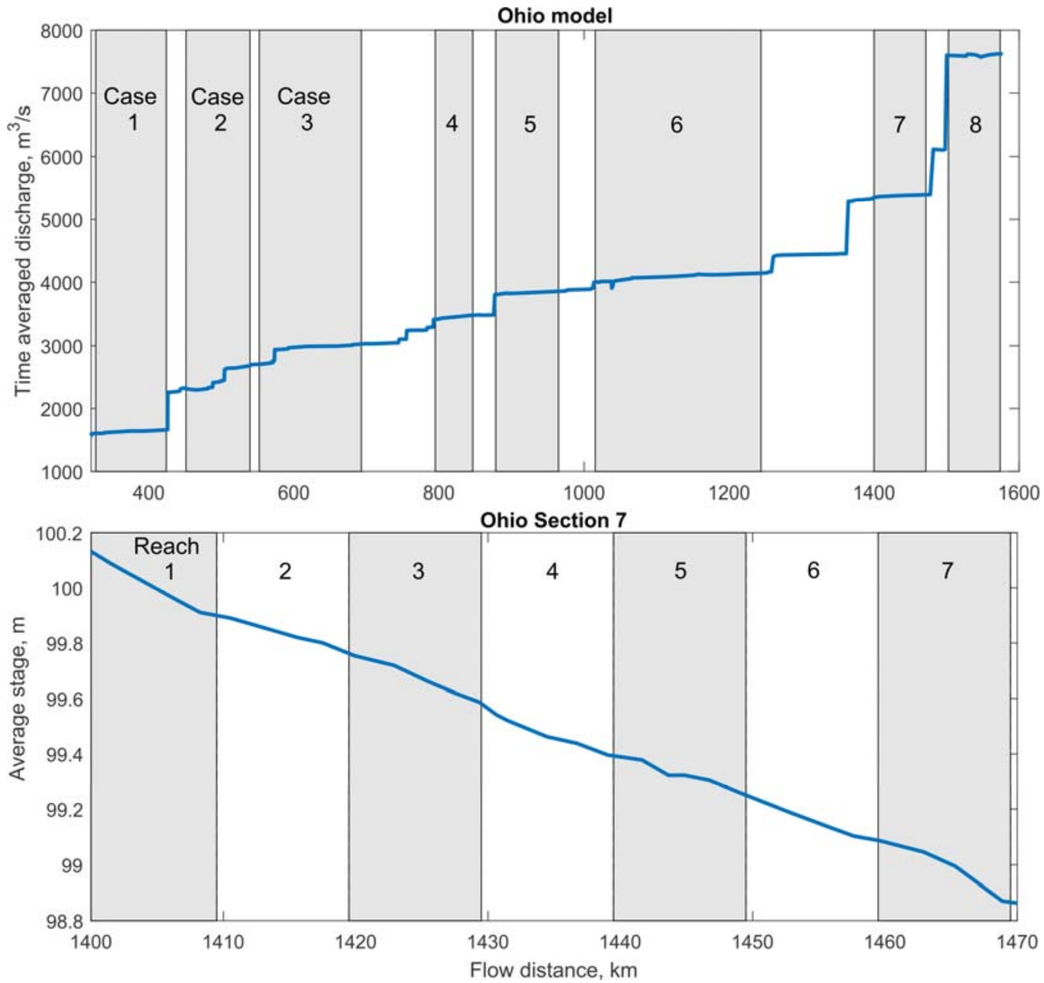
Model	Mass conserved cases
Ganges-Brahmaputra-Meghna Basin	5 “mass conserved” cases
San Joaquin Basin	12 cases
Ohio River	7 cases
Iowa River	1 case
Missouri	3 cases
Seine	2 cases
Mississippi	1 case
Olentangy	1 case

- Total number:
  - 32 cases
- Discharge range:
  - $1 m^3/s$ to $80,000\ m^3/s$
- Width range
  - 26 m to 16 km
- Cases with flow reversal

Case and reach definitions

Main criteria:

- Case definition:
  - Avoid abrupt increases in discharge
  - Up to 15% changes were allowed to retain enough cross-sections
- Reach definition:
  - Select reaches with homogeneous slopes
  - At least 4 cross-sections per reach
  - At least 4 reaches per case
  - Isolate locks and dams



Phase 1 – Perfect observations, daily sampling

- Observations:
  - Stage
  - Width
  - Water surface slope
- Prior estimates:
  - Mean annual flow from WBMsed (Qwbm)

- Algorithms:
  - BAM
  - MetroMAN
  - MOMMA
  - HiVDI

Estimated discharge

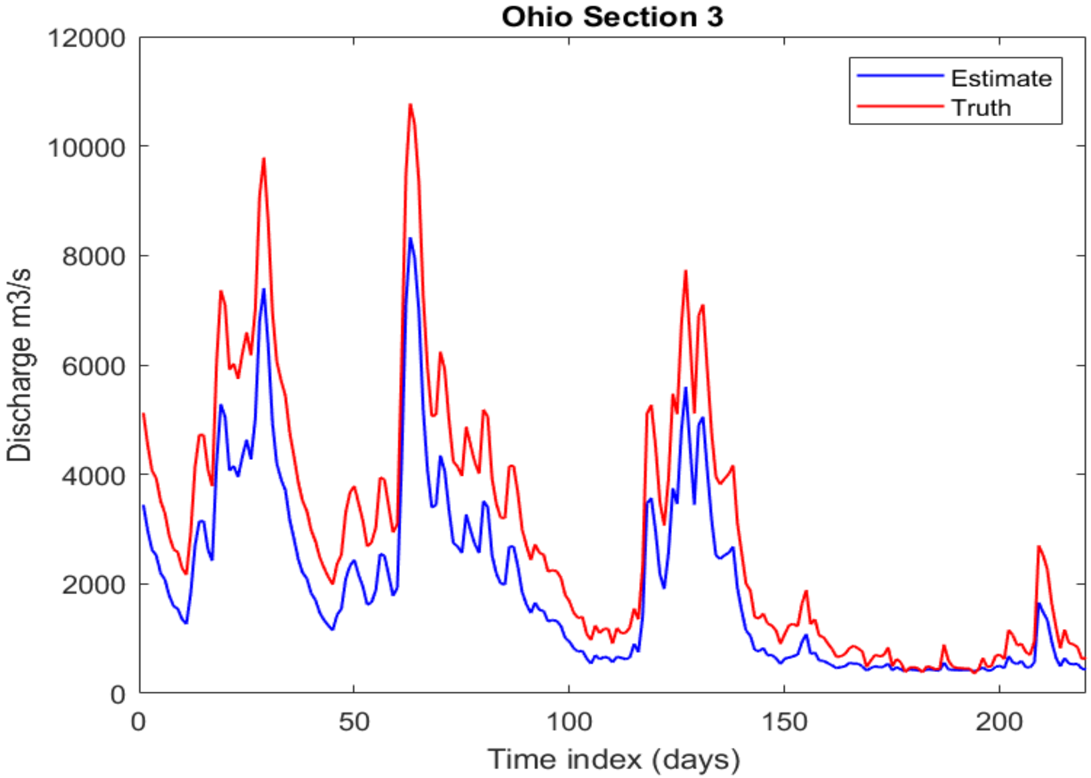
Spatial aggregation

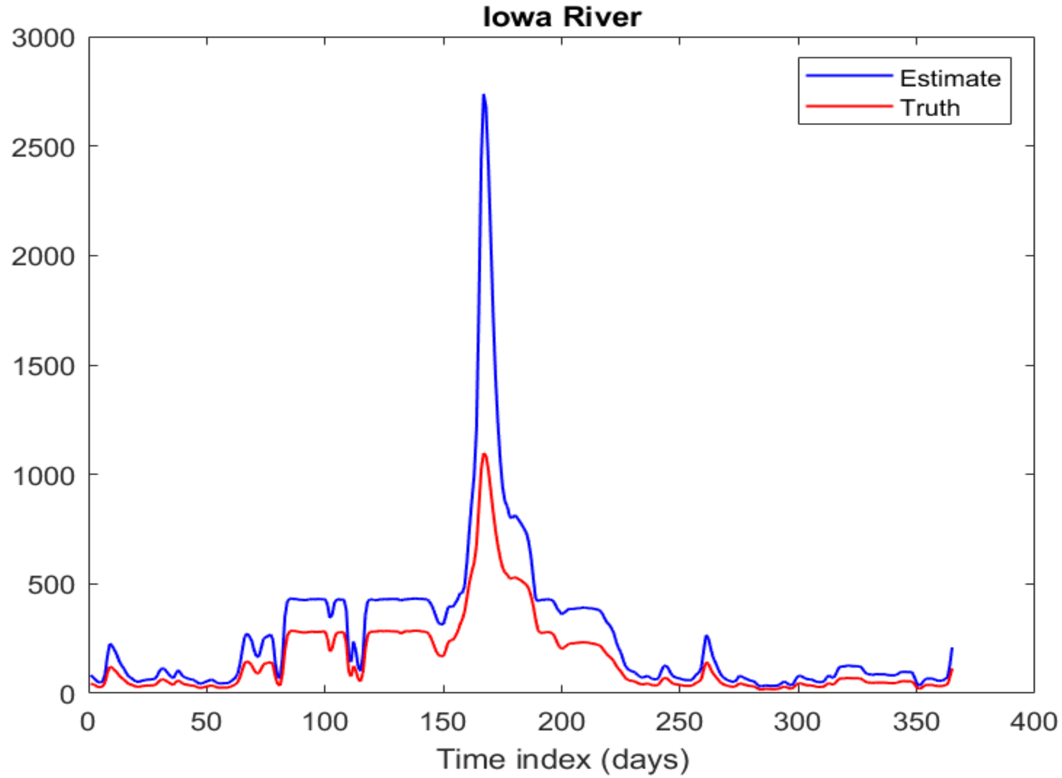
Single Q time series per case

Evaluation of model performance:

- Nash-Sutcliffe Efficiency
- Normalized RMSE

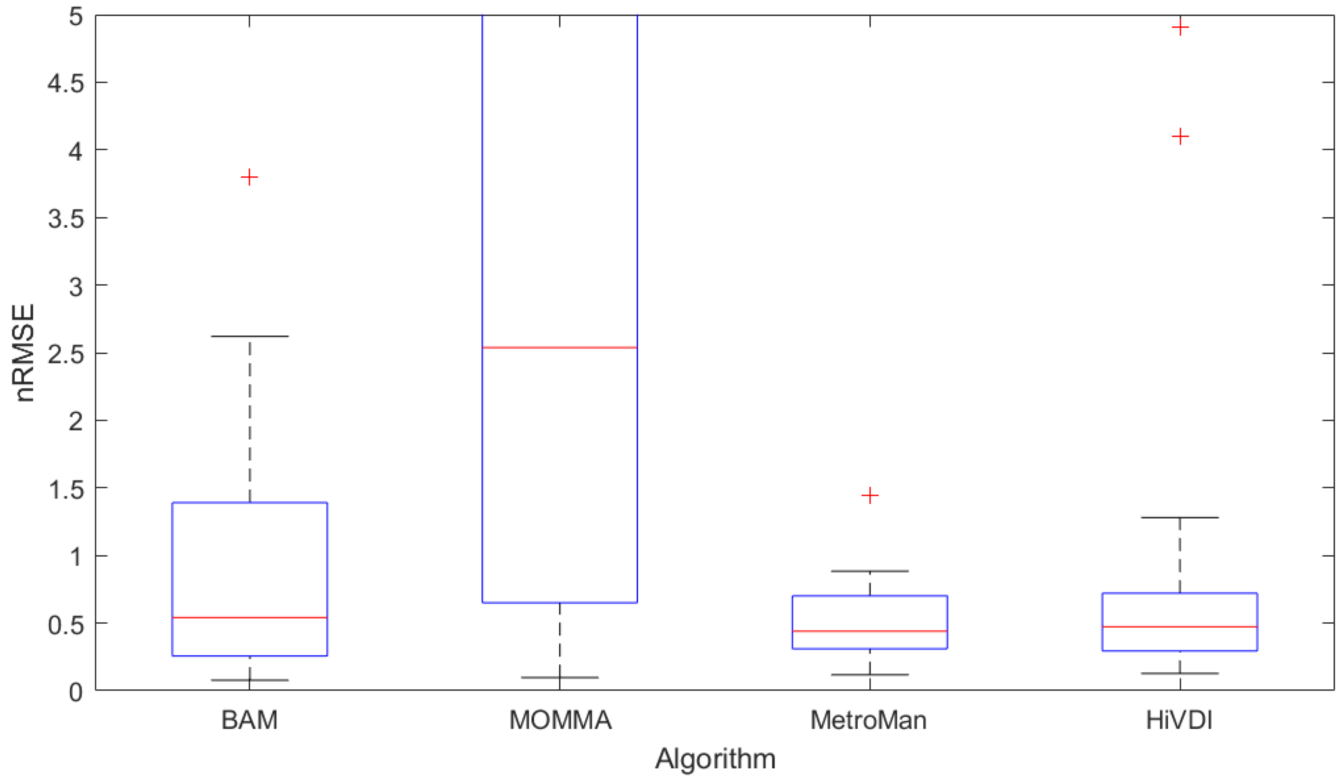
Phase 1 – Typical hydrographs





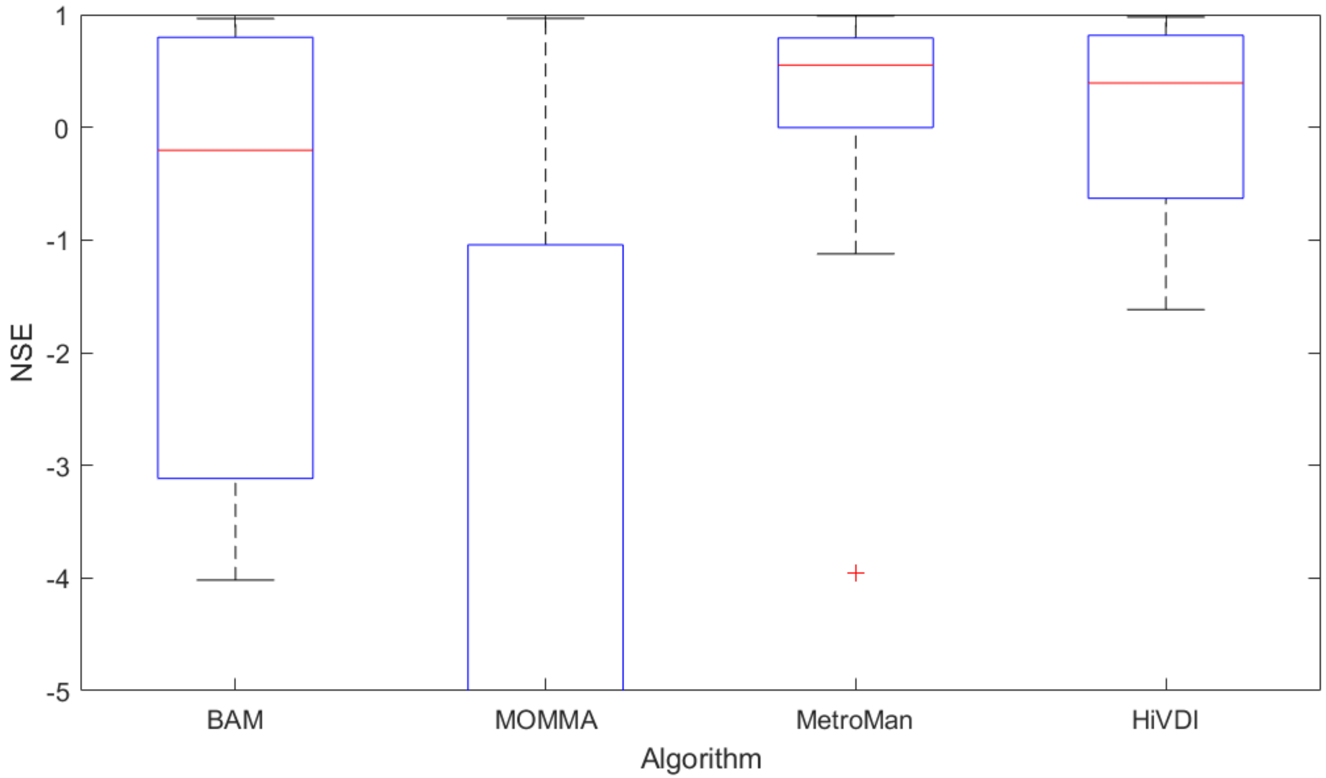
Phase 1 – Algorithm performance

- # Good cases (NRMSE ≤ 0.35)
  - BAM: 12
  - MOMMA: 5
  - MetroMan: 12
  - HiVDI: 11
- # Fair cases (0.35 ≤ NRMSE <0.45)
  - BAM: 2
  - MOMMA: 1
  - MetroMan: 4
  - HiVDI: 5
- # Poor cases (NRMSE ≥ 0.45)
  - BAM: 18
  - MOMMA: 25
  - MetroMan: 16
  - HiVDI: 16



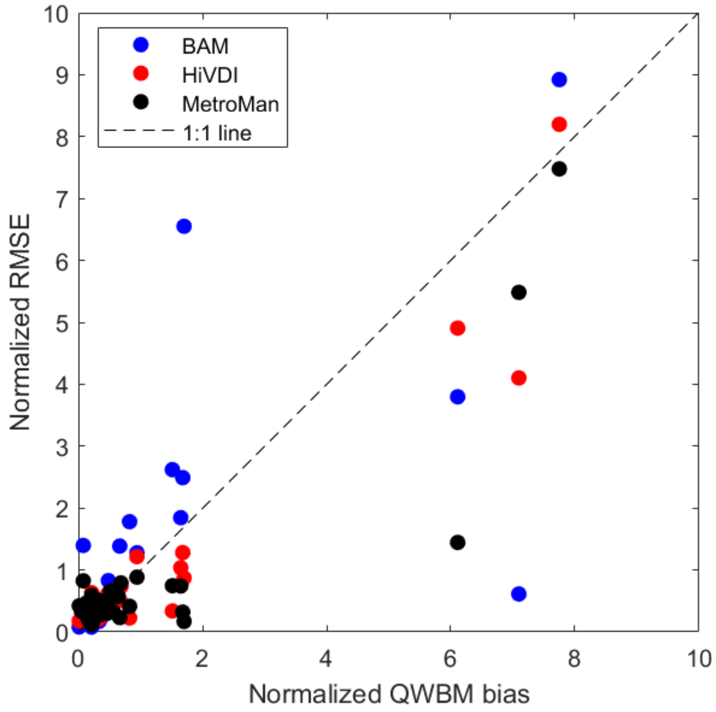
Phase 1 – Nash-Sutcliffe Efficiency

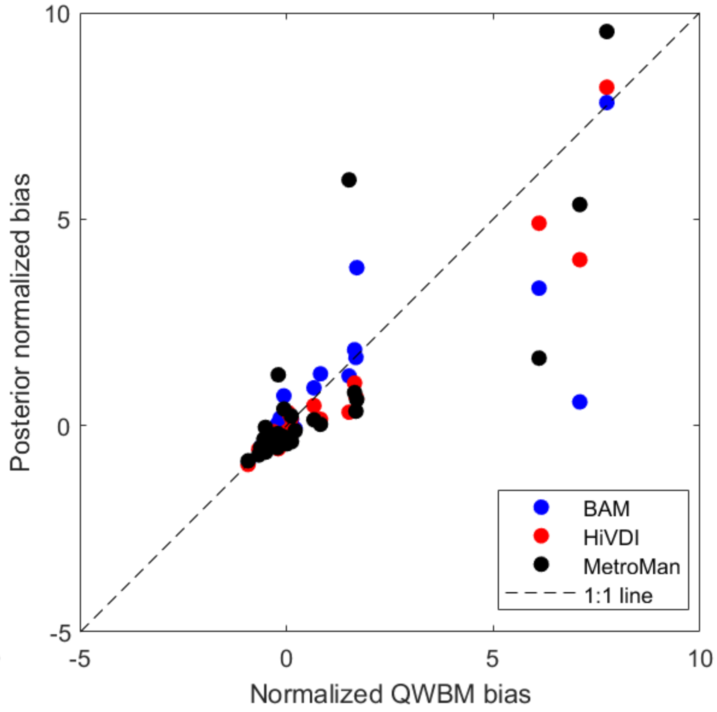
- # Good cases (NSE>0.7)
  - BAM: 12
  - MOMMA: 5
  - MetroMan: 12
  - HiVDI: 12
- # Fair cases (0.7 ≥ NSE>0.5)
  - BAM: 0
  - MOMMA: 0
  - MetroMan: 6
  - HiVDI: 2
- # Poor cases (NSE≤0.5)
  - BAM: 20
  - MOMMA: 26
  - MetroMan: 14
  - HiVDI: 18



Phase 1 – What impacts algorithm performance?

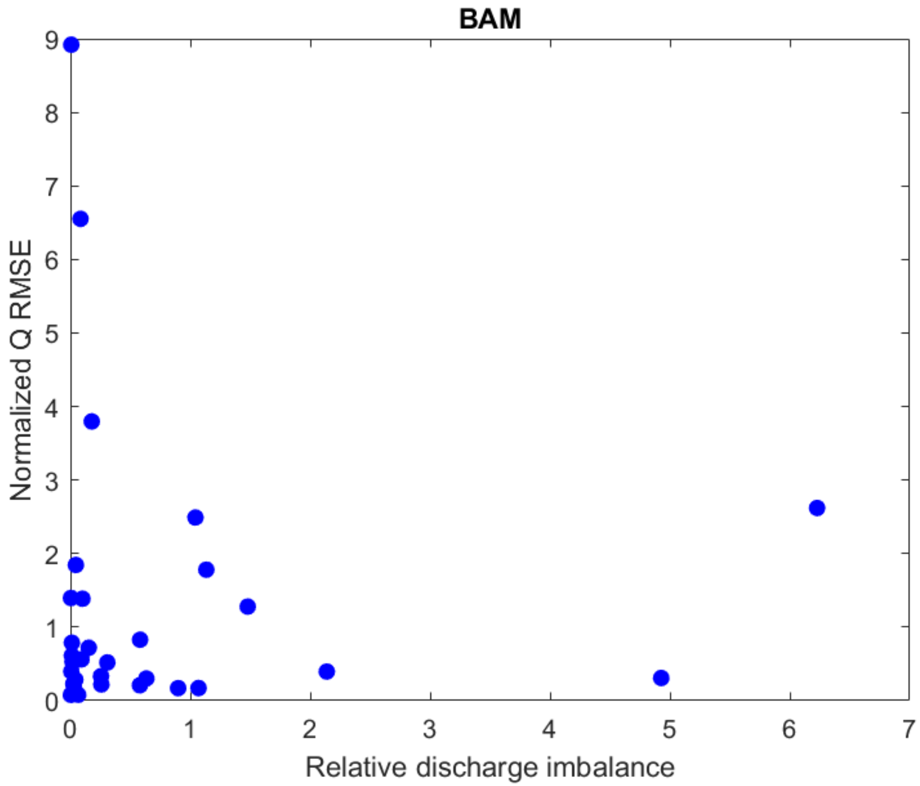
1. Quality of the prior discharge estimate
2. Violation of mass conservation
3. Flow law errors:
    1. Median nRMSE 0.03 for variable roughness
    2. Median nRMSE 0.08 for fixed roughness (Manning's n)

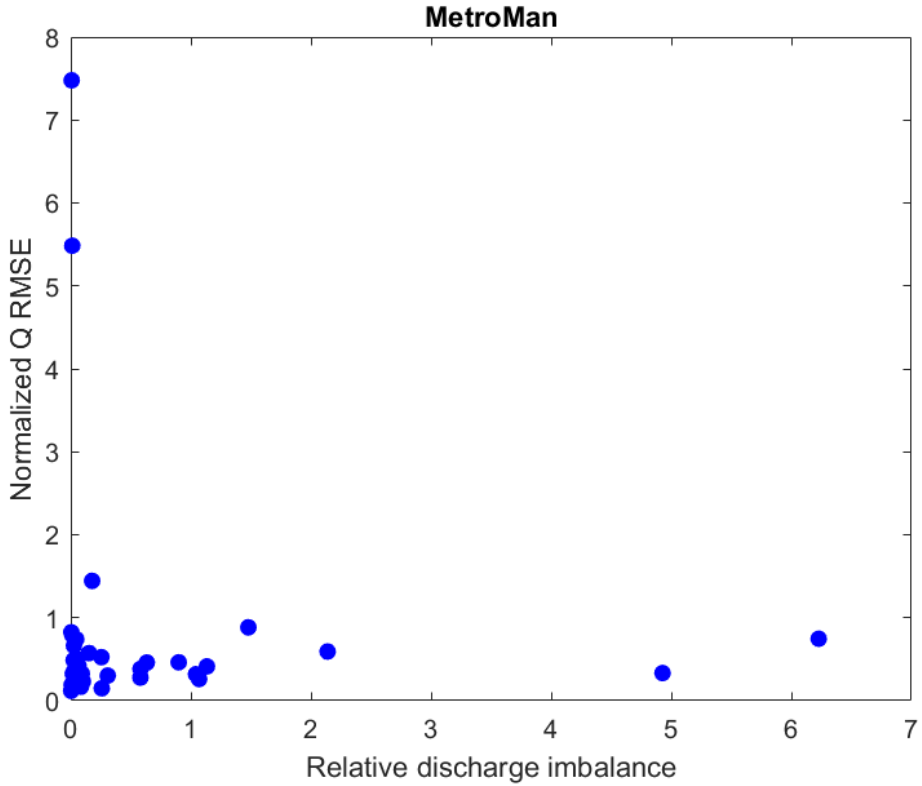




Phase 1 – Robustness to flow imbalance

$$(Q_{down} - Q_{up}) + \frac{\Delta Volume}{\Delta time} = Q_{imbalance}$$





Phase 2a – Time sampling effects on hydraulic variability

Produced datasets regularly sampled every 2, 3, 4, 5, 7, 10, and 21 days

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Estimated discharge

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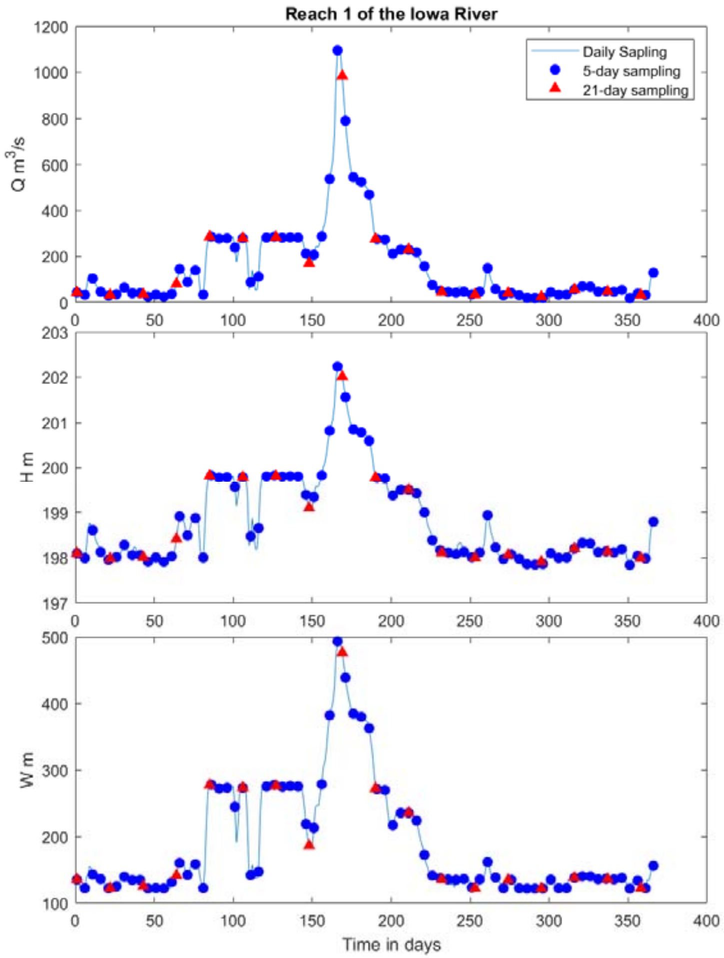
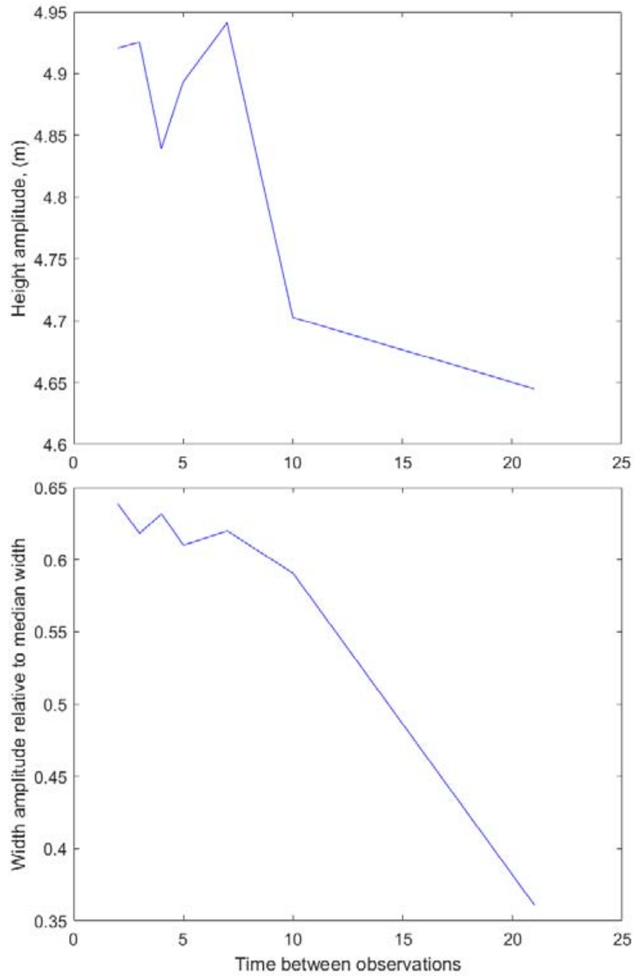
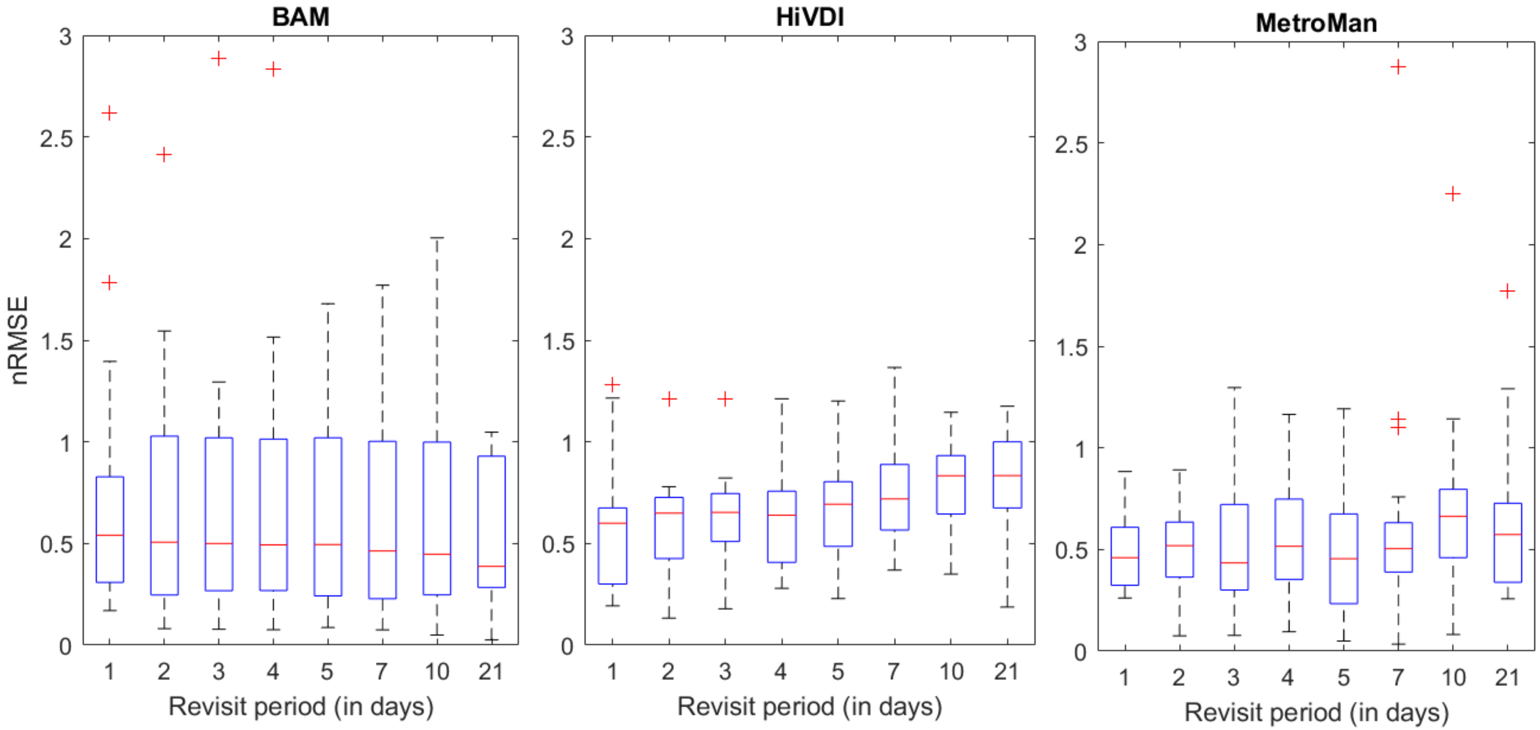
Computed error metrics





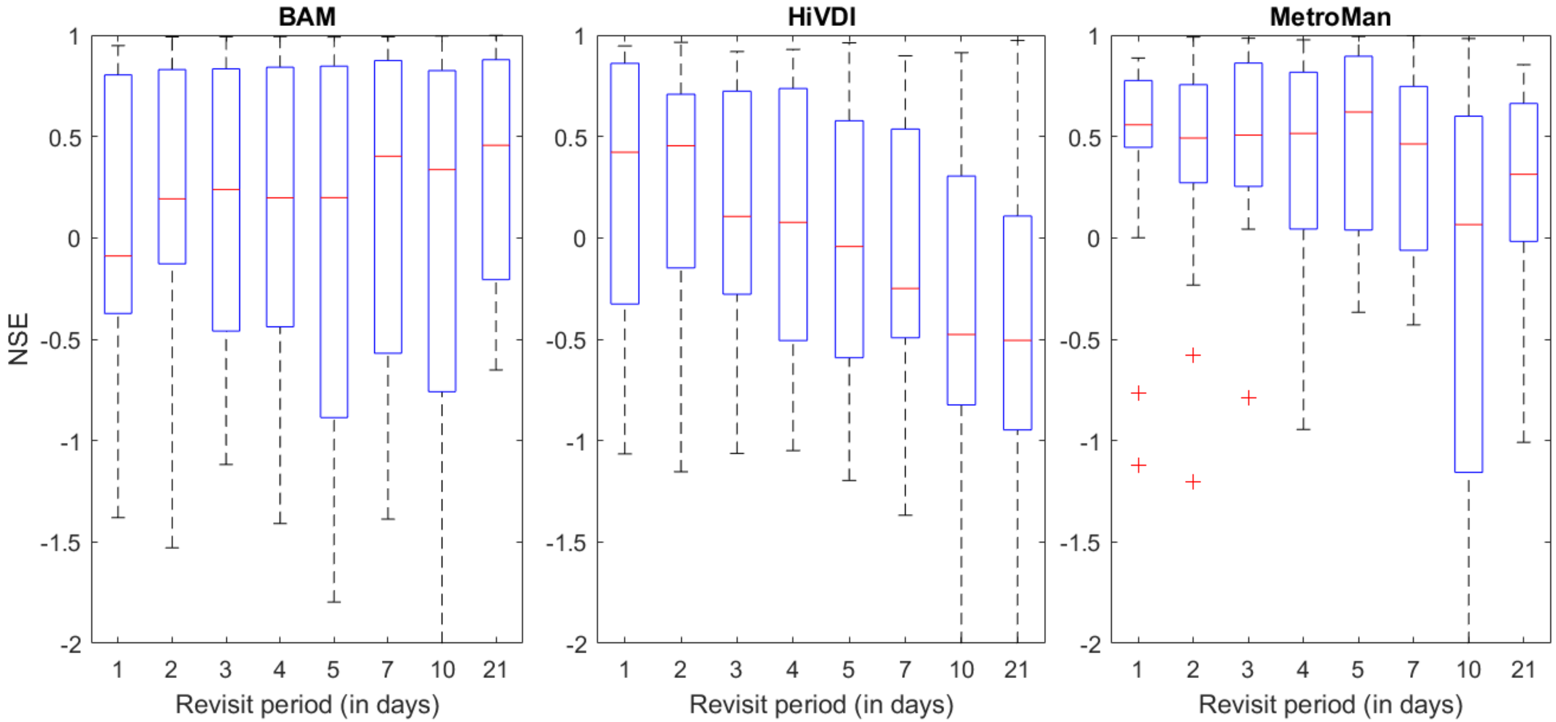
Phase 2a – Time sampling vs algorithm performance

- BAM: across the board consistency
- MetroMan: nRMSE < 0.5 for periods < 10 days
- HiVDI: degradation for periods ≥ 7 days



Phase 2a – Time sampling vs algorithm performance

- BAM: across the board consistency
- MetroMan: Positive NSE for periods < 10 days
- HiVDI: Positive NSE for periods < 5 days
- HiVDI's performance much improved by use of ancillary information



Phase 2b – Measurement error vs algorithm performance

Corrupted node heights and widths, computed reach observations

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Estimated discharge

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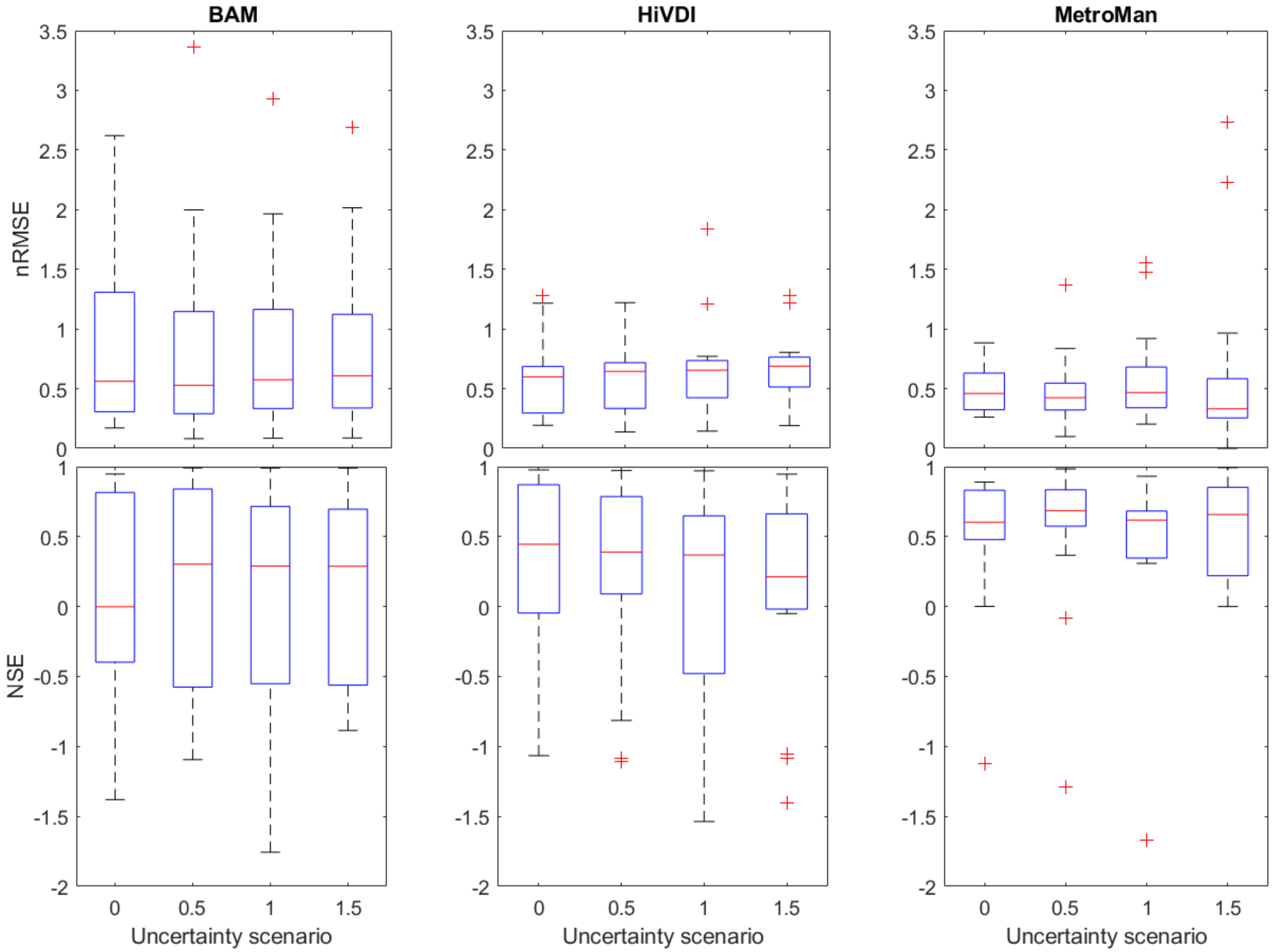
Computed error metrics



Where are we now

- We can retrieve discharge with **no ancillary** information in river models ranging from **1** m^3/s to **80000** m^3/s with resulting median nRMSE around 0.5 and NSE better than 0.5.
- **Physics** implemented in current inversion methods is **adequate** to describe our **suite of hydraulic models** to within 8% of mean annual flow.
- Our algorithms are **robust** to height and width **measurement errors**. Even in the presence of height **biases**.
- At least one of the MCFLI methods can retrieve discharge at the **most sparse time sampling** offered by SWOT.
- When **ancillary** information is available median **NSE** as high as **0.7 and nRMSE** as low as **0.35** even at the most sparse time sampling.

Where should we go next

- Improve our prior estimate of discharge
  - Most egregious results came from the cases where Qwbm was off by a factor of 5 and 13.
  - Move beyond priors on mean annual flow. HiVDI and MOMMA are ready to work with multiple flow quantiles!
- Ancillary data is available at many locations.
  - How can we better use them?
  - If using these data, how can we correctly estimate discharge uncertainty?
- McFLI requires simultaneously observed sets of mass conserved reaches or nodes (depending on method). SWOT sampling and river networks won't often give you more than 5 simultaneously observed mass conserved reaches.
  - Smart methods to fill gaps where inversions can't work are necessary!

Thank you for your attention!

Please come see poster 34 if you want to know more about the Pepsi challenge v2

Next: Hind Oubana’s presentation!