SWOT Derived River Bathymetry for Global Flood Model Applications

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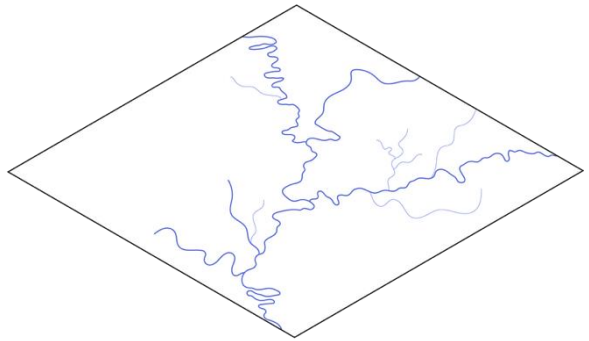
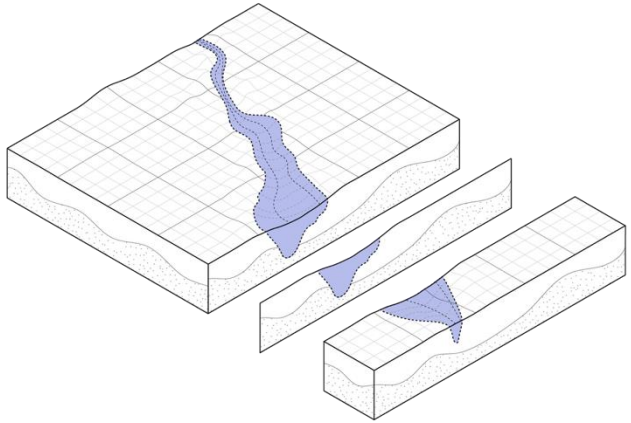
Why are river channels important for flood inundation models?

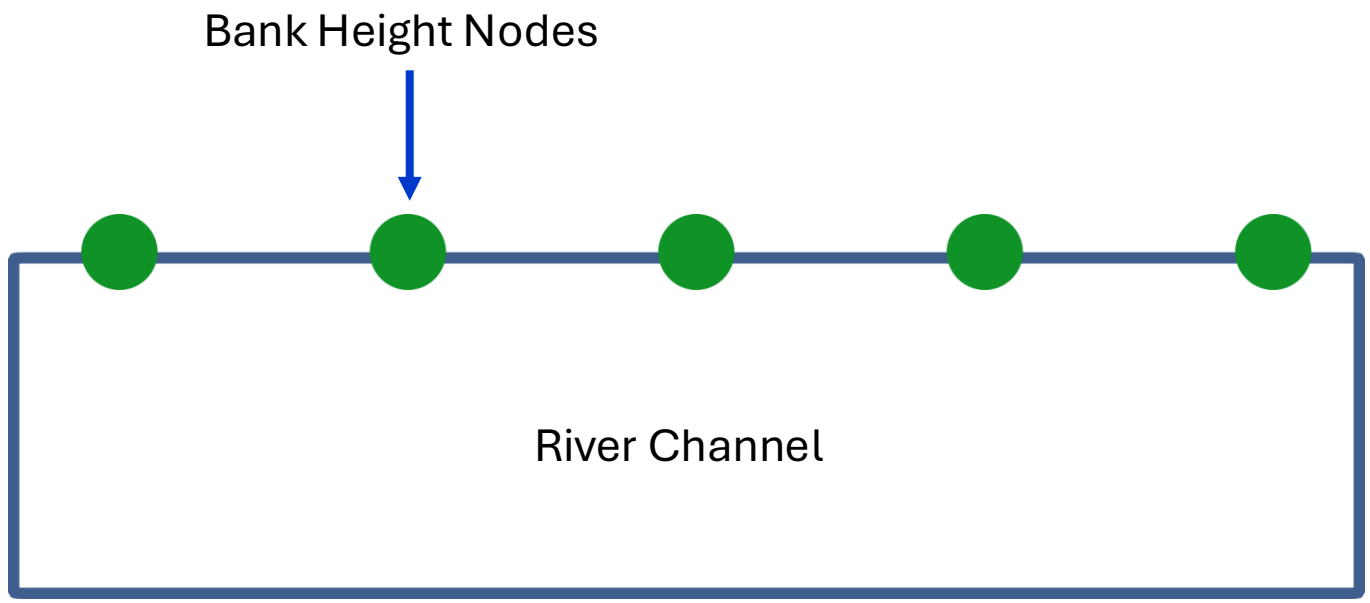
- Knowledge of floodplain topography has advanced enormously.
- River Channels are a critical parameterization in global flood inundation models – very limited direct measurements.
- Can be inferred if we know:
  - Water Surface Elevation (WSE)
  - Discharge (Neal et al 2021).





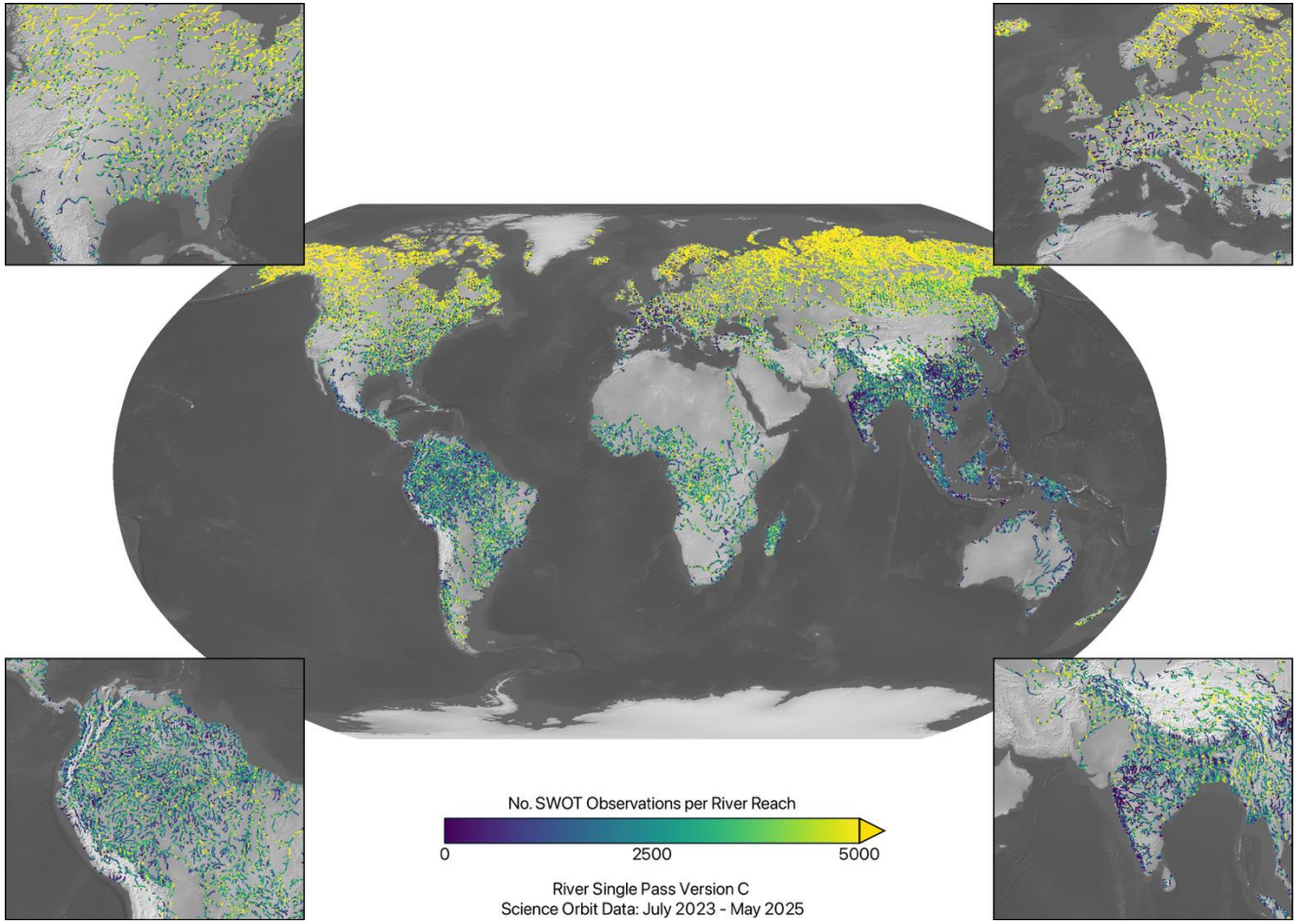
What's the current state of the art?

- Water surface elevation = DEM riverbank height (~1m accuracy)
- River Discharge = 1-in-2 discharge from model/statistical analyses
- Geometry = rectangular cross-section
- Channel bed elevation then calculated by inverting the Gradually Varied Flow equations



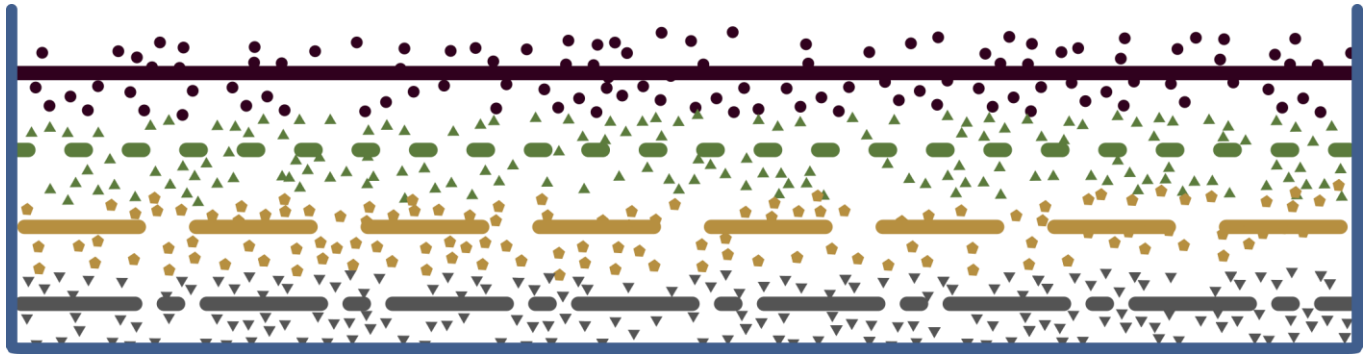
SWOT is a revolution in capability

- SWOT RiverSP Node Version C Data
- Science orbit July 2023 – May 2025
- 10 million locations
- >700 million WSE observations over this time.
- 0.1m accuracy – order of magnitude greater than previous assumptions



How can we use SWOT to improve channel geometry?

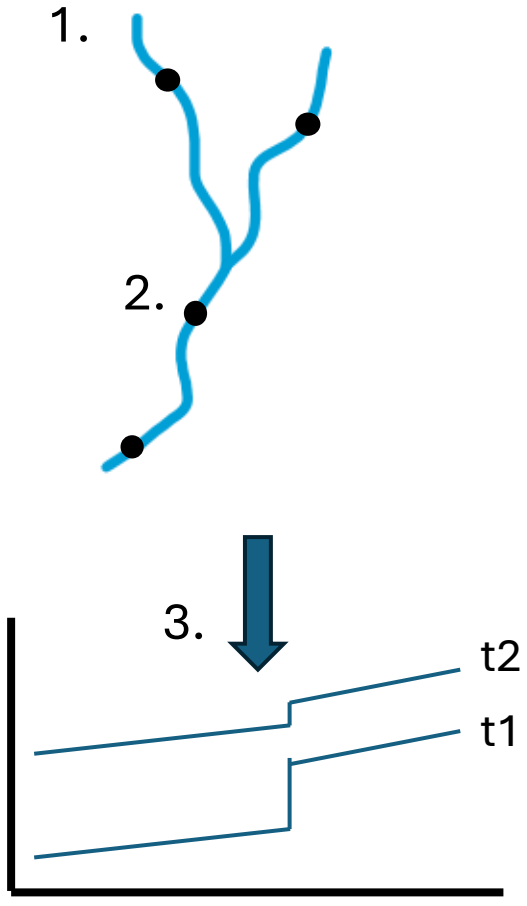
- Water surface elevation = multi-temporal directly from SWOT
- River Discharge = Contemporaneous observations/models
- Geometry = rectangular cross-section
- Channel bed elevation then calculated by inverting the Gradually Varied Flow equations

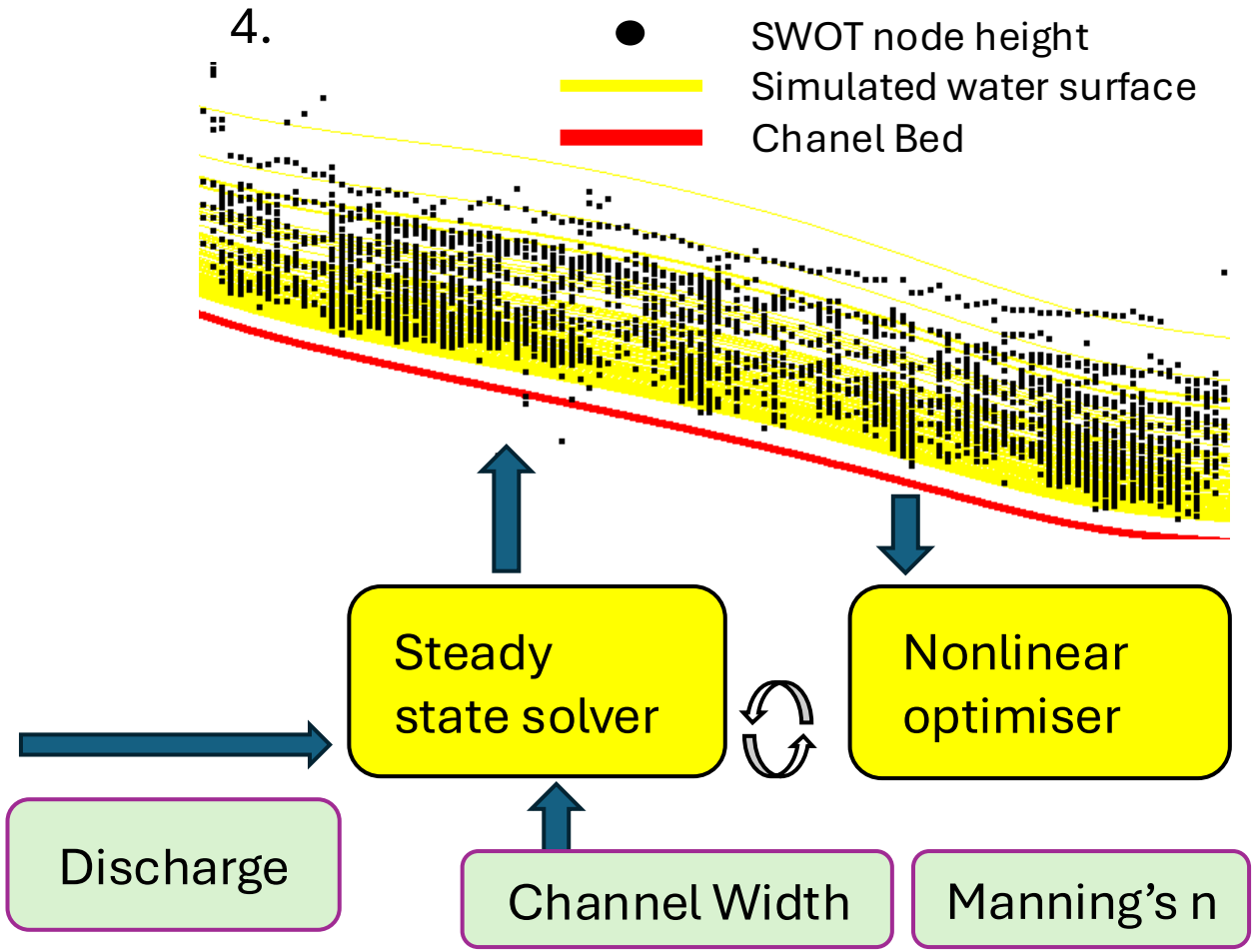


River Channel

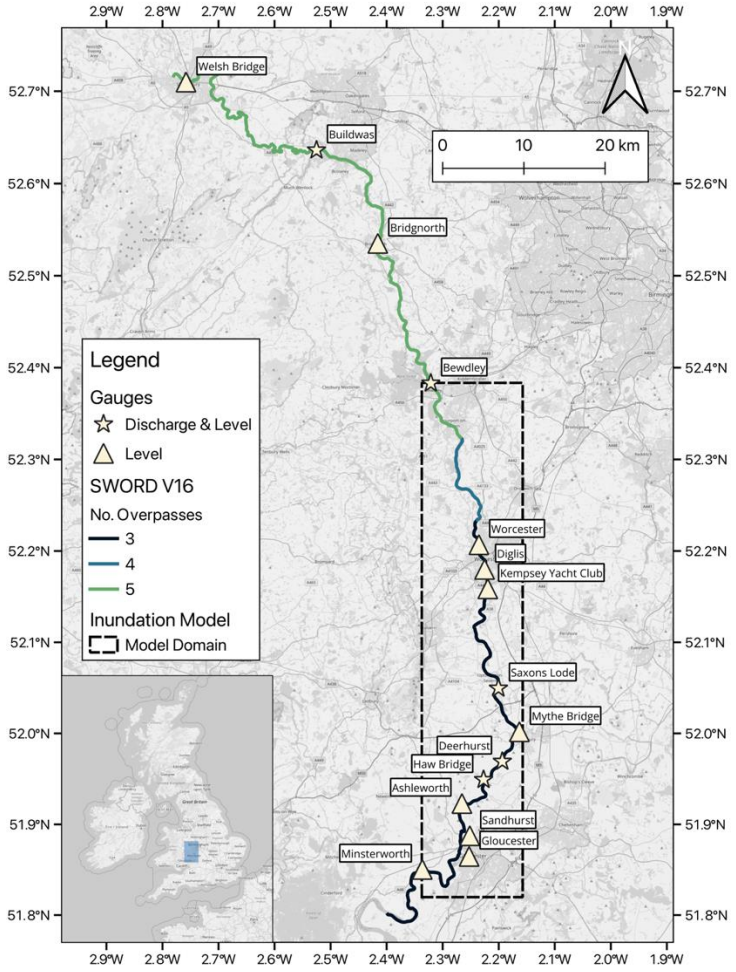
Solving channel bathymetry using a gradually varied flow (GVF)

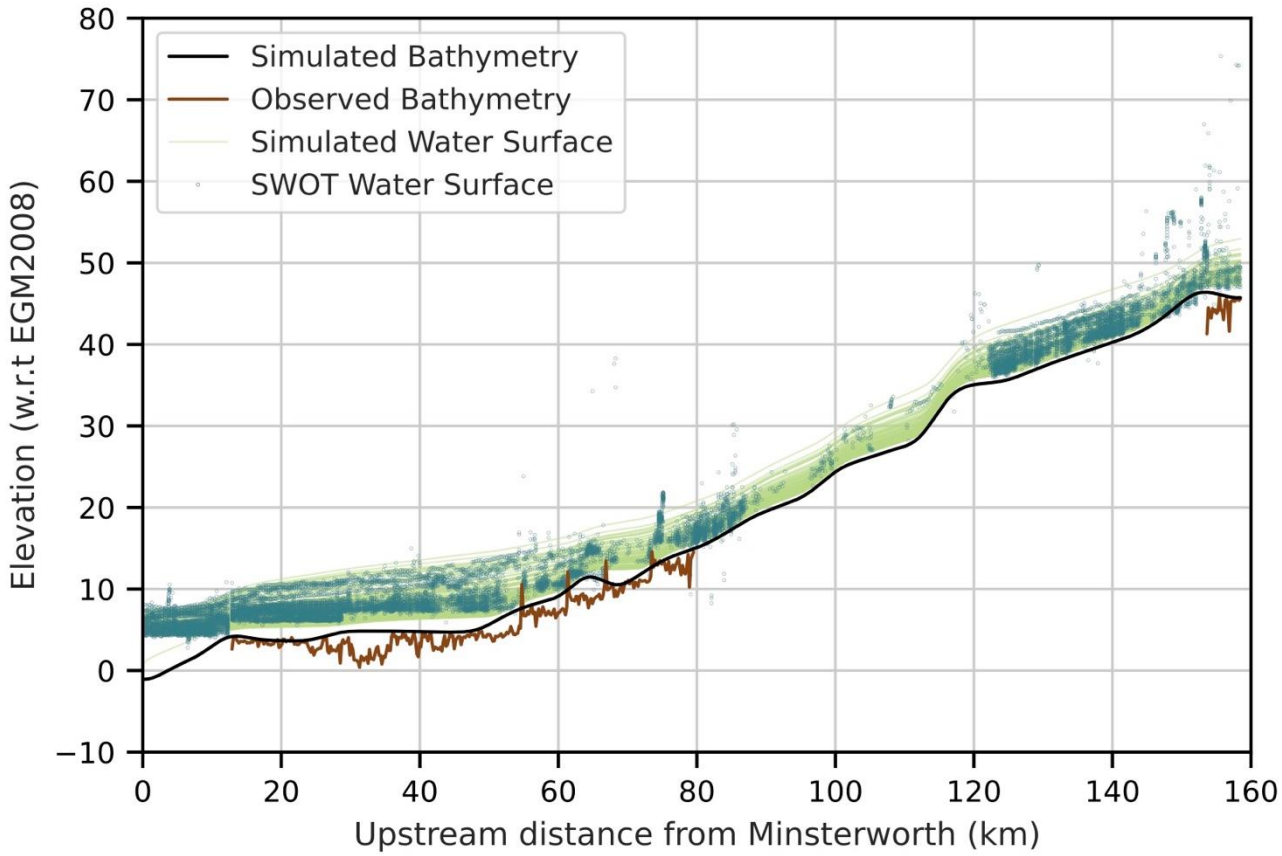
1. River Network
2. Discharge data (e.g., gauges)
3. Approximate steady state discharge for each SWOT overpass
4. Find bed that best simulates SWOT heights





Proof of concept – River Severn UK Case Study





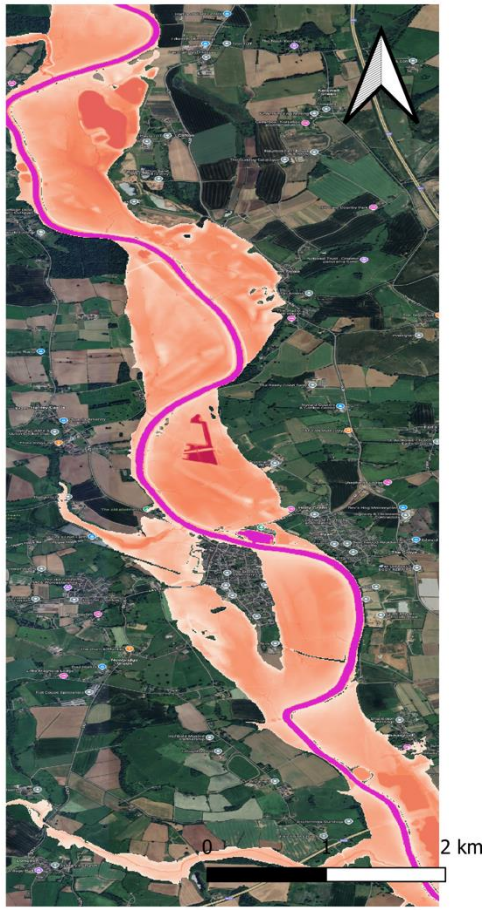
Source - Neal et al, 2025, ESS Open Archive . March 28, 2025

Proof of concept – River Severn UK Case Study

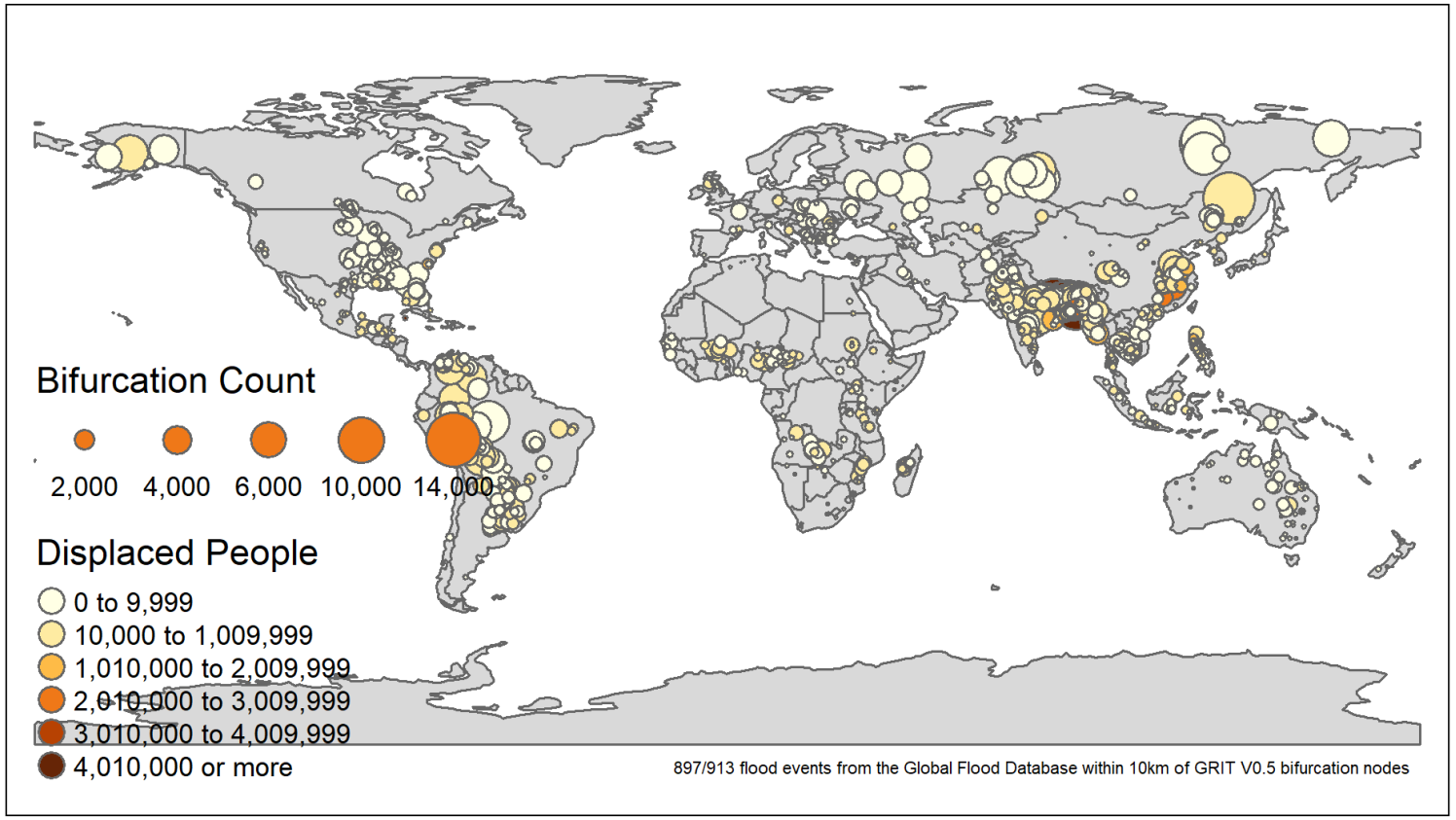
- Upton-Upon-Severn Model Comparison
- Simulation of winter 2000 floods
- Comparison of model outputs to airborne SAR data acquisition during flood event
- SWOT model bathymetry matches best in class field models.
- Baseline for global applications on SWORD

EA Sonar Bathymetry

SWOT Bathymetry



Going beyond single channel networks



- MODIS (250m resolution)
- 2000-2018
- Flood <10km from bifurcation node
- 913 floods recorded
- 98% floods have bifurcations

Tellman, B., et al https://doi.org/10.1038/s41586-021-03695-w

GRIT – Bifurcating River Bathymetry

SWOT River SP nodes

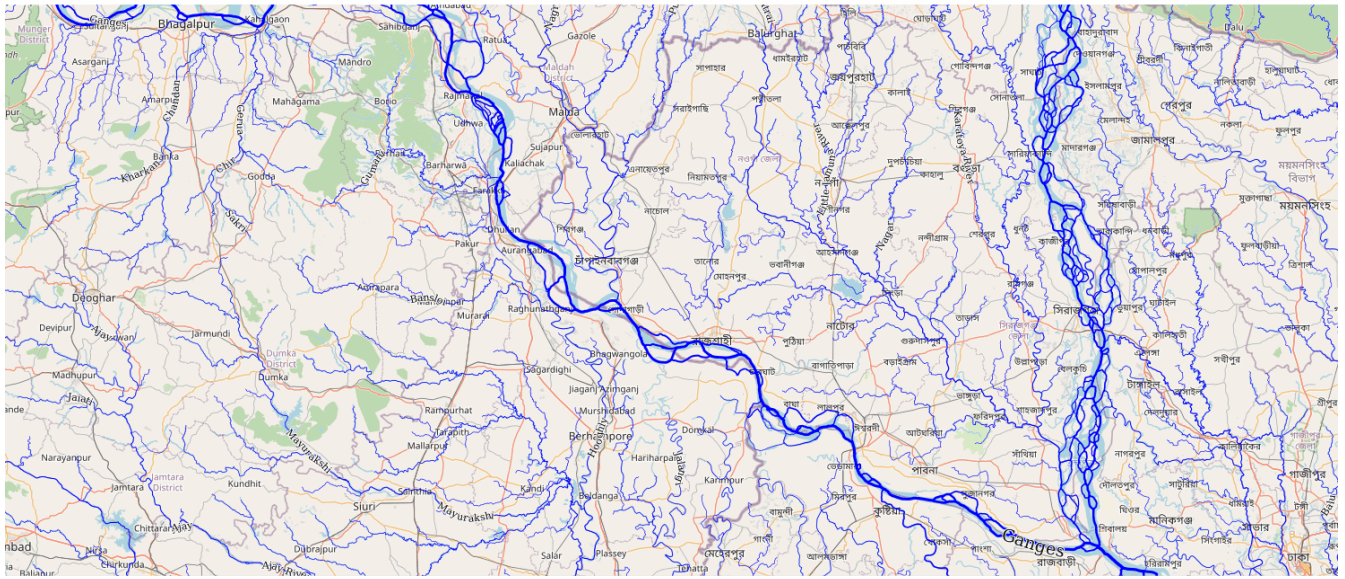
Fathom DEM

GRWL
(Allen & Pavelsky, 2018)

River bank elevations

GRIT
(Wortmann et al 2025)

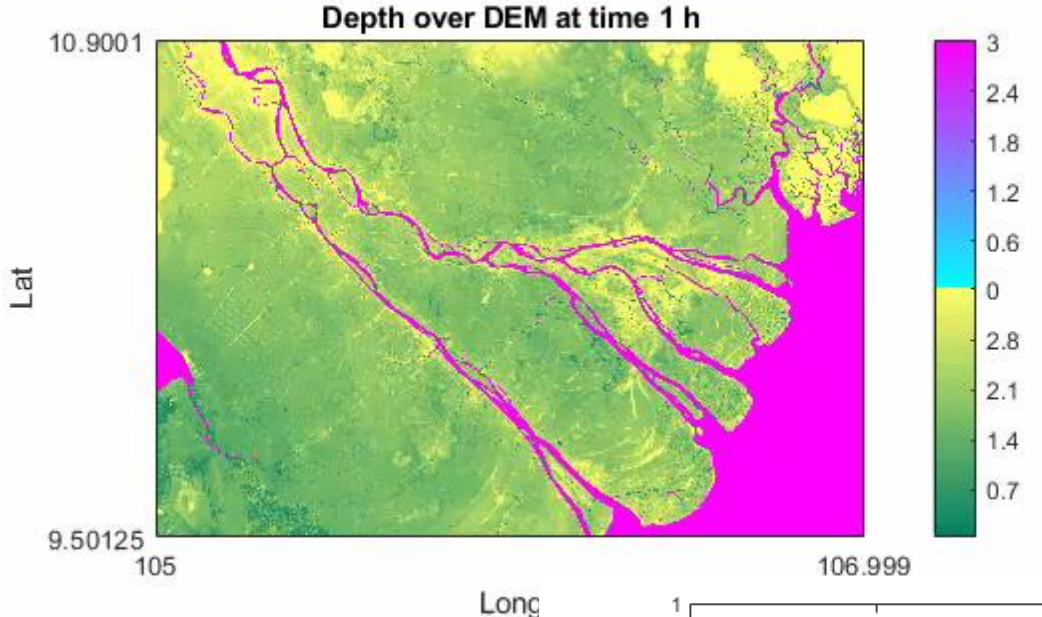
GRITv0.5 segments with river names



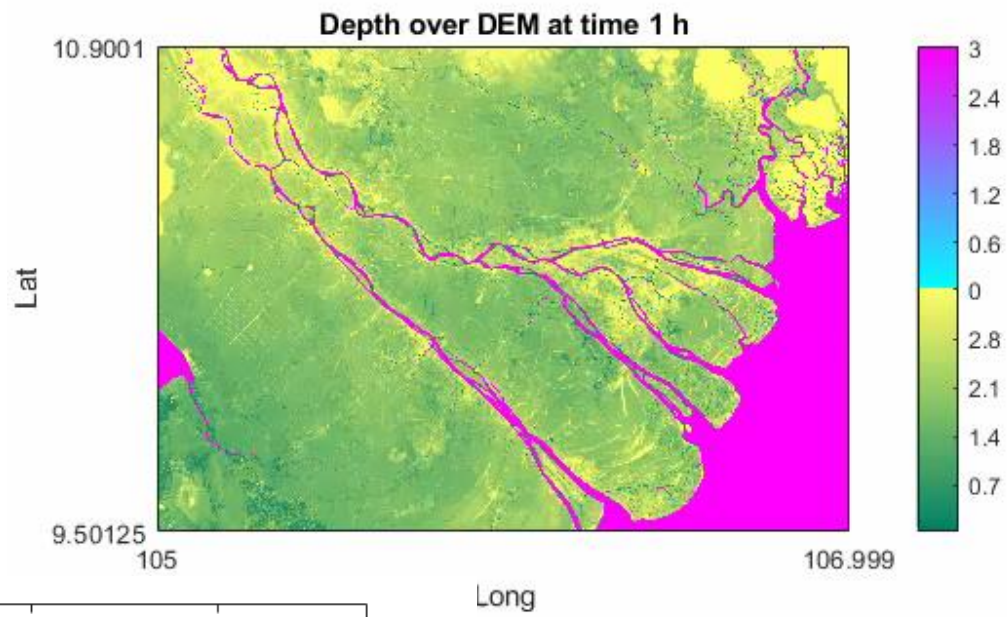
Wortmann et al 2025

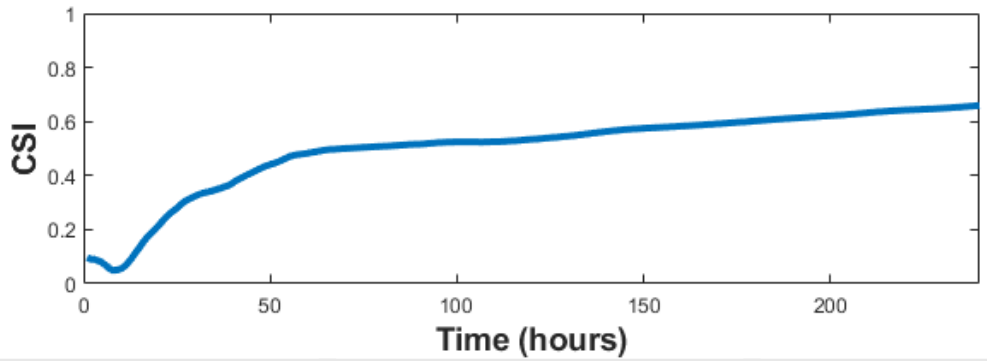
Mekong Delta Example

GRIT with bifurcations



GRIT no bifurcations





Summary

- SWOT is transformational for river geometry understanding
- Potential to go from 1m to 0.1m accuracy
- GRIT expands our knowledge to bifurcating channels to simulate complex flood dynamics.
- Bathymetry is dependent on discharge data source used – will be specific to model.
- Only the beginning – SWOT can see much smaller rivers than <50m width