Supporting Information for "Topological relationships-based flow direction modeling: stream burning and depression filling"

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October 22, 2022, 5:53pm

Introduction

This supplementary information includes details of the following topics.

1. The differences in neighbor definitions between PyFlowline and HexWatershed (Text S1)

2. Elevation profile retrieval from the National Hydrography Dataset(NHD)/National Elevation Dataset(NED) (Text S2)

3. Model algorithms (Figures S1 and S2)

4. Study area (Figure S3)

5. Full maps of meshes with flow direction fields (Figure S4-S7)

6. Distributions of channel slope, drainage area, and travel distance (Figures S8-S10)

7. Major model configurations (Table S1).

Text S1.

In the PyFlowline model, only cells that share edges are considered neighbors although the shortcut algorithm allows the diagonal path in the Cartesian coordinate system. In contrast, in HexWatershed v3.0, the diagonal path cell is always considered a neighbor in the rectangle coordinate system.

Text S2.

The following steps are used to retrieve the elevation profile from the NHD/NED datasets:

1. Select the list of river segments that run from the headwater to the watershed outlet. These segments were produced from the part 1 study as the simplified river networks.

2. Extract the NED DEM elevation for each vertex of the segments. Because the segment vertices are ordered, the elevations are ordered too.

Because the NED DEM has depressions, the elevation profile also has depressions.

Figure S1.

Figure S2.

Figure S3.

Figure S4.

Figure S5.

Figure S6.

Figure S7.

Figure S8.

Figure S9.

Figure S10.

Table S1.

The configuration JSON file shares the same structure as the PyFlowline model.

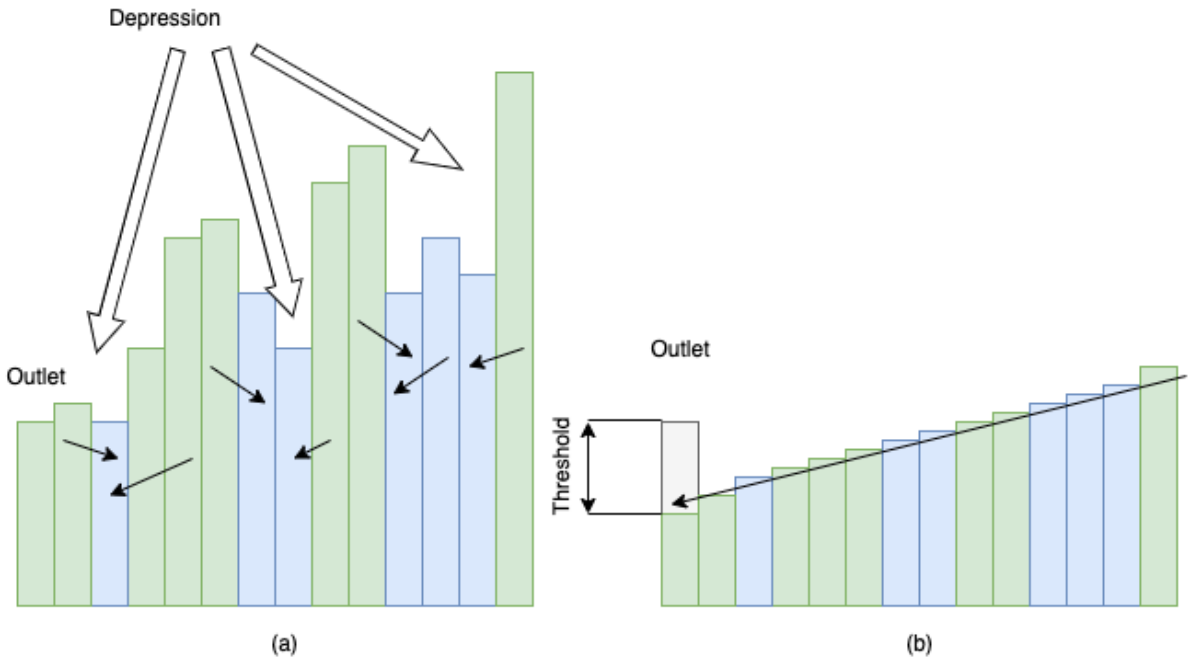

Figure S1. Illustration of stream burning through outlet breaching on a 1D transaction. (a) is the original river cell elevation profile with several depressions. The outlet is the last river grid on the left. (b) is the elevation profile after stream burning. A user-provided threshold is used to lower the outlet elevation. All the remaining river grid elevations are modified using a gentle slope (e.g., 1%).

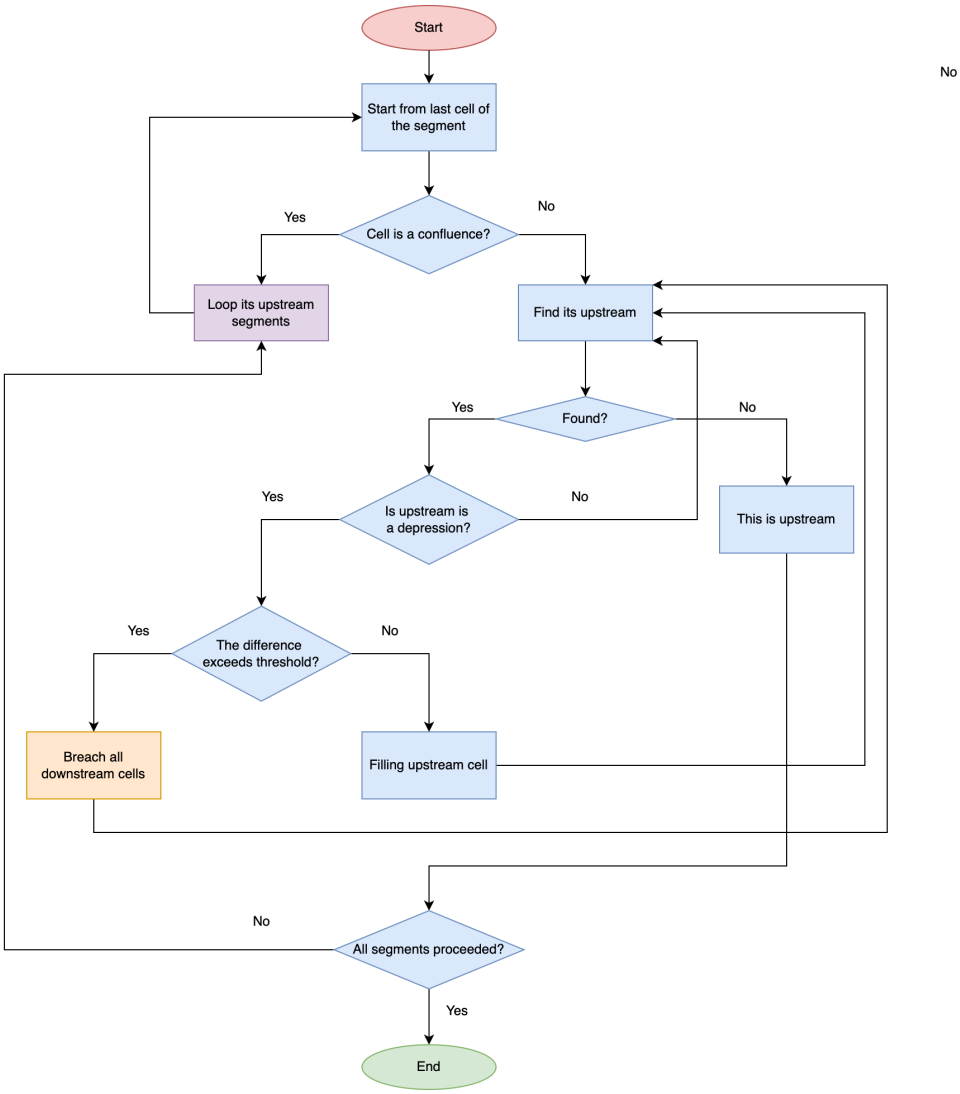

Figure S2. Workflow of the topological relationships-based hybrid breaching filling stream burning algorithm.

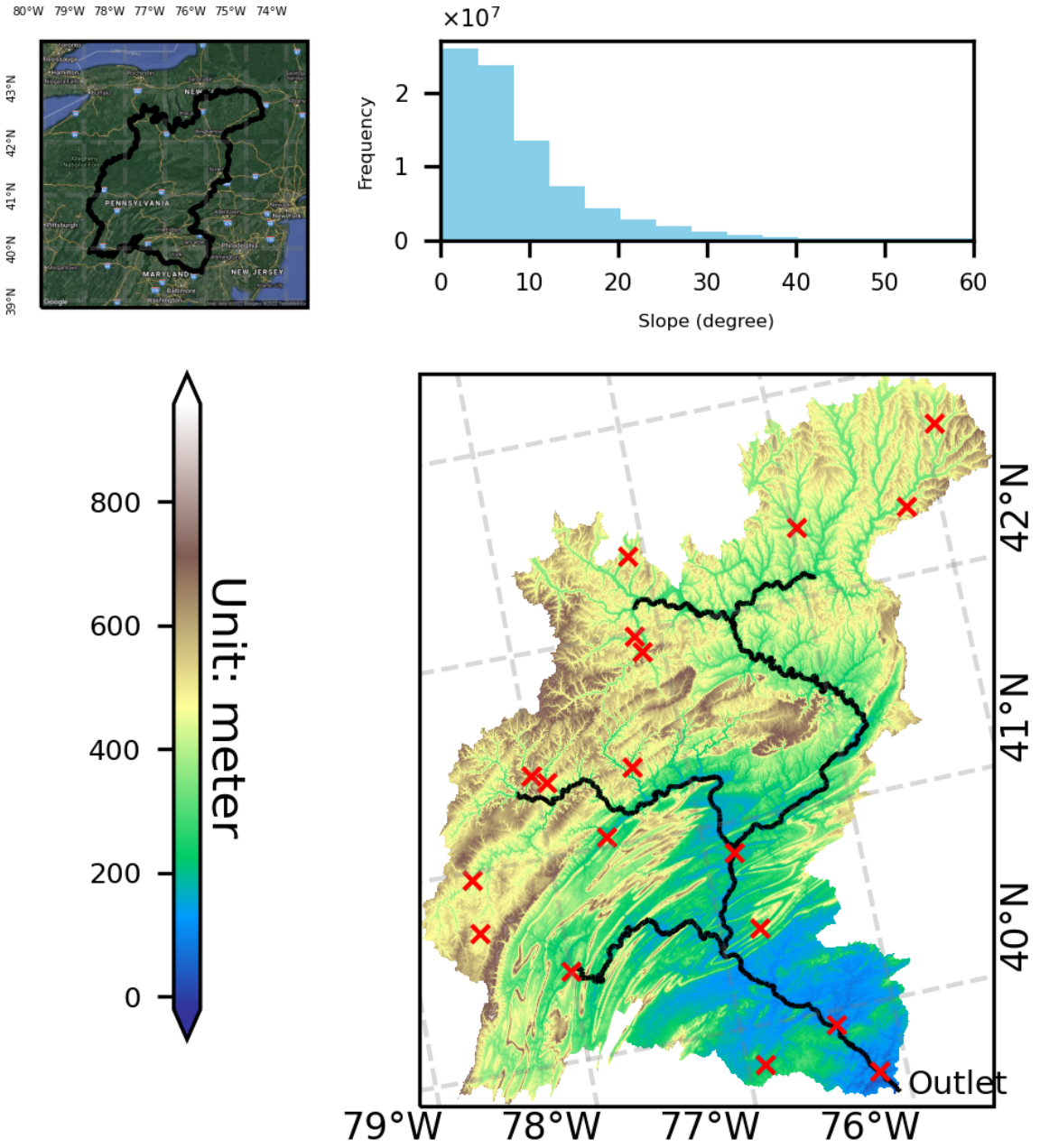

Figure S3. The spatial location, surface elevation, and surface slope distribution (based on high-resolution DEM) of the Susquehanna river basin. The upper left red polygon is the Watershed Boundary Dataset watershed boundary on Google Maps; the upper right is the histogram of surface slope (degree); and the bottom is the topographic map (m). In the topographic map, the black lines are major river channels. The red crosses are major dams. The outlet is in the lower right corner.

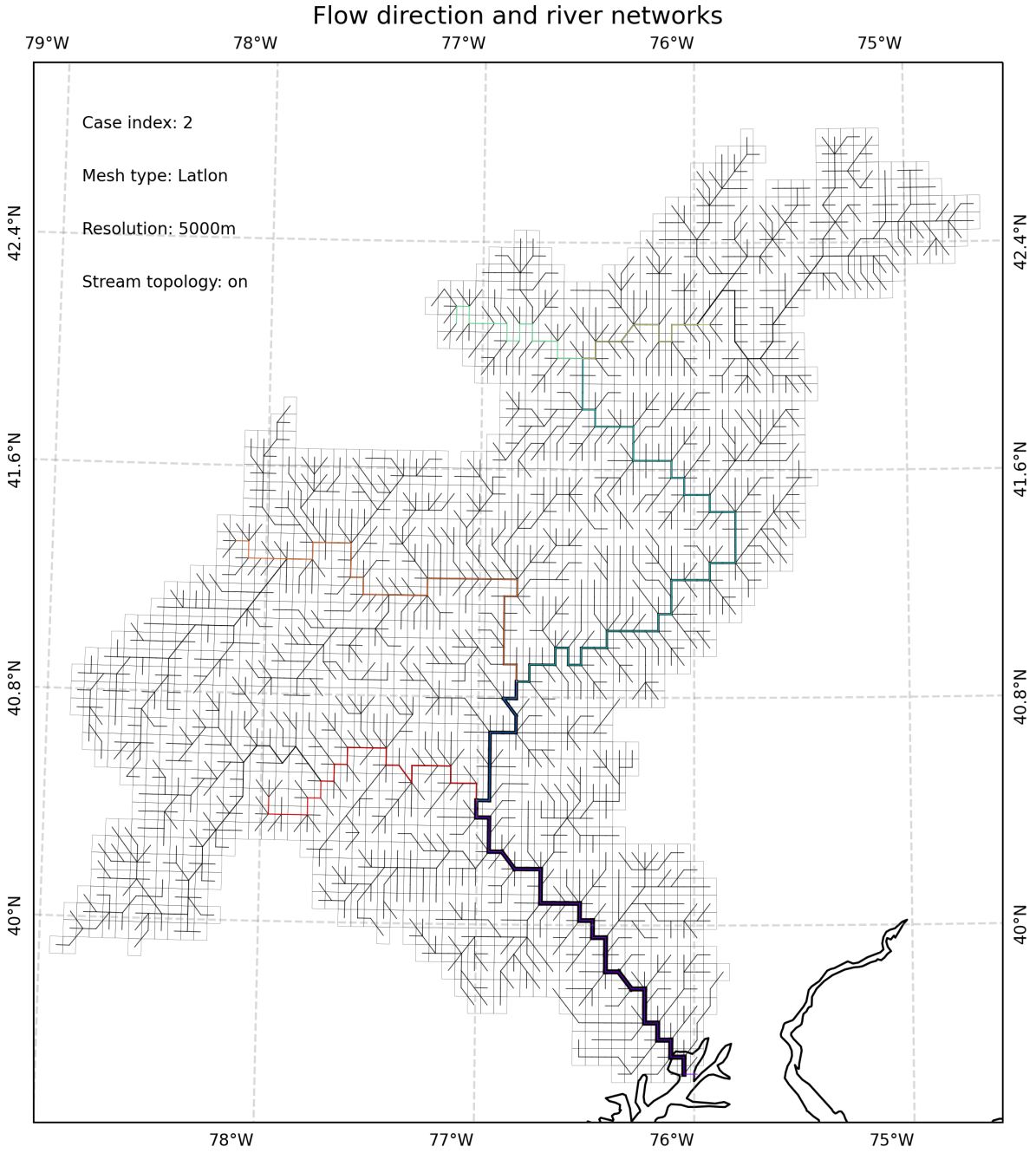

Figure S4. The modeled flow direction field from Case 2.

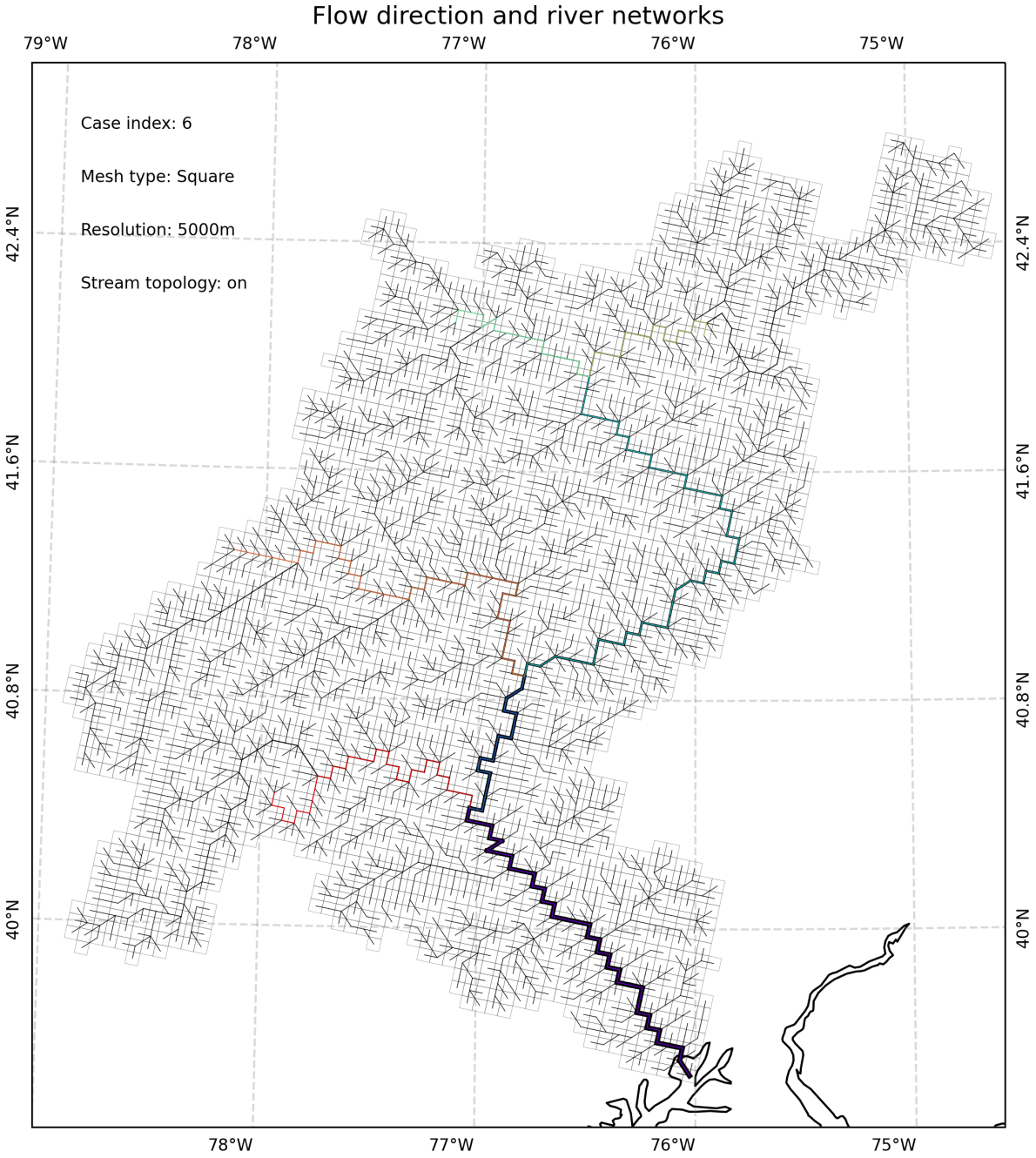

Figure S5. The modeled flow direction field from Case 6.

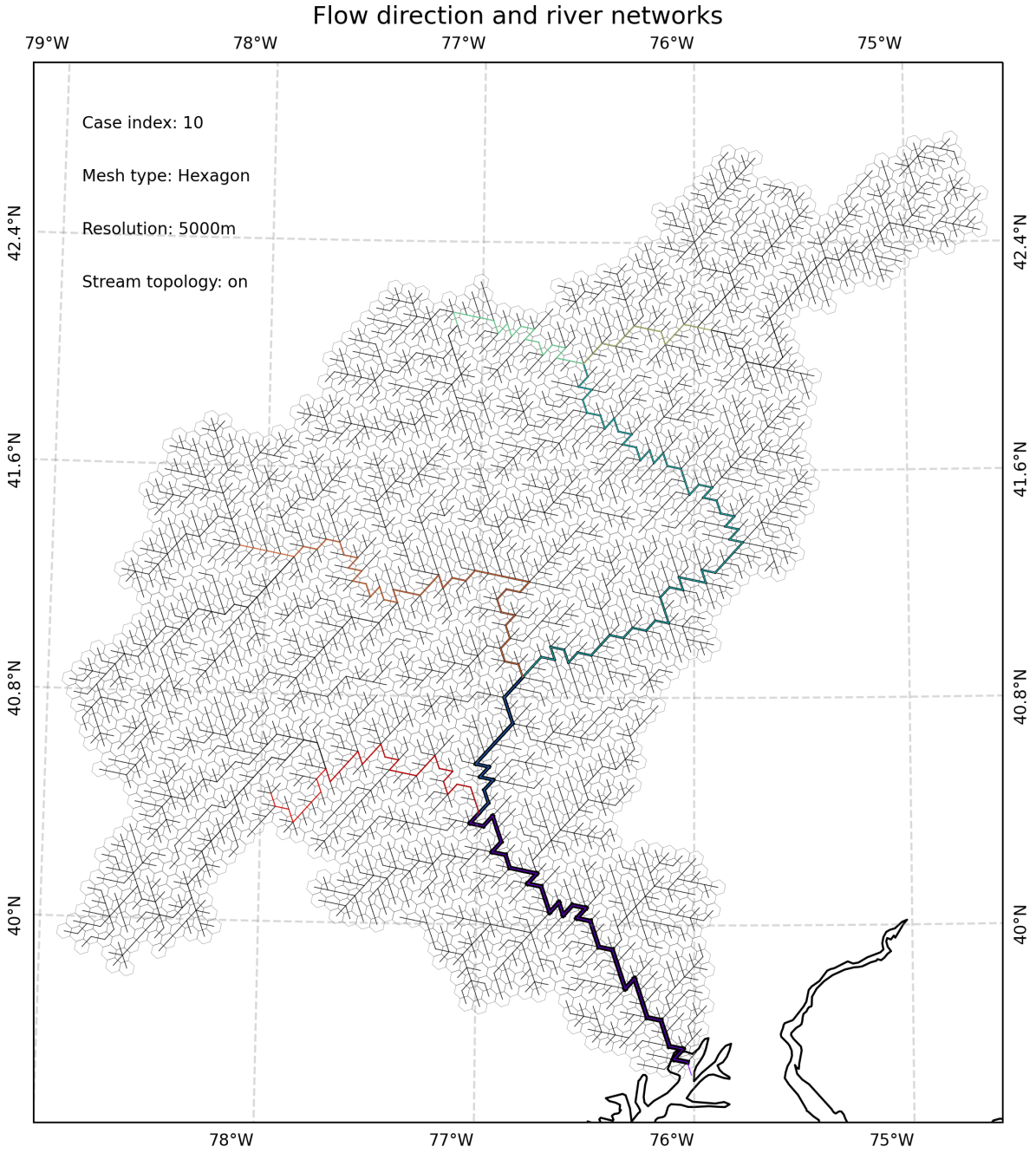

Figure S6. The modeled flow direction field from Case 10.

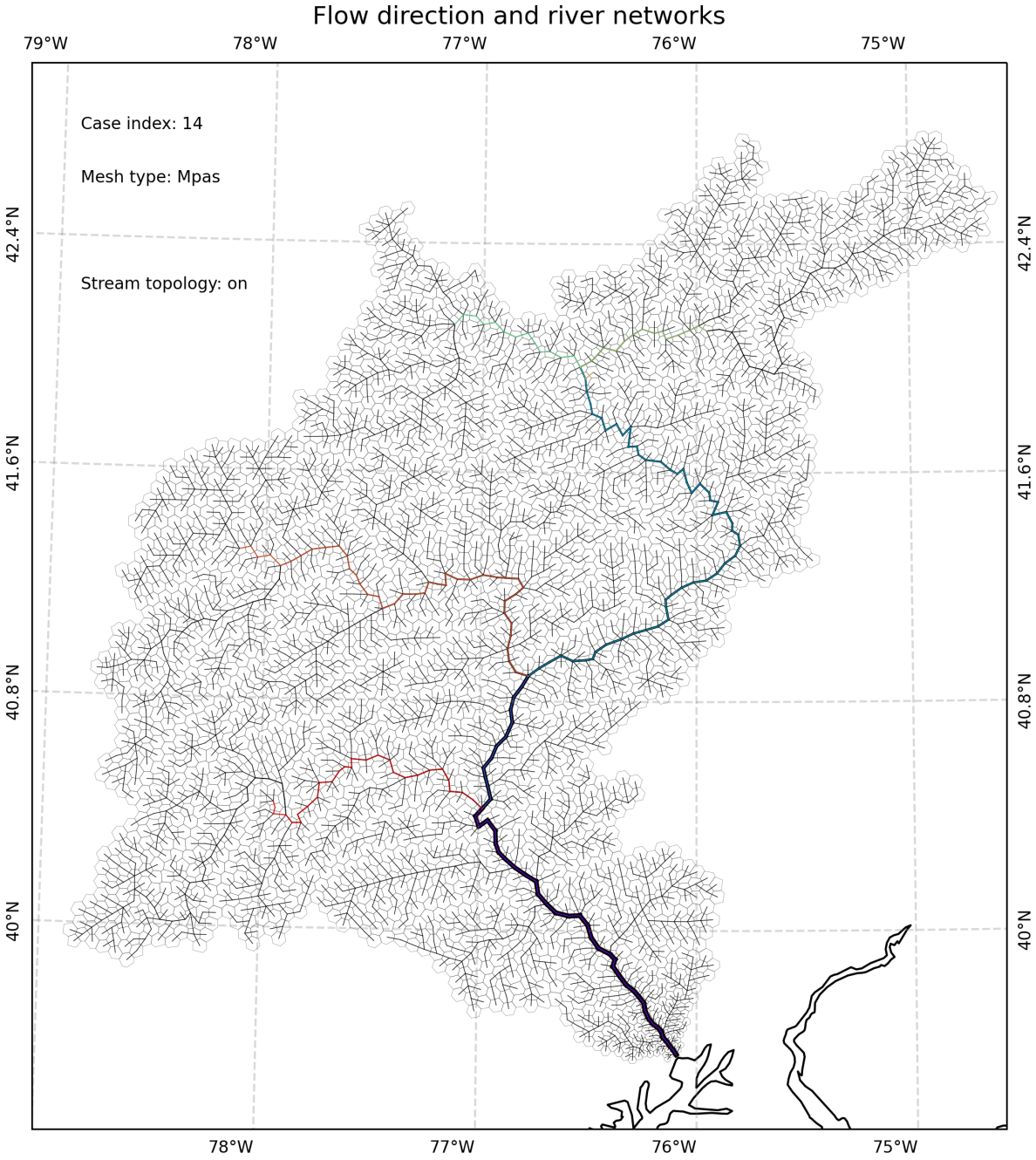

Figure S7. The modeled flow direction field from Case 14.

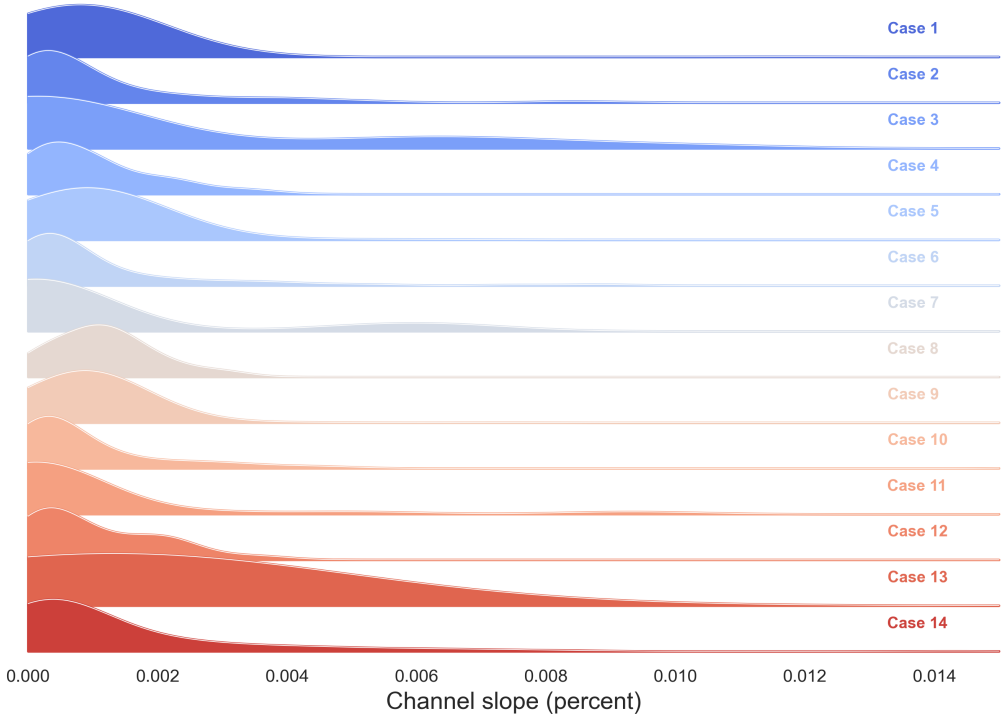

Figure S8. Distributions of the channel slope (percent) from Cases 1 to 14.

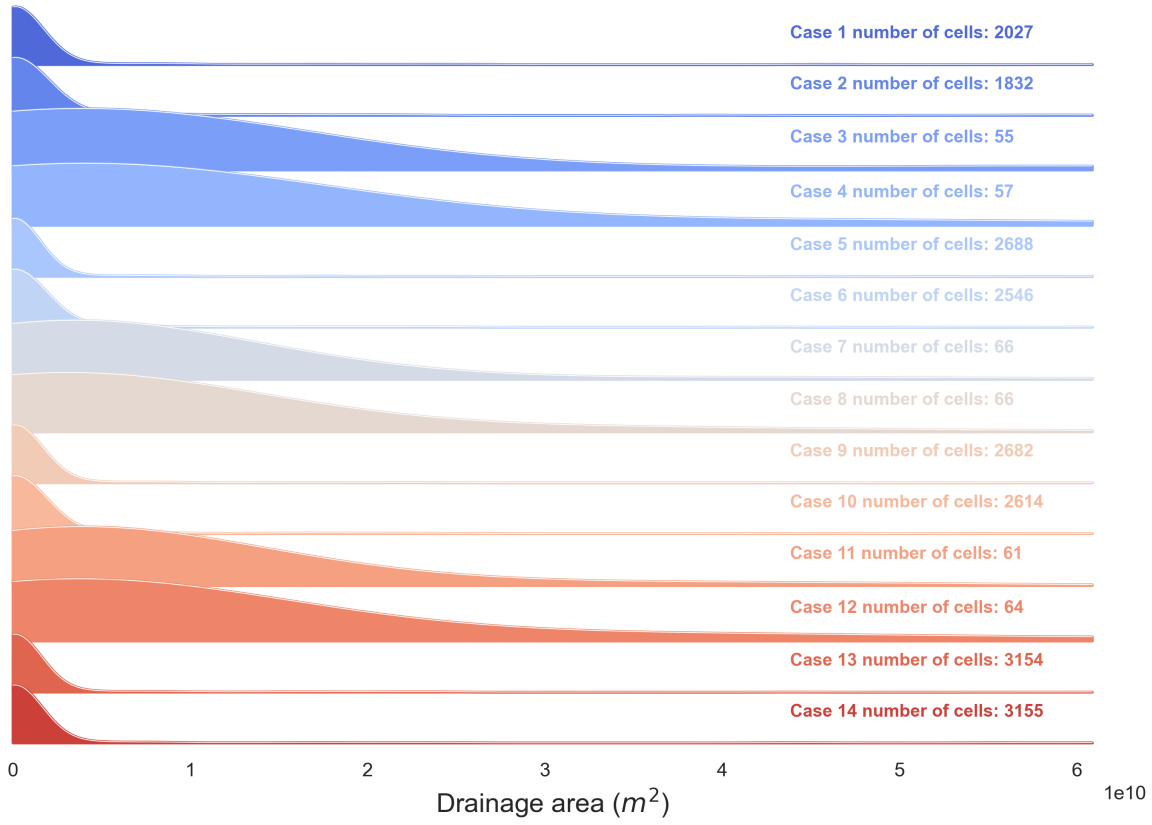

Figure S9. Distributions of the drainage area (m^2) from Cases 1 to 14.

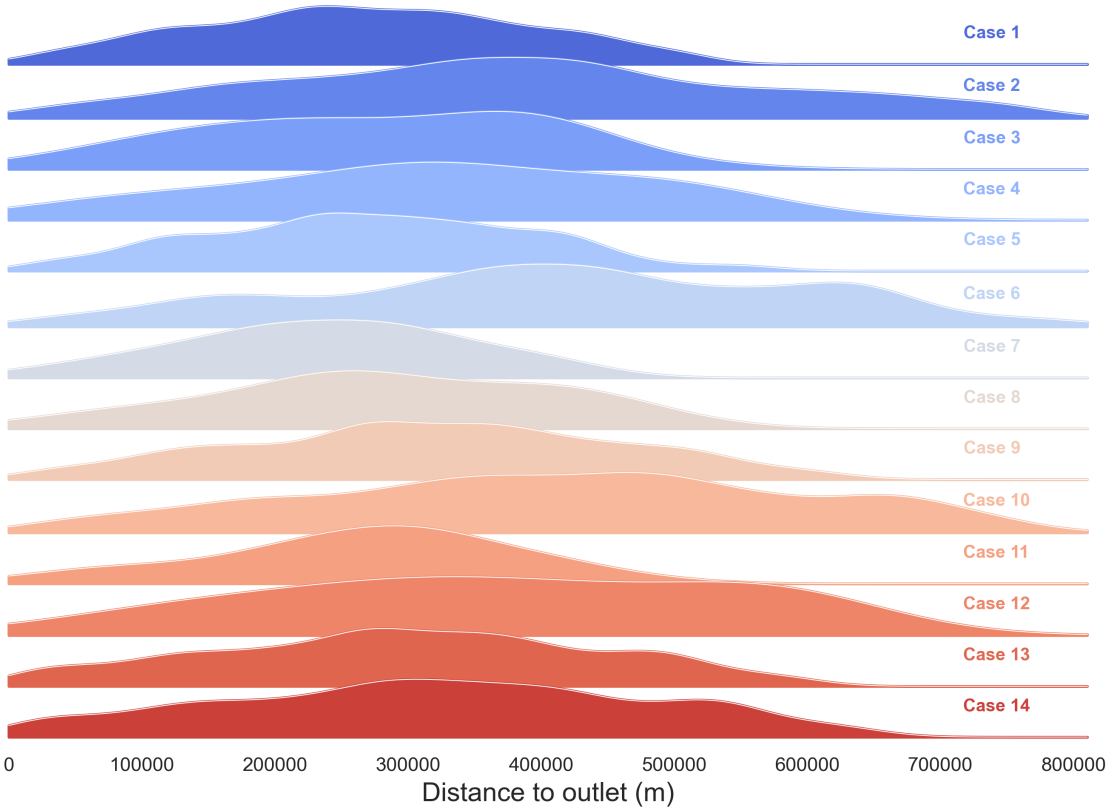

Figure S10. Distributions of the travel distance (m) from Cases 1 to 14.

Table S1. Major model configurations.

Parameter	Usage	Default
iFlag_stream_burning_topology	Option to turn on the topological relationships-based stream burning	1
iFlag_use_mesh_dem	Option to use the elevation within the mesh file	1
iFlag_global	Option to turn on the global scale simulation	0
iFlag_resample_method	Method (1: nearest; 2: zonal mean) for DEM resampling	1
iFlag_multiple_outlet	Option to turn on the multiple outlet simulation	0
dResolution_meter	Mesh resolution	10000 m
dAccumulation_threshold	Threshold to define the stream grid	10000 m
dBreach_threshold	Threshold to breach a stream depression	10 m
sMesh_type	Mesh type	hexagon
sFilename_dem	The filename of the DEM data	None