Reducing a Stream Network's Horton-Strahler Stream Order Improves the Skill of Flood Inundation Maps from Height Above Nearest Drainage Method

Continental Flood Inundation Mapping

Observing FIM skill improve by reducing the stream order for derivation of Height Above Nearest Drainage

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Introduction

- The NWM produces almost 3 million forecast streamflow values at multiple time horizons every hour.
- Post-processing is required to convert these discharges into stages and inundation extents.
- Height Above Nearest Drainage (HAND) is a terrain index that detrends or normalizes elevation away from mean sea level to the nearest relevant stream elevation.
- Synthetic Rating Curves (SRC) are used to convert stream flows to stages and those are converted to inundation extents using HAND.
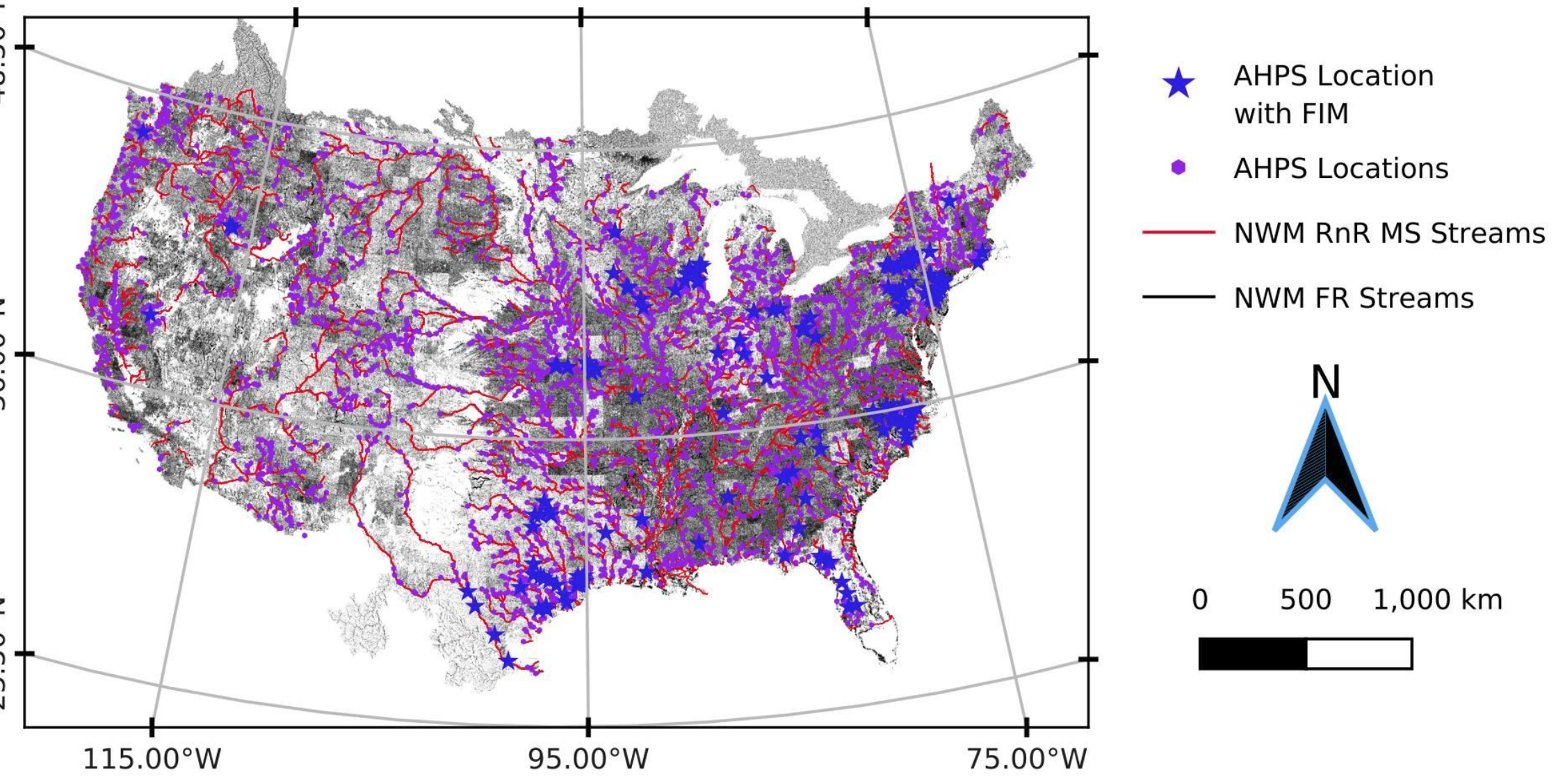
NWM Stream Networks, Full Resolution (FR) and Mainstems (MS), as well as the Advanced Hydrologic Prediction System (AHPS) locations and those with FIMs.
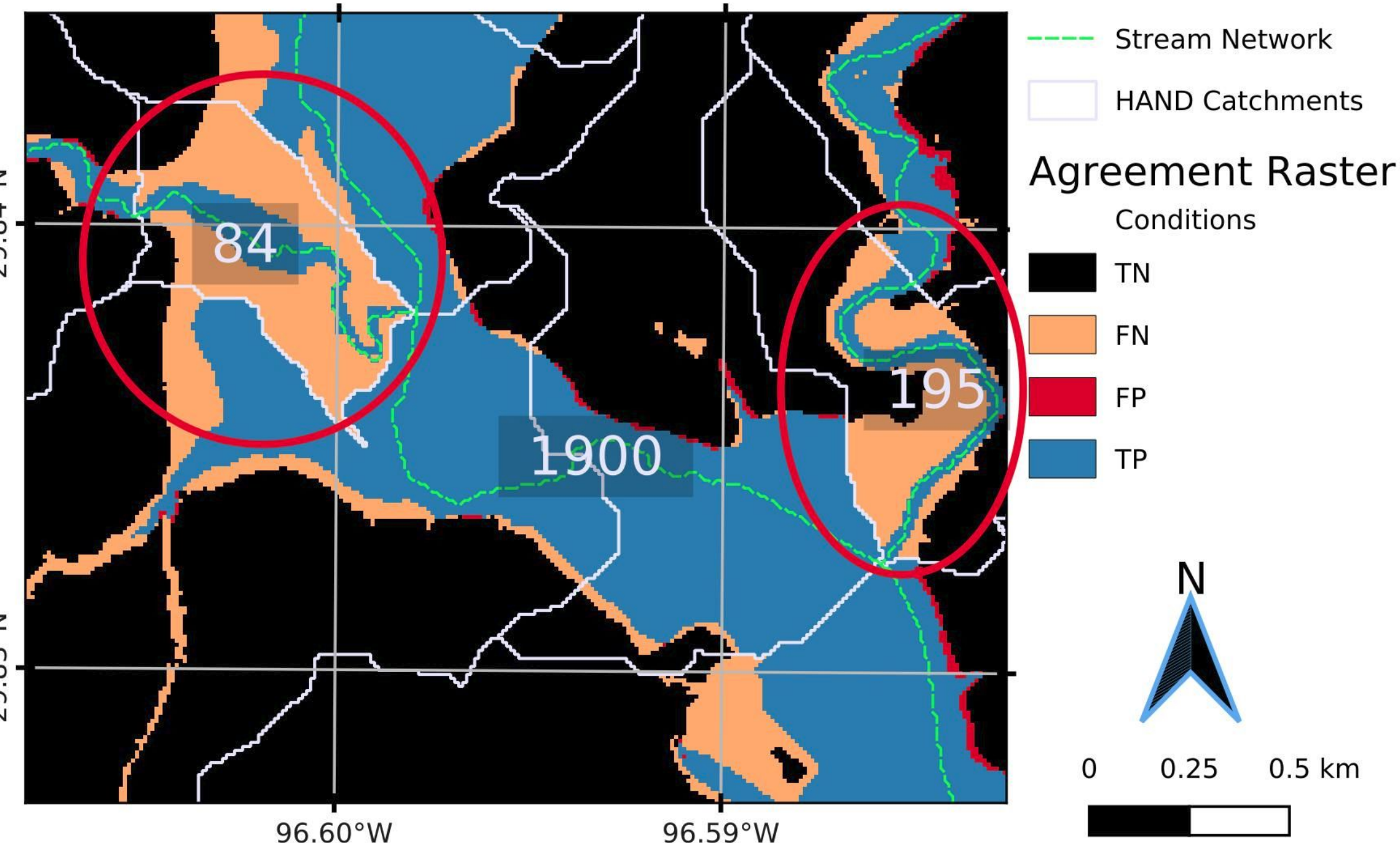

False Negatives (FN) associated with HAND inundation at junctions of high flow rivers and lower flow tributaries. This is caused by independent catchments which lack hydrodynamic connectivity. Above map compares to HEC-RAS 1D models for 100 year events as furnished by FEMA Region 6.
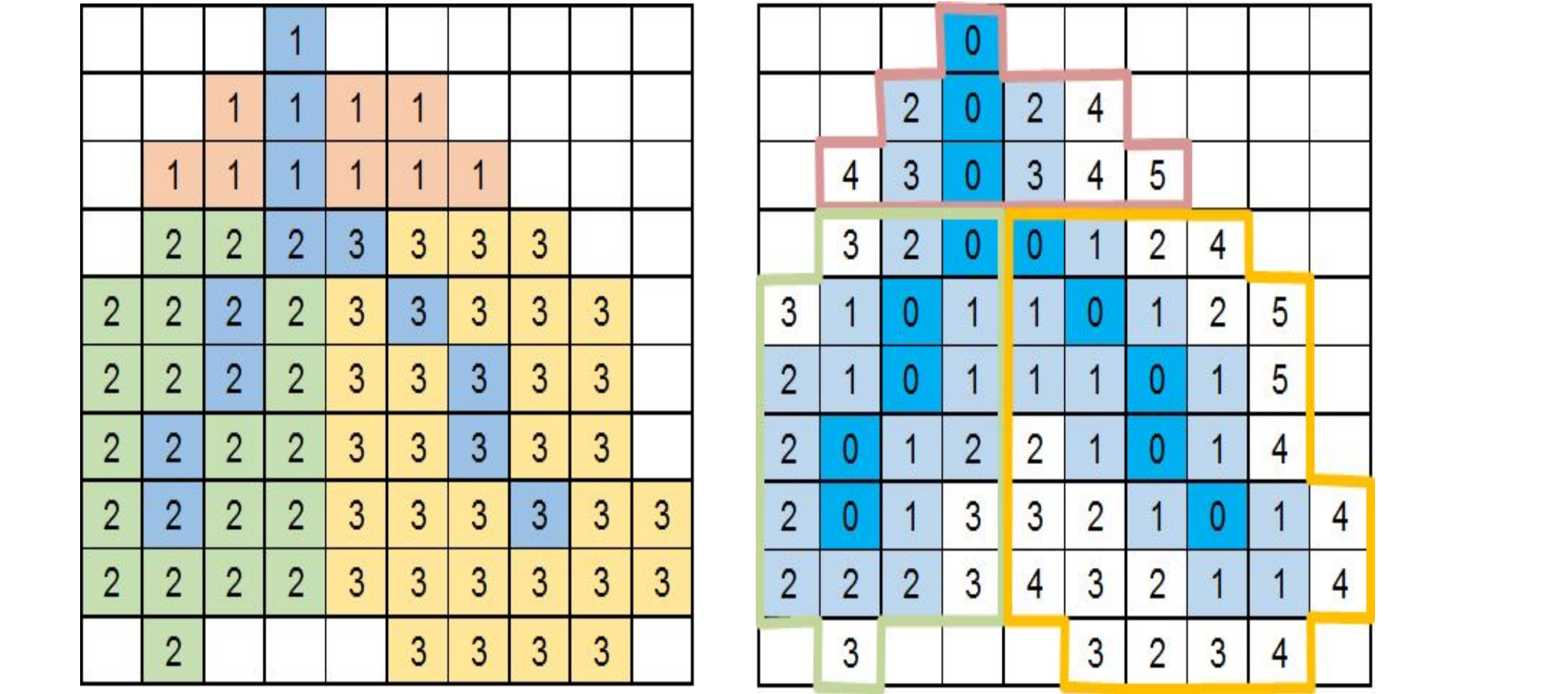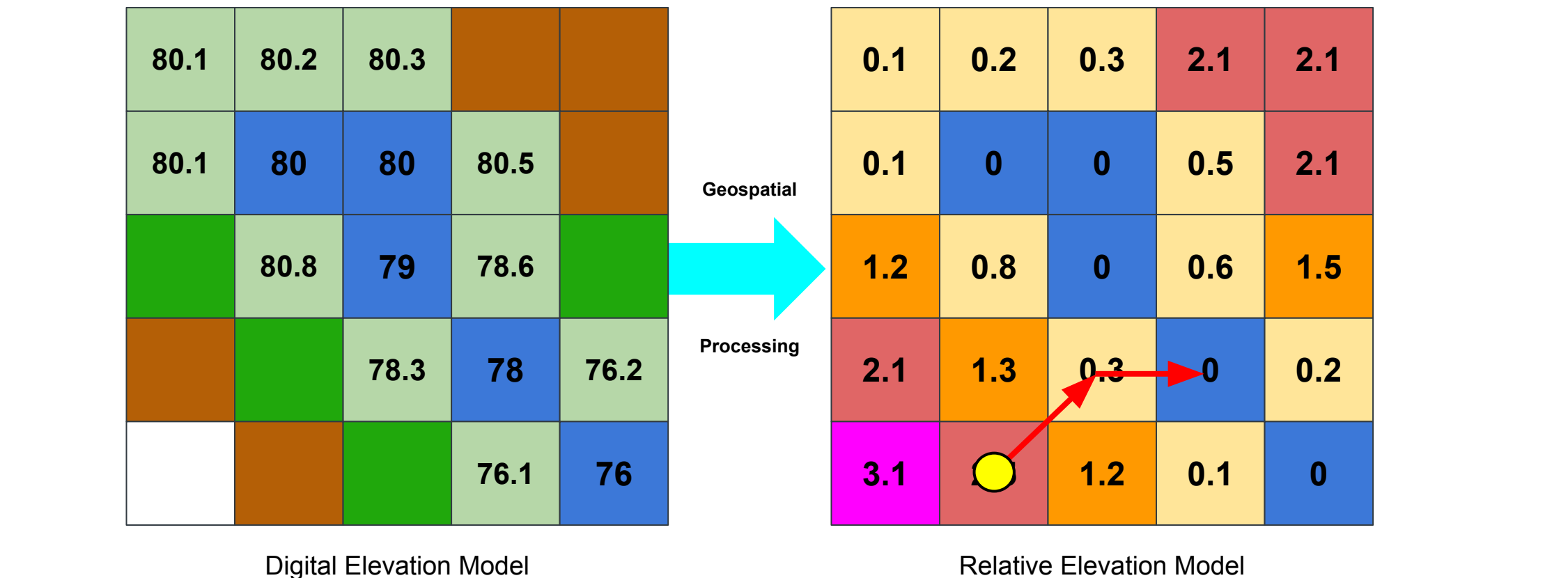

Detrending digital elevation models (DEM) by normalizing elevation to the nearest, relevant drainage line elevation. The resulting catchments and HAND values are used to derive synthetic rating curves using reach-averaged parameters.

$$Q_{[y]} = \frac{1}{n} \frac{V_{[y]}^{5/3} S^{1/2}}{LB_{[y]}^{2/3}}$$

Methods
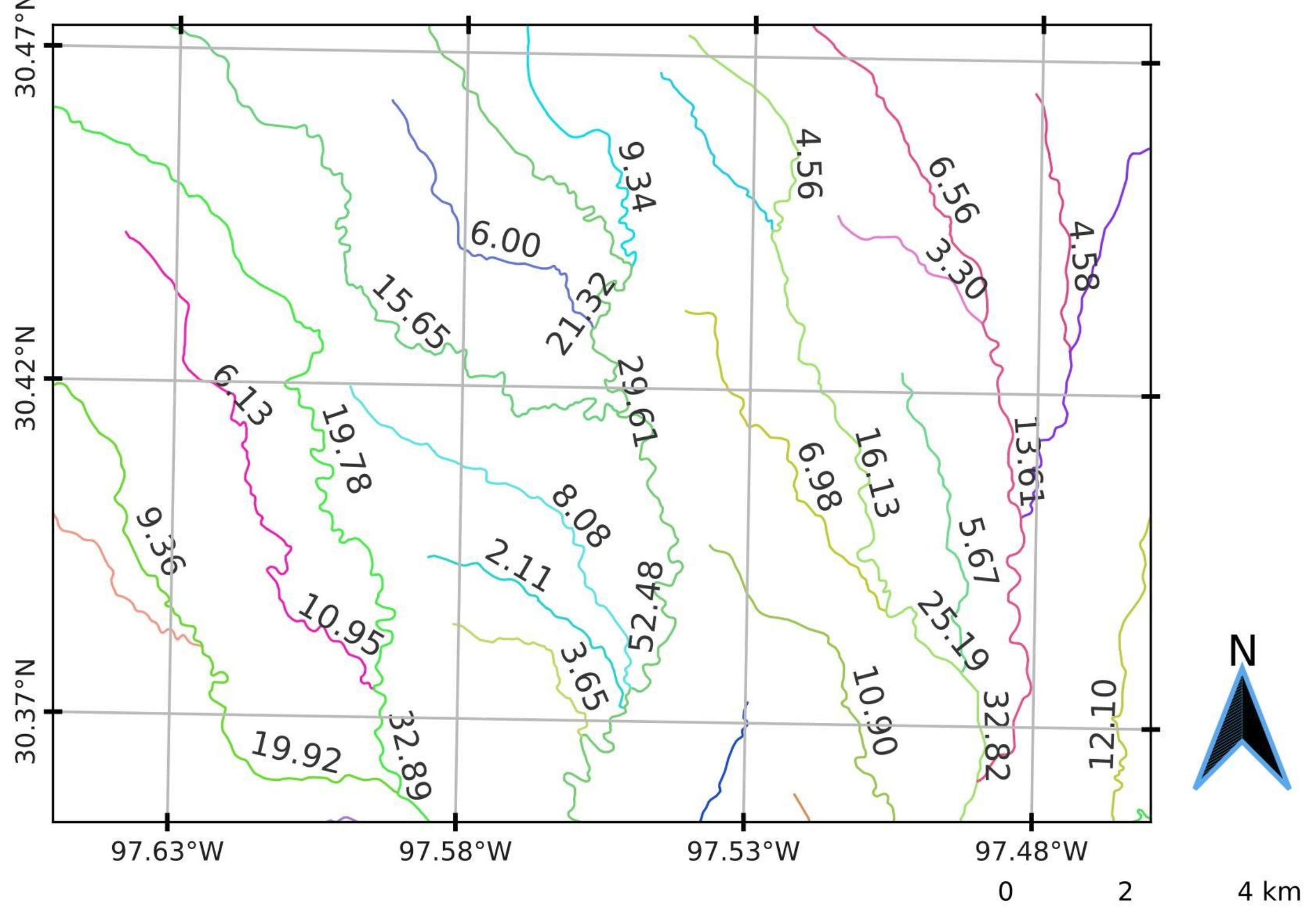
Unique colors illustrate level-path designations based on arbolate sum. Level path identifiers are propagated upstream following the direction of maximum arbolate sum at each junction. The other directions are assigned a new unique levelpath identifier.
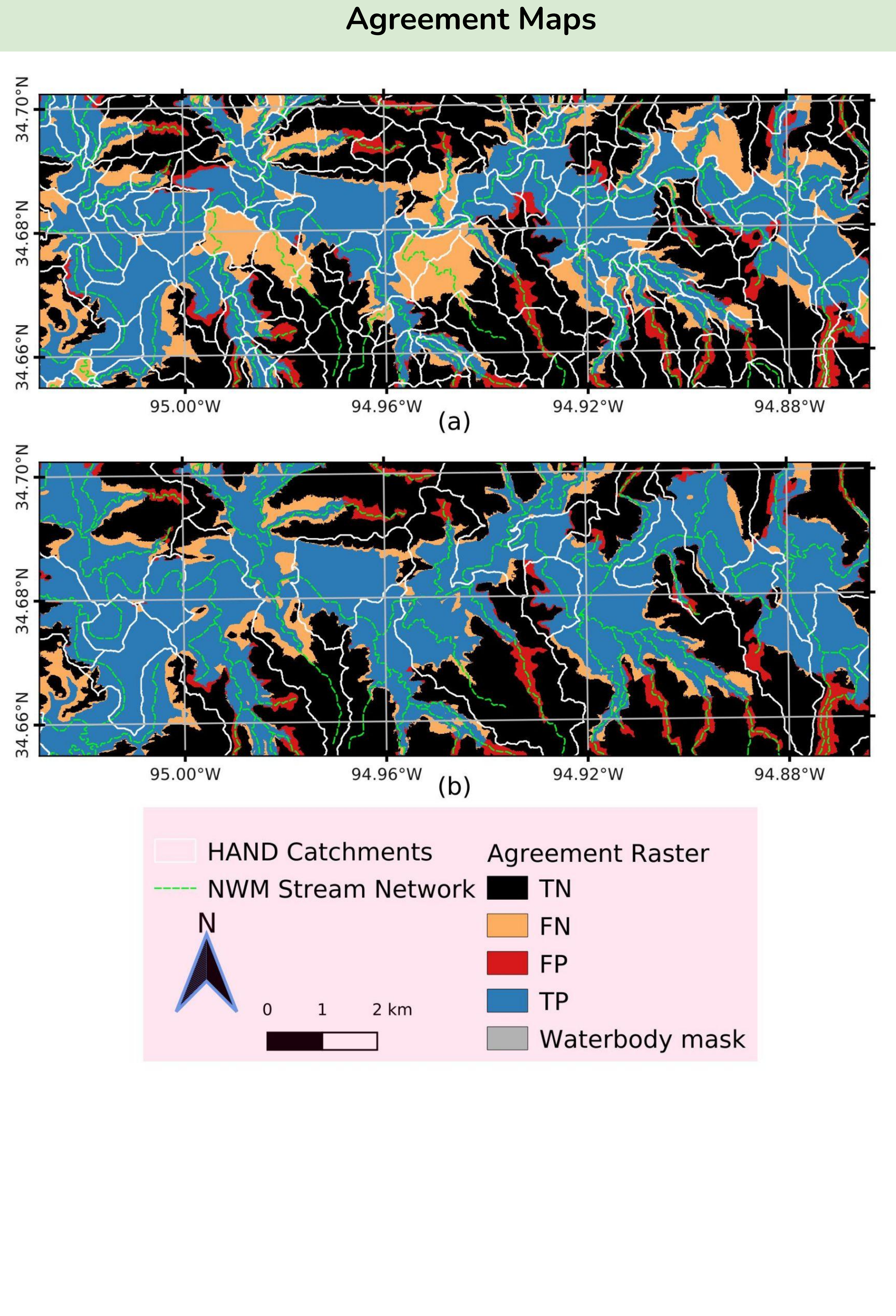
Agreement Maps

Agreement maps showing distribution of results when compared to validation maps. Results for FR HAND (a) and GMS HAND (b).

Violin Plots of Metrics
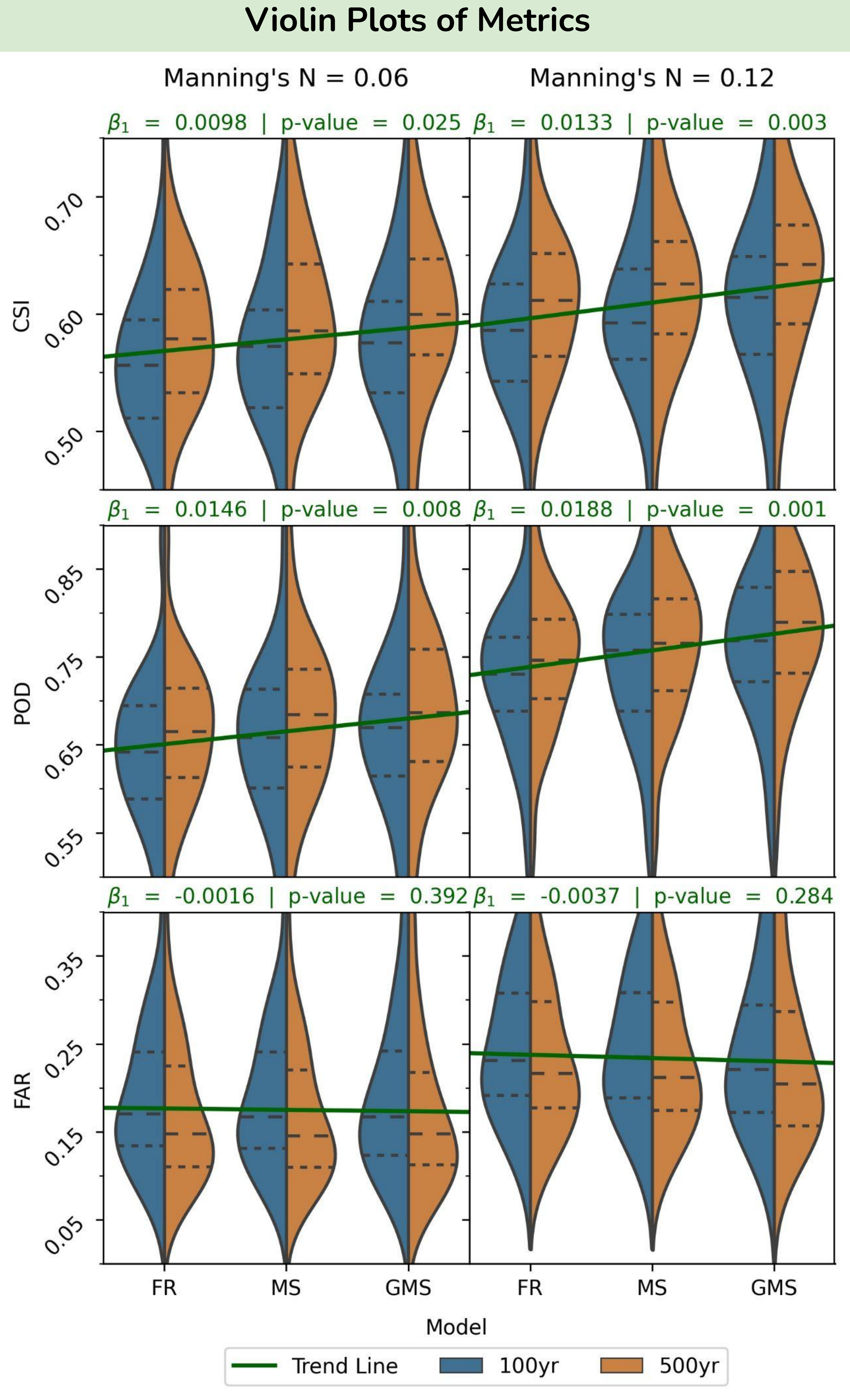
Violin plots comparing FR, MS, GMS versions of HAND with increasing reliance on stream networks of lower stream order. Performance increases for two event magnitudes across two Manning's N values due to improvements in POD and FAR.
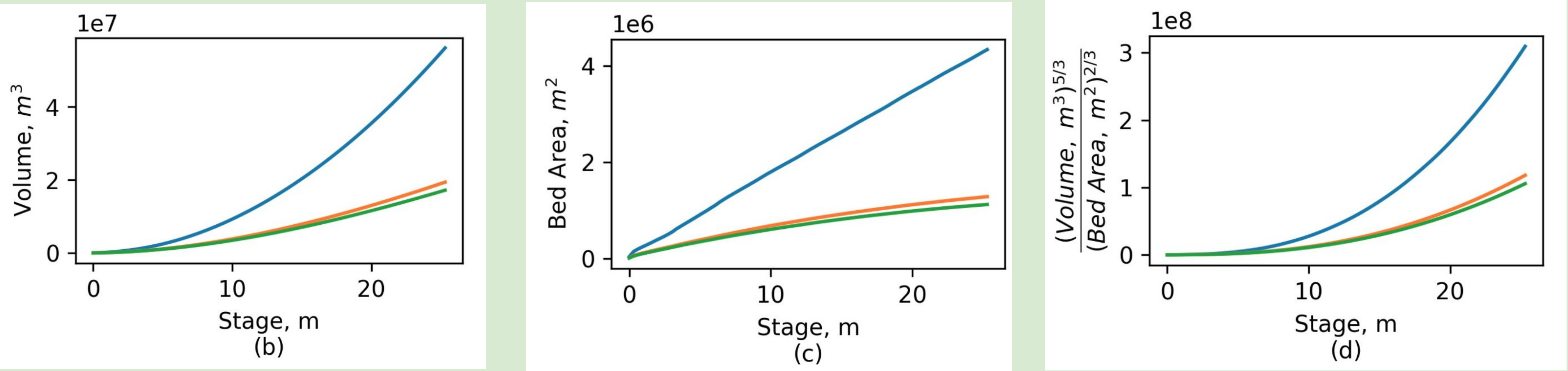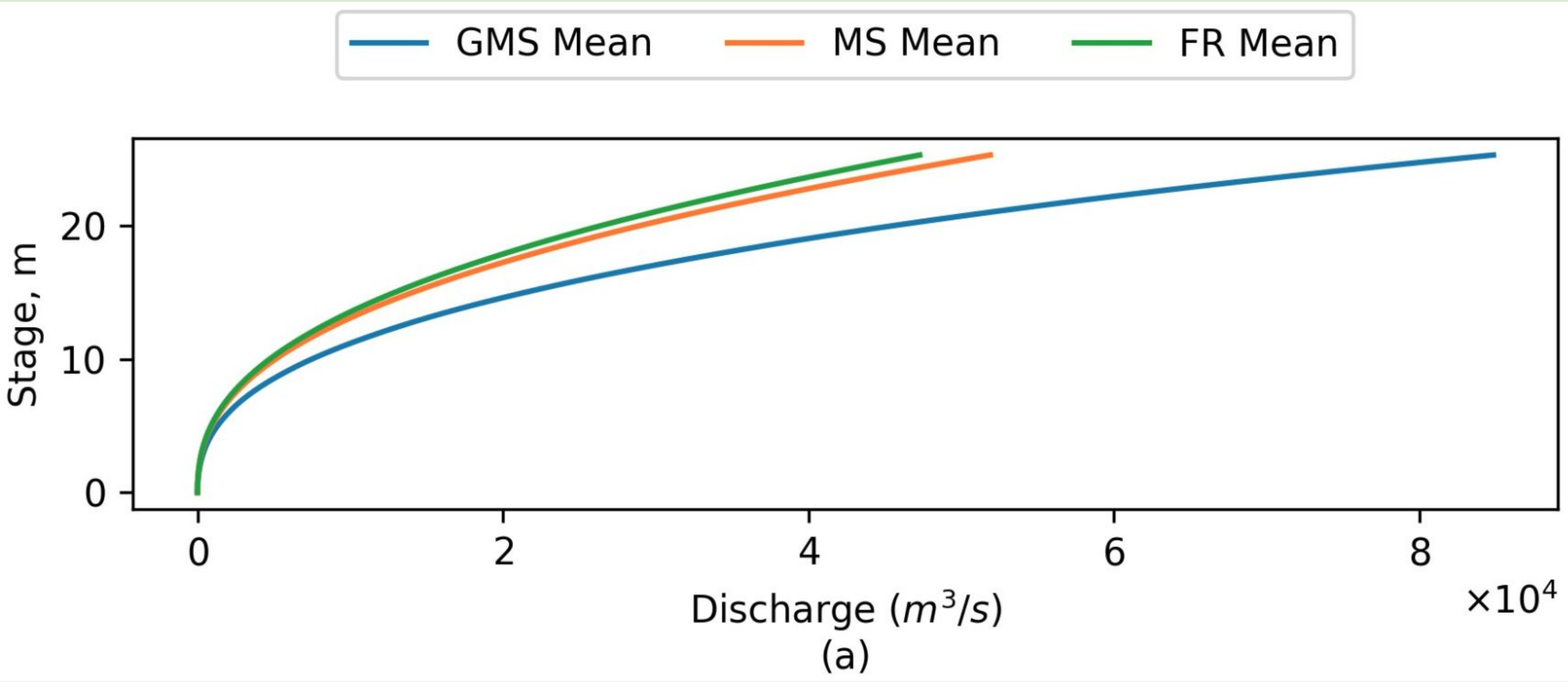

Shows the average rating curve for each model FR, MS, and GMS (a). The more stream order reduction is relied on the more the rating curve gets biased downward. Shows how volume is biased up (b) and how the same effect on bed area is observed (c). Shows the net effect of the changes on volume and bed area which is explained by the larger catchments (d).

Methods (continued)
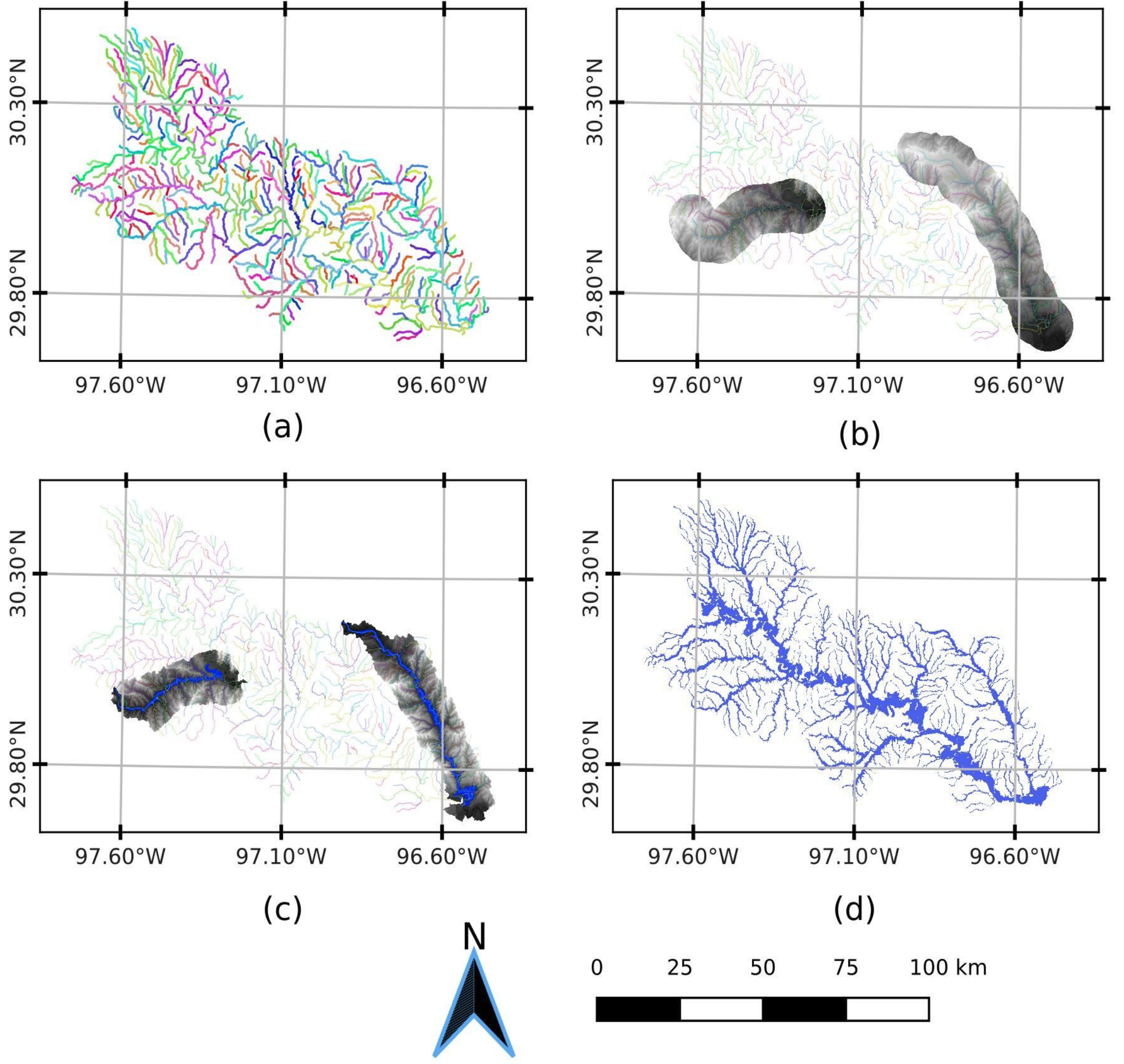
Shows levelpaths for an entire HUC8 (a). DEMs are clipped for every levelpath independently but only two are shown (b). Every levelpath is independently used to derive HAND but only two are show for clarity (c). FIMs for each HAND dataset are mosaiced together (d)
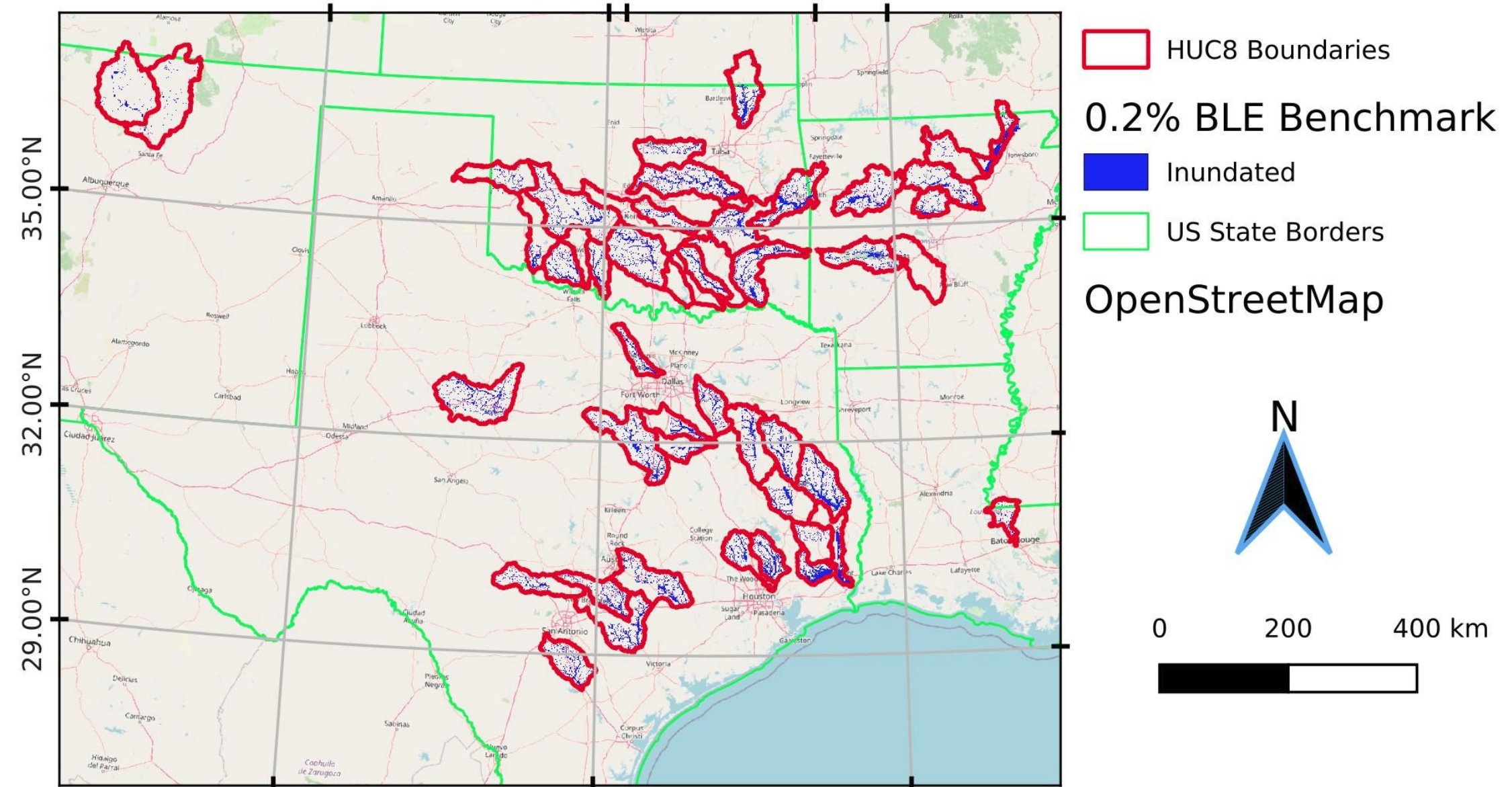
FEMA Region 6 Base Level Engineering (BLE) maps modeled with HEC-RAS 1D for 49 HUC8's at 100yr and 500yr recurrence intervals.
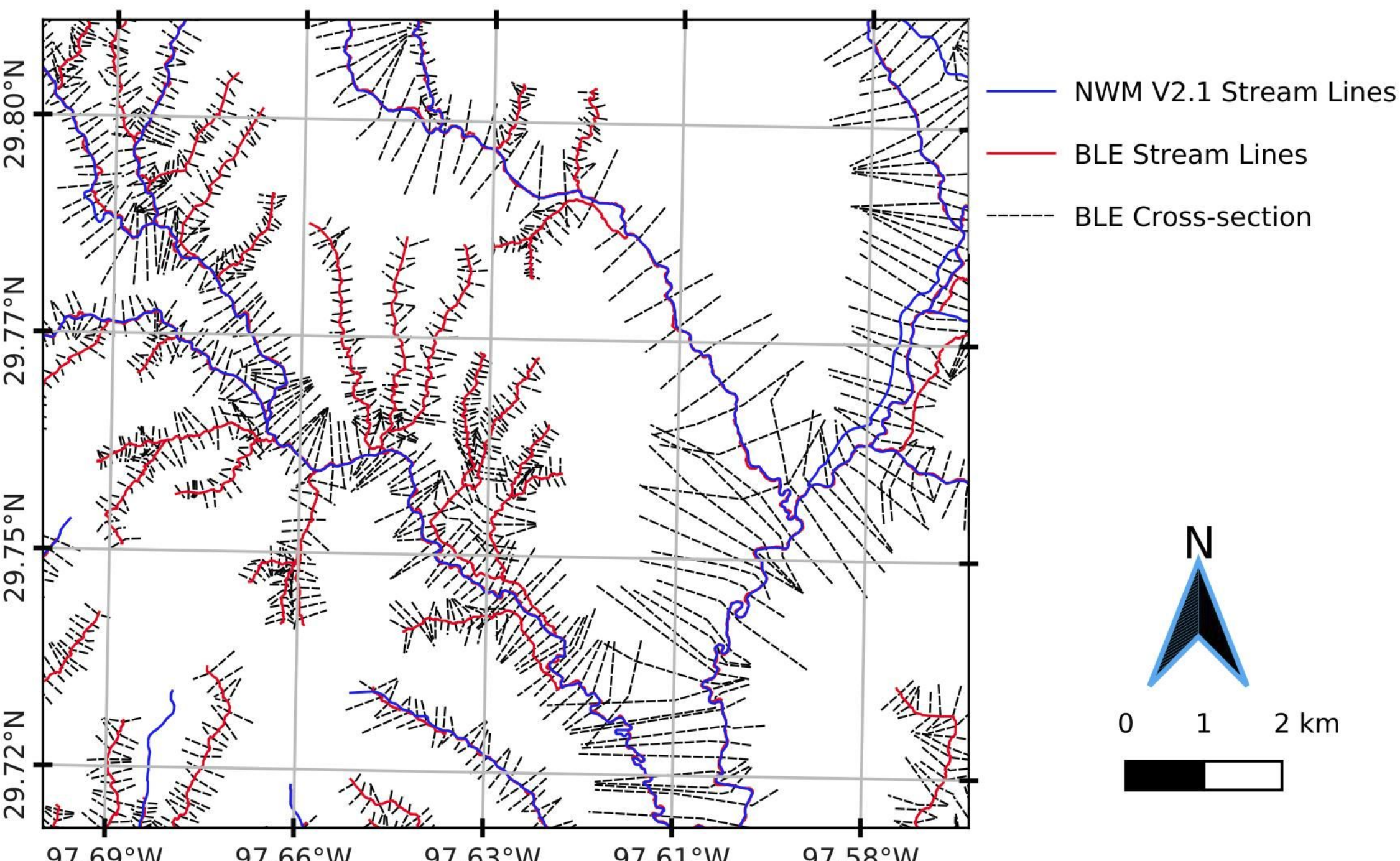
BLE cross-sections are intersected with NWM stream lines to derive stream flows used for validation.

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