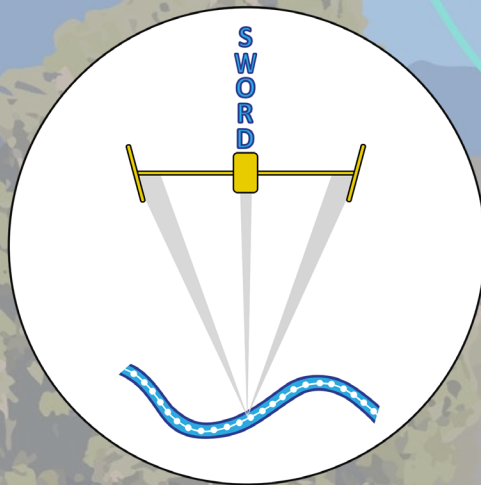# SWOT, SWORD, and River Flow Routing

Tamlin Pavelsky, Elizabeth Altenau, Elyssa Collins, Jake Gearon

University of North Carolina at Chapel Hill
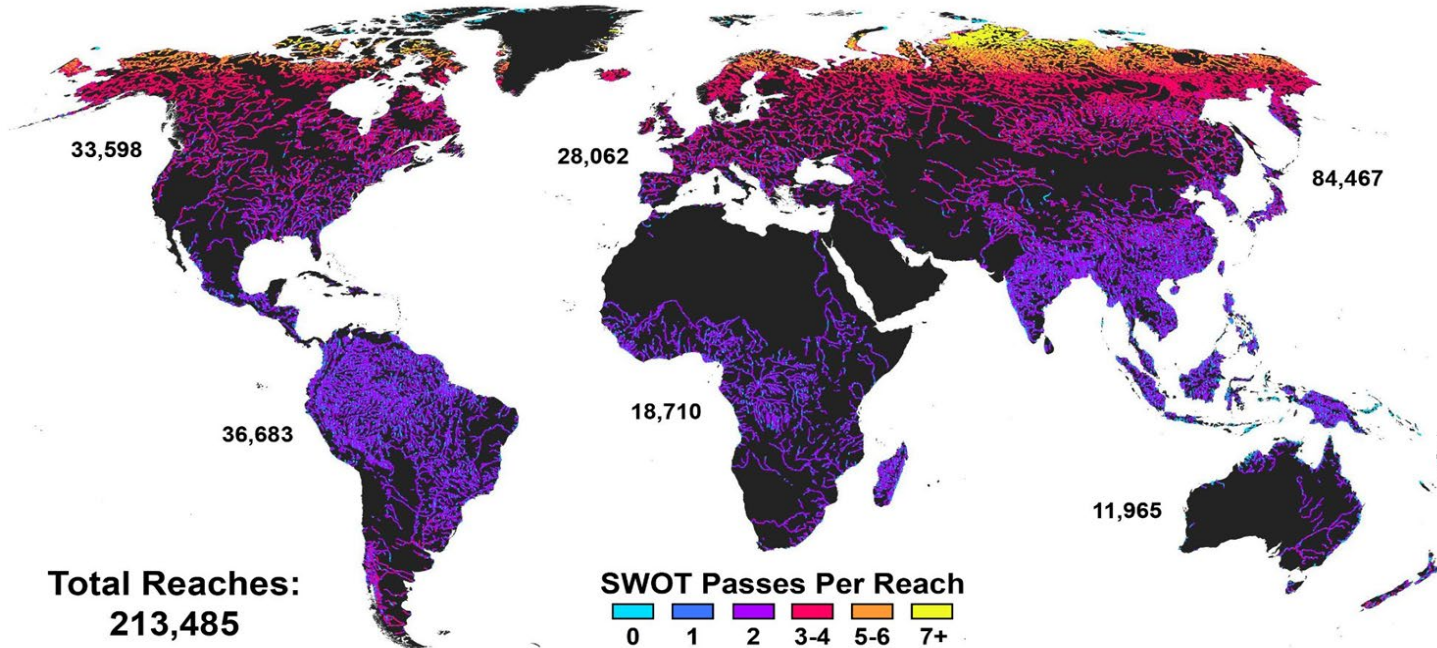
October 14, 2025
SWOT Science Team Meeting
Arcachon, France

SWORD: The SWOT River Database

Goal: provide a vectorized framework for SWOT river data products

Origin: Work began in 2014 (i.e. before GRWL, MERIT-Hydro)

33,598

28,062

84,467

36,683

18,710

2021 SWORD Paper

11,965

Total Reaches:
213,485

SWOT Passes Per Reach

| 0 | 1 | 2 | 3-4 | 5-6 | 7+ |

SWORD Requirements

Provide ~10 km reaches that:

- Break at tributary junctions, obstructions (e.g. dams), and do not cross SWOT swath boundaries.
- Represent rivers in a way such that many years of data can be attached to the same set of centerlines to enable multitemporal analysis.
- Ensure that reaches are generally perpendicular to the direction of flow so that slope and width make sense (not just WSE).

Divide reaches into ~200 m nodes.

Overall goal is to make the SWOT river data products as useful as possible for the hydrology community.

Geolocated RiverSP Pixel Assignments to Nodes

River Reach WSE Profile
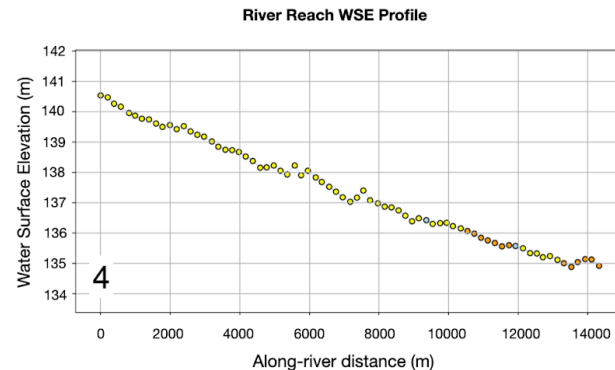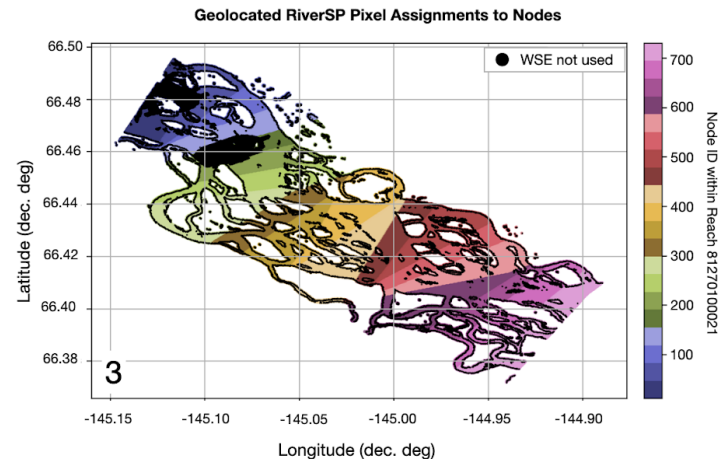
SWORD Topology Challenges

When first developing SWORD:

- **Chose optically derived centerline to represent river complexity greater than available from DEMs alone.**

- **Global hydrography datasets were limited - MERIT-Hydro was not published yet.**

- **Topology was not considered a critical variable**

Ob River, Siberia

MERIT Hydro Vector
SWORD
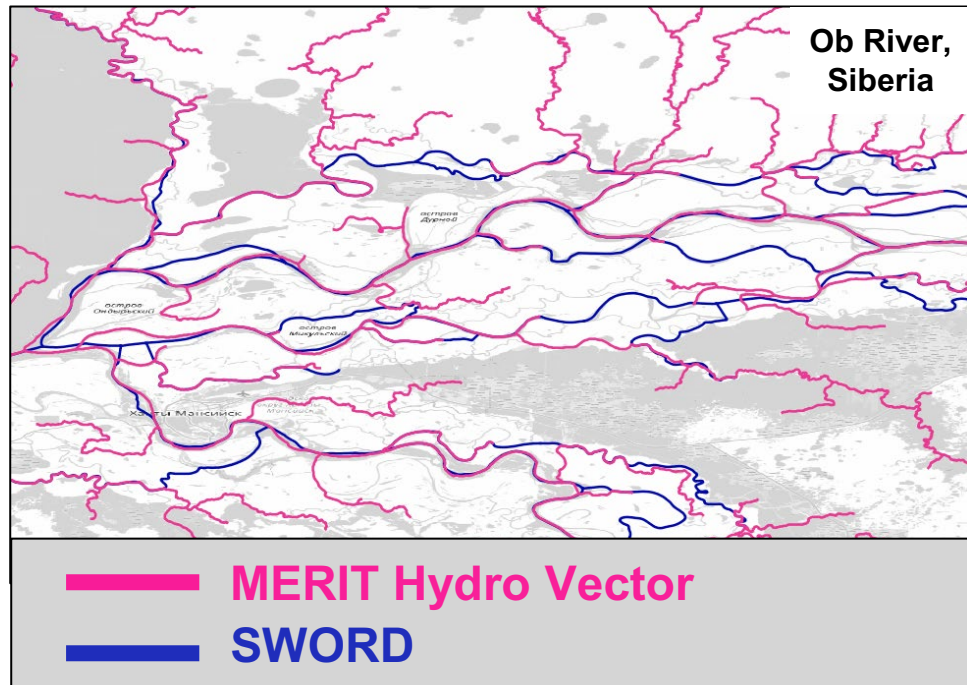
SWORD Topology Challenges

Consequences of optically-derived centerlines:

- **Typical variables used for topology have errors / inconsistencies due to merging problems in areas where centerlines don't match well.**

- **Discontinuities are more common in the river network.**

- **Small localized errors can lead to large propagations upstream.**
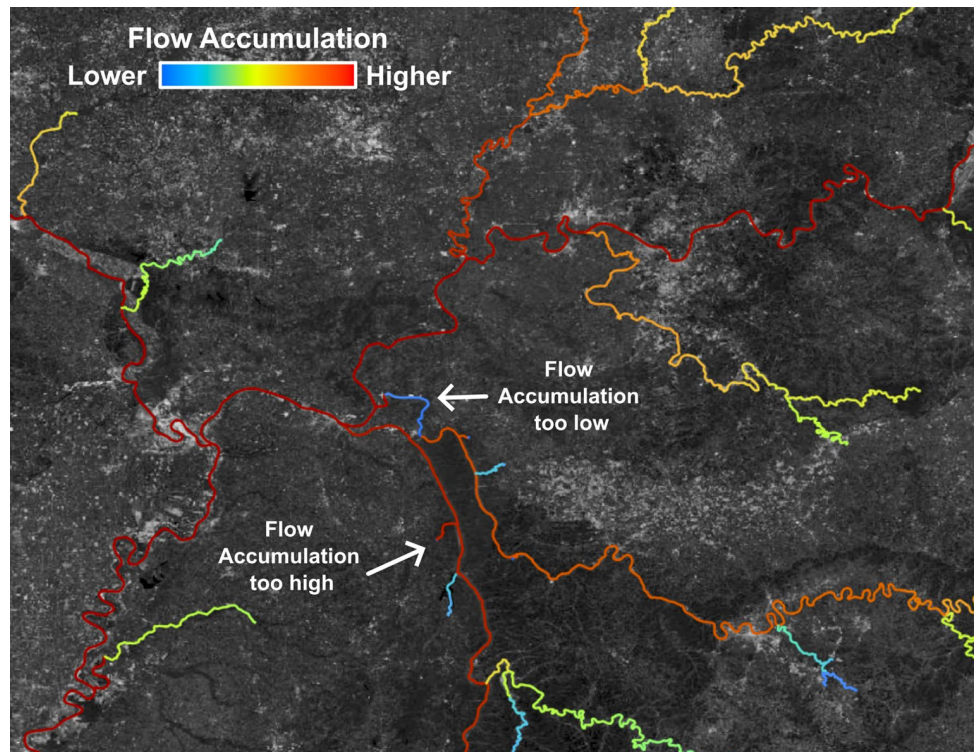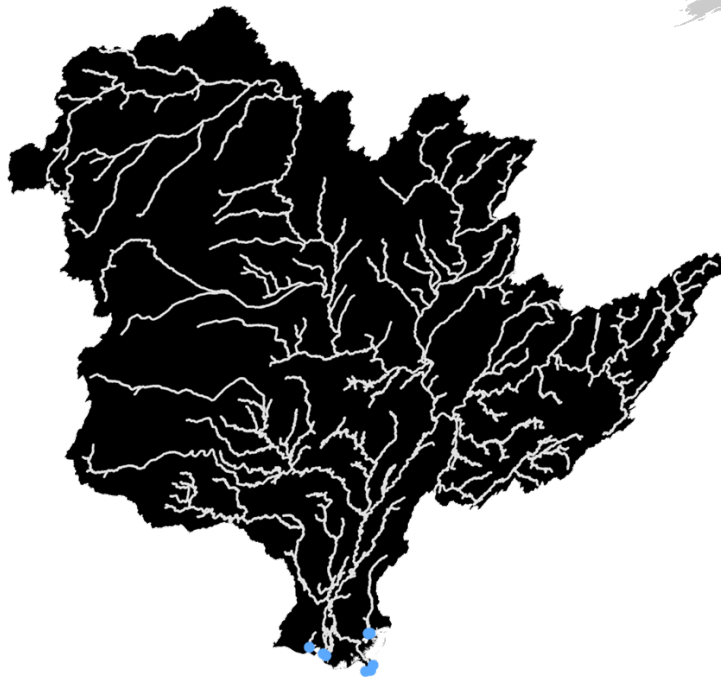
Solution

Needed a SWORD-based variable for calculating topology.

Method:
Built a new distance from outlet variable based on pathways from outlets to headwaters.

Used a shortest path algorithm to map all paths from every outlet to all associated headwaters

Mississippi Basin

● Outlets

Solution

Needed a SWORD-based variable for calculating topology.

Method:
Built a new distance from outlet variable based on pathways from outlets to headwaters.

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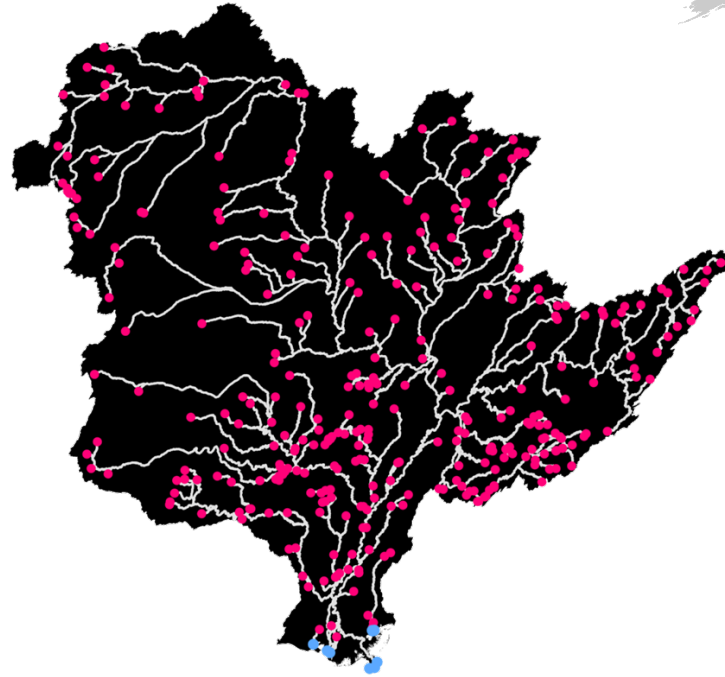

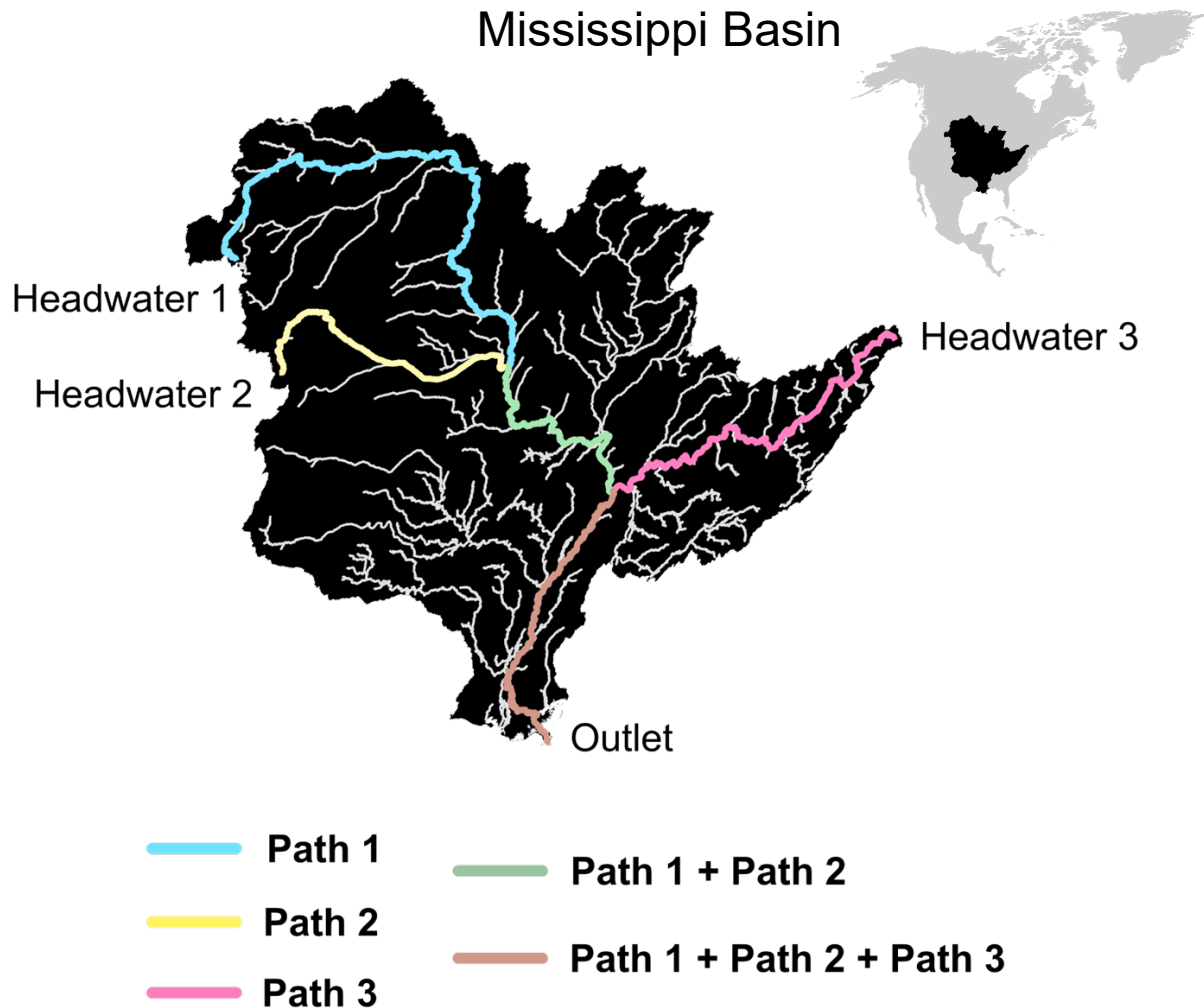Mississippi Basin

● Outlets

● Headwaters

Solution

Needed a SWORD-based variable for calculating topology.
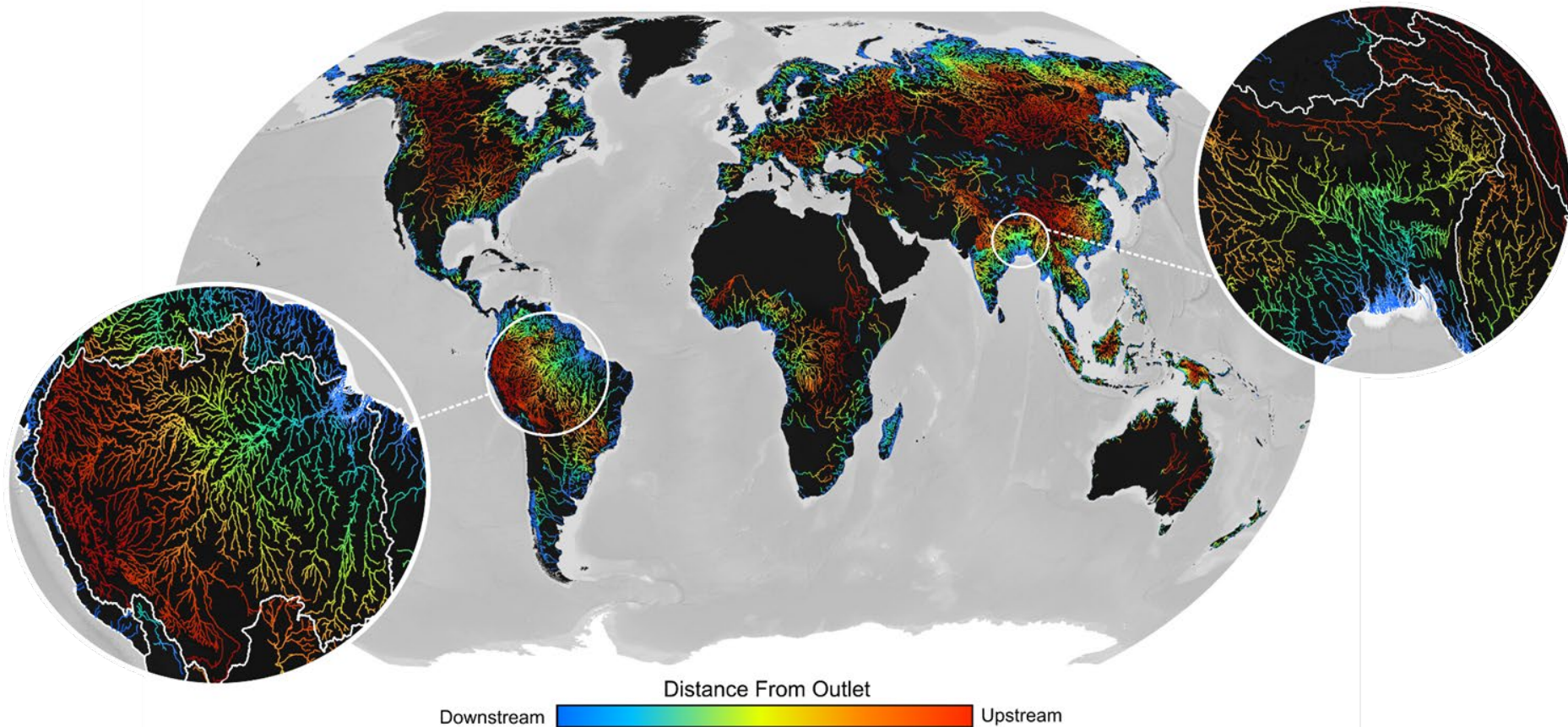
Method:
Built a new distance from outlet variable based on pathways from outlets to headwaters.

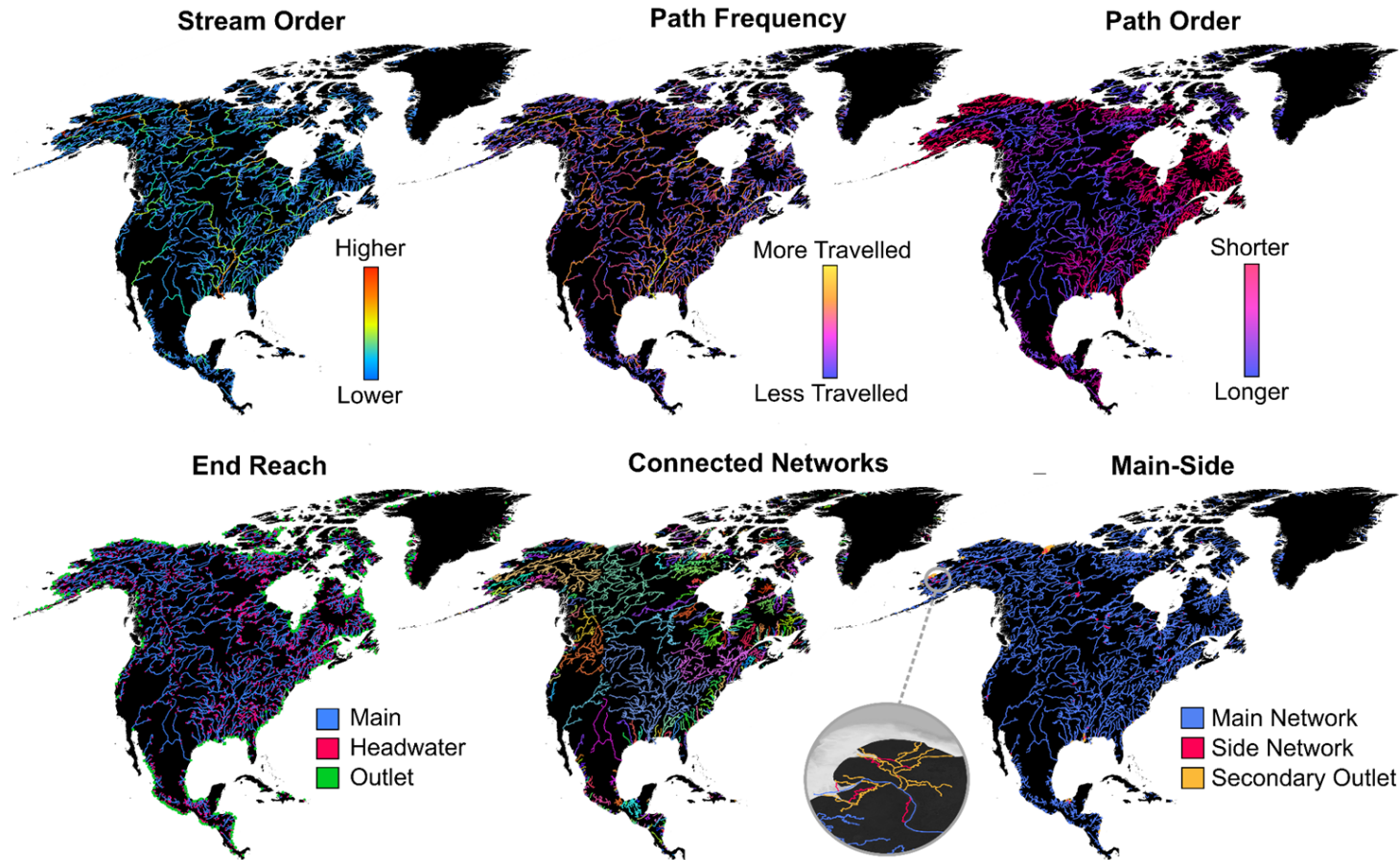**Used a shortest path algorithm to map all paths from every outlet to all associated headwaters**

Mississippi Basin
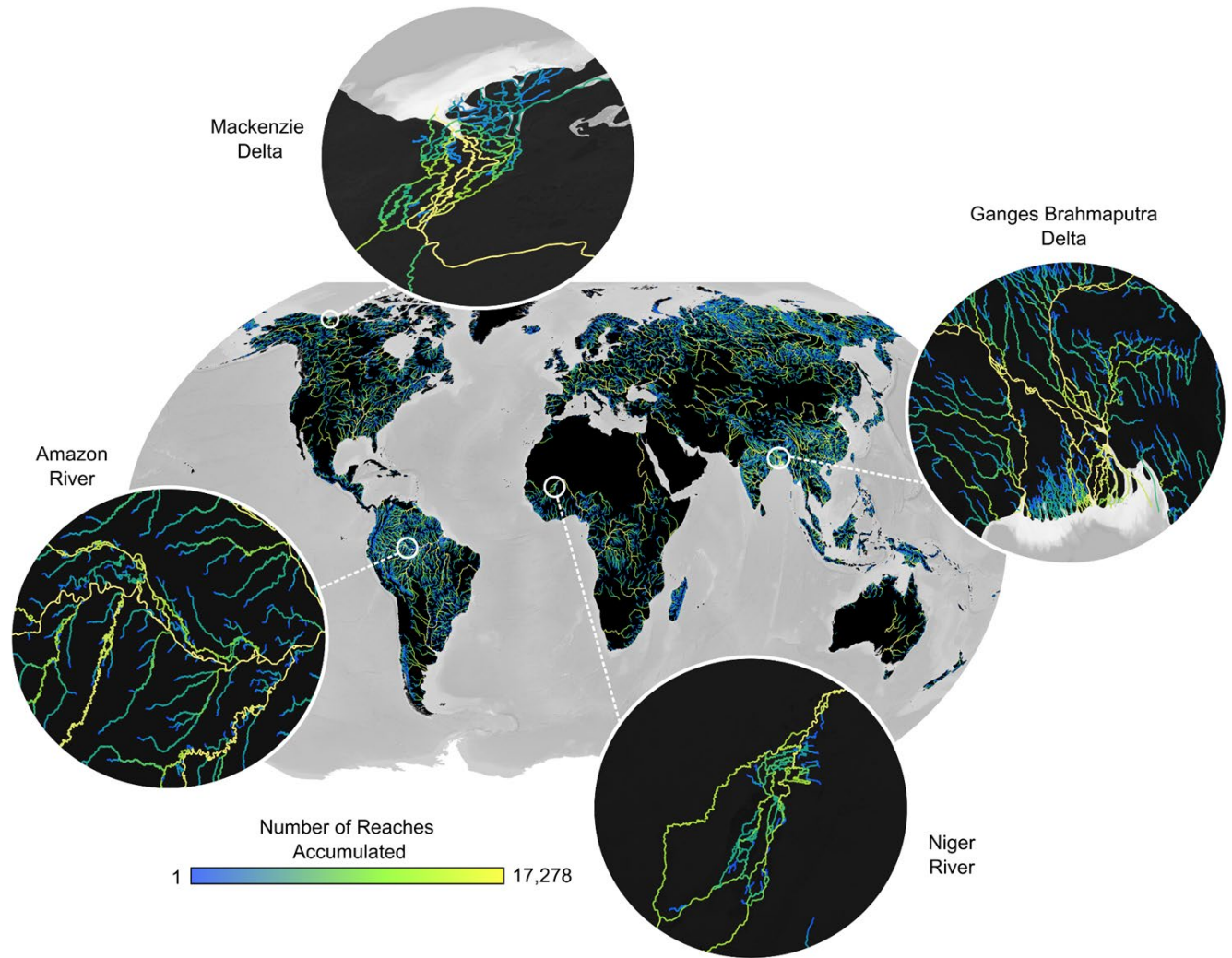
Headwater 1

Headwater 2

Headwater 3

Outlet

Path 1

Path 2

Path 3

Path 1 + Path 2

Path 1 + Path 2 + Path 3

New Distance from Outlet

Distance From Outlet

Downstream — Upstream

New Additional Path-Based Variables

Stream Order

Path Frequency

Path Order

Higher / Lower

More Travelled / Less Travelled

Shorter / Longer

End Reach
- Main
- Headwater
- Outlet

Connected Networks
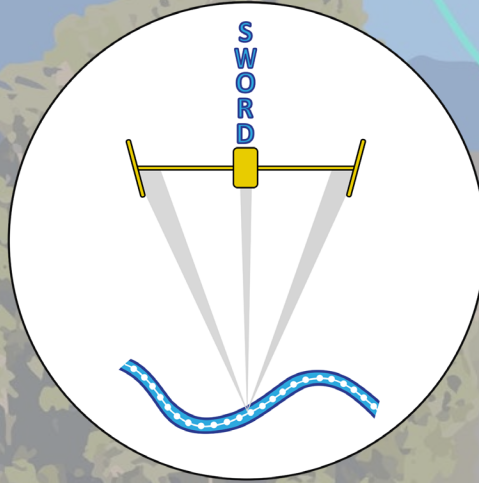
Main-Side
- Main Network
- Side Network
- Secondary Outlet

VALIDATION

Automatic
Consistency
Checks
+
Modified Lumped
Routing Code
to Visualize
Topology

**Algorithm by
Dr. Elyssa Collins***

Mackenzie
Delta

Ganges Brahmaputra
Delta

Amazon
River

Number of Reaches
Accumulated

1 — 17,278

Niger
River

Collins et al., *WRR*, Accepted

Next Steps

The current version of SWORD is v17b.

We are working on a v17c and v18 for future release.

v17c   vs.   v18

- Reach/Node IDs identical to V17b

- Updated connectivity, flow direction, etc.

- May or may not be used directly to process SWOT data

- Timing: hopefully within the next year

- Major updates to Reach/Node IDs

- Changes to reach geometry and representation

- Will not be finished or used until Version E reprocessing

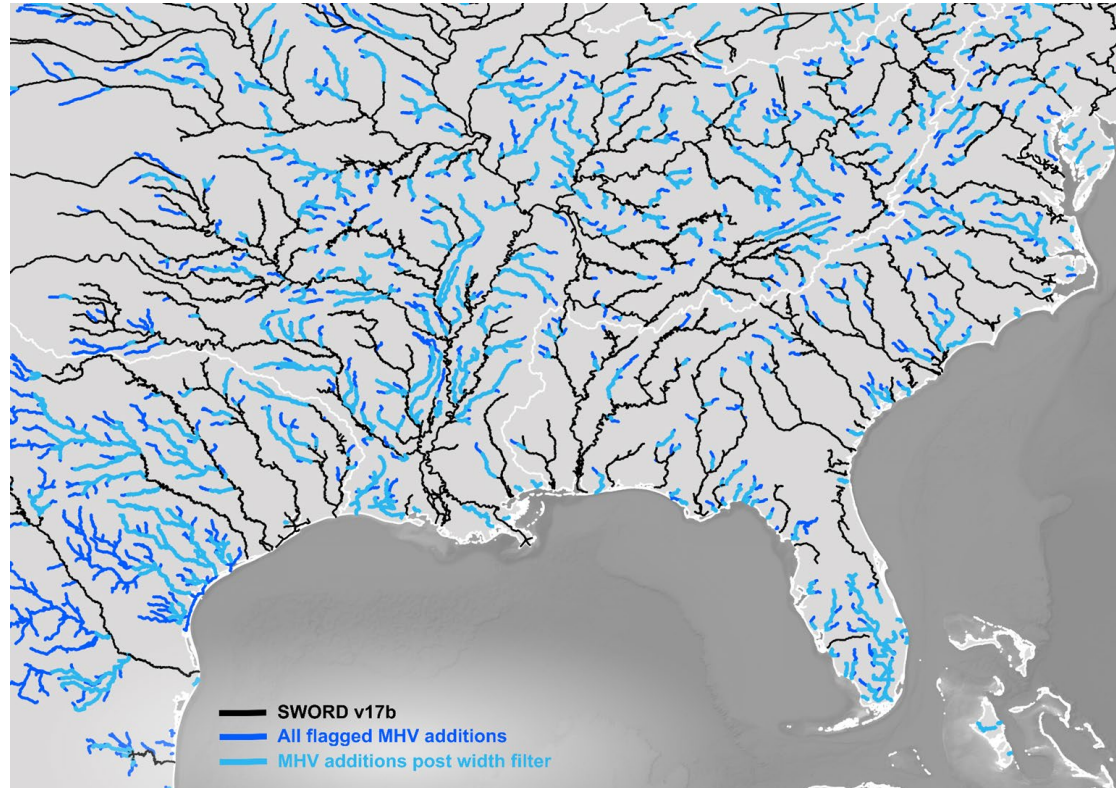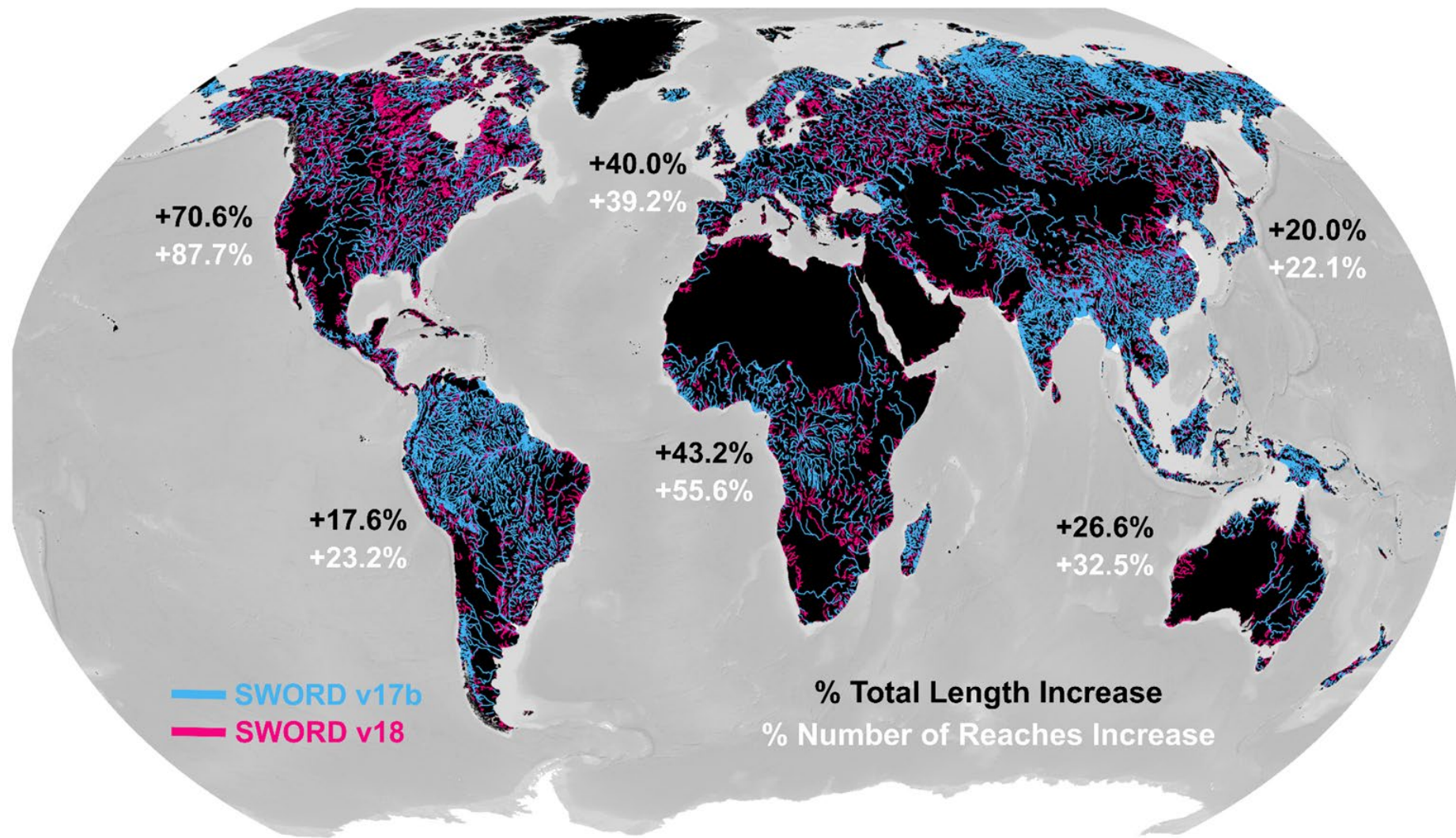- Timing TBD, but not soon

Rest of presentation about v18

SWORD Extensions

Process:

Centerline extensions based on MERIT Hydro Vector (MHV):

- MHV rivers >= 30 meters at join site (down to stream order 3) that are not included in SWORD.
- MHV additions must have a good location match with joining SWORD rivers (within a radius of 200 m).
  - i.e. don't attempt additions in complex multichannel rivers or deltas.
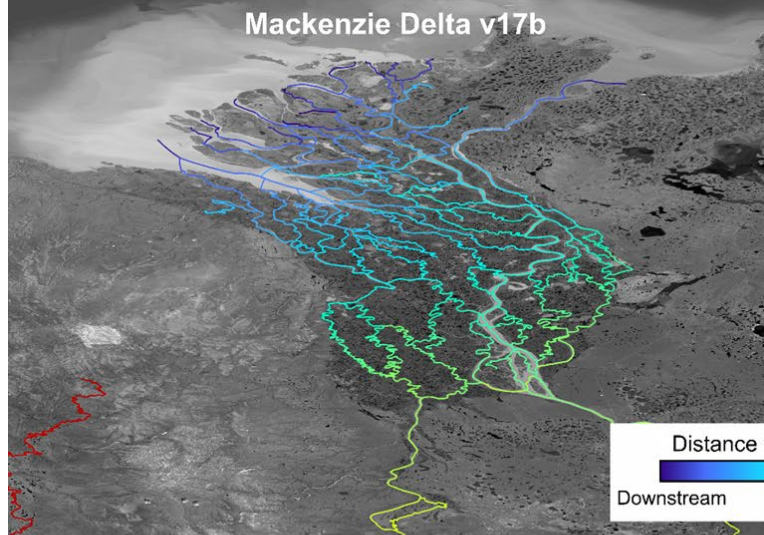- Width is used to filter out upstream MHV reaches with zero width values.

SWORD v17b
All flagged MHV additions
MHV additions post width filter

+40.0%
+39.2%

+70.6%
+87.7%

+20.0%
+22.1%

+43.2%
+55.6%

+17.6%
+23.2%

+26.6%
+32.5%

SWORD v17b
SWORD v18

% Total Length Increase
% Number of Reaches Increase
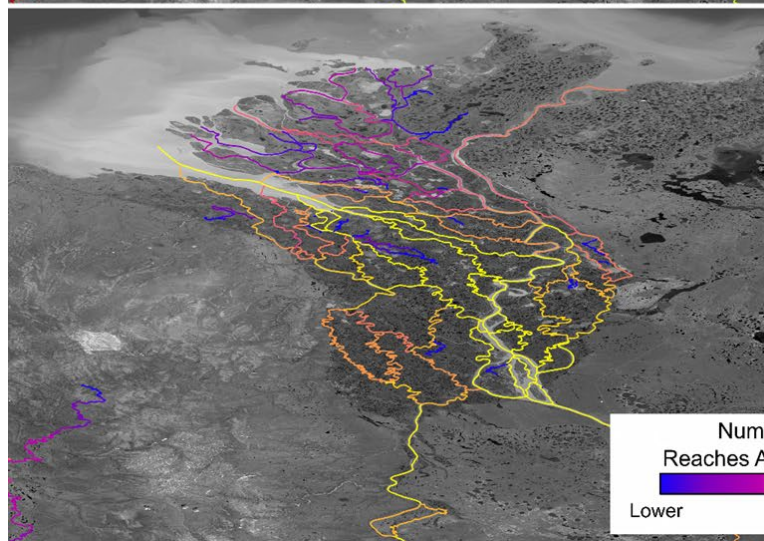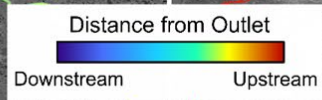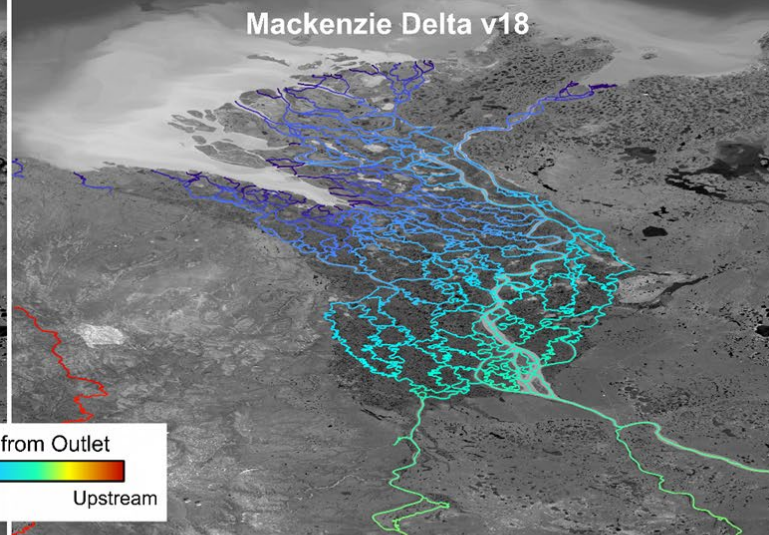
Delta Updates

Process:

- Working with Paola Passalacqua's PassaH2O Team at UT Austin/ETH Zurich and Collaborators.

- The PassaH2O Team provides the centerlines and topology.

- UNC integrates the new centerlines and topology into SWORD.
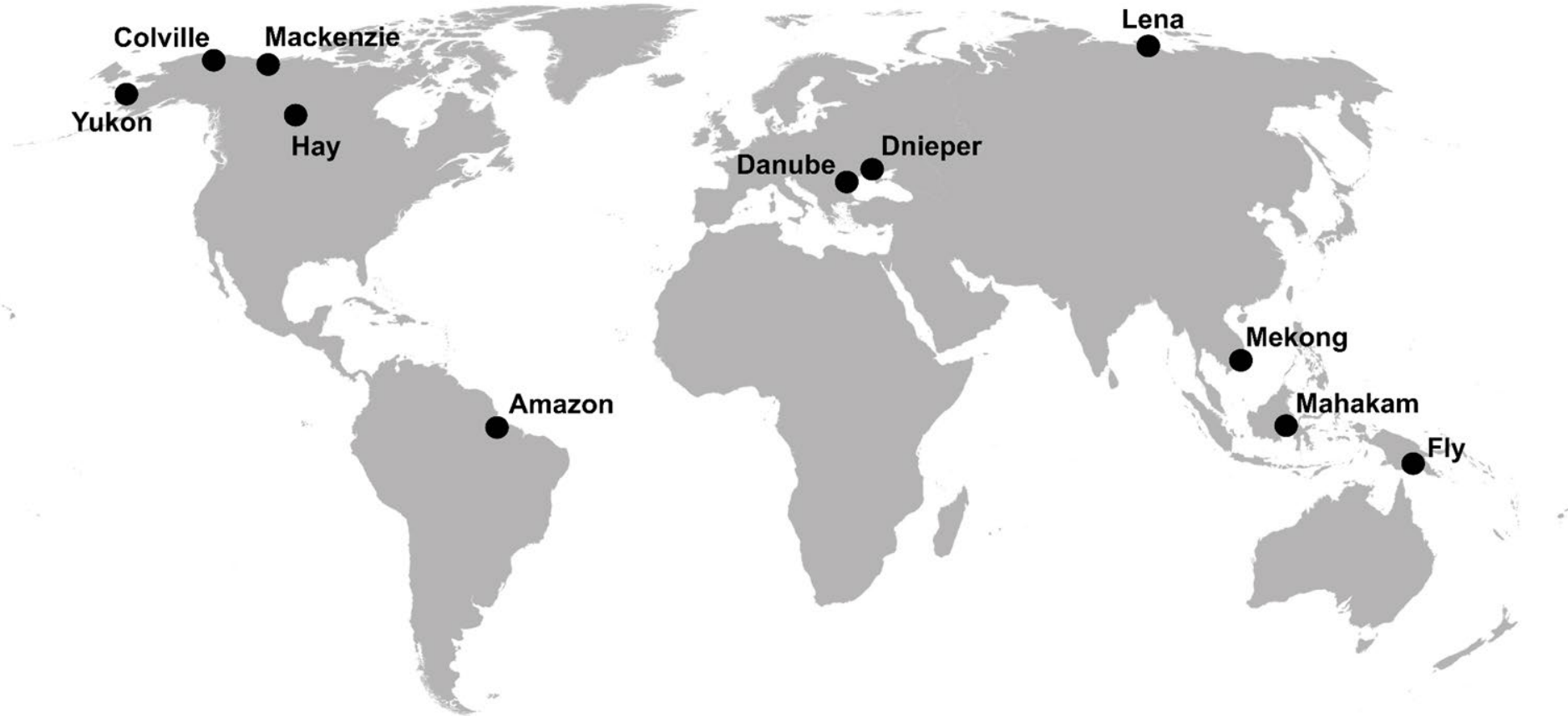
- Plan is to update 40+ deltas.

Mackenzie Delta v17b

Mackenzie Delta v18

Distance from Outlet

Downstream — Upstream

Number of
Reaches Accumulated

Lower — Higher
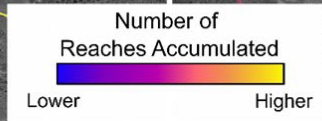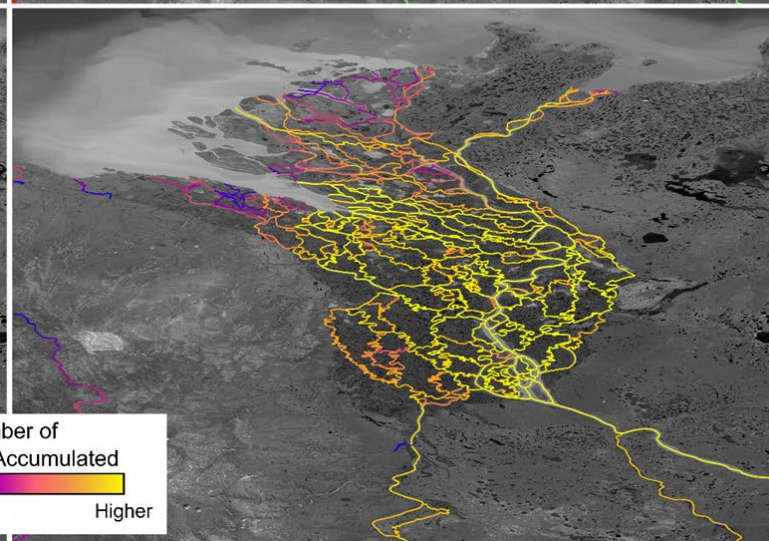
Deltas updated in SWORD v18 so far:

Planned Updates

Centerline shifting
- Original geolocation errors in the Global River Widths from Landsat (GRWL) water masks resulted in some SWORD centerlines being shifted away from the true river center.
- Most prevalent in North America.
- Plan to fix as many locations as possible.

Multichannel rivers
- Many multichannel rivers are represented with a single-channel, effective centerline.
- Plan to update multichannel rivers to have multiple centerlines where it makes sense for SWOT processing algorithms.

Plan is to use JRC global surface water occurrence data for flagging offset rivers, then use MERIT Hydro Vector locations to guide shifting the SWORD centerlines.

Pre-shift centerlines
Post-shift centerlines
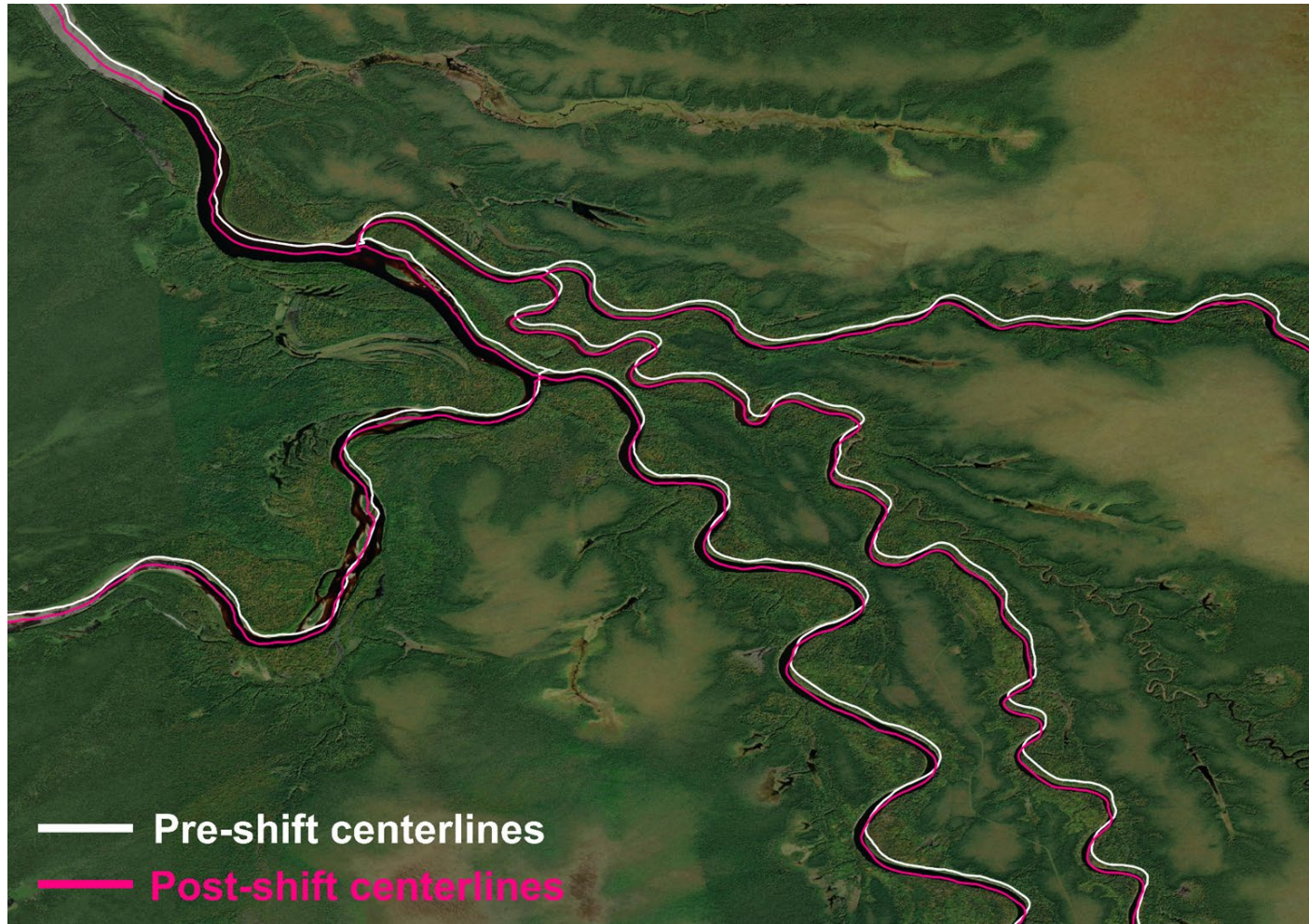
Ideal multichannel rivers to update are large, anabranching rivers with stable islands. Braided rivers are best kept single channel because the braids are often unstable in time.

Plan is to use build updated centerlines using RivGraph software, then integrate the new centerlines into SWORD.

SWORD v17b

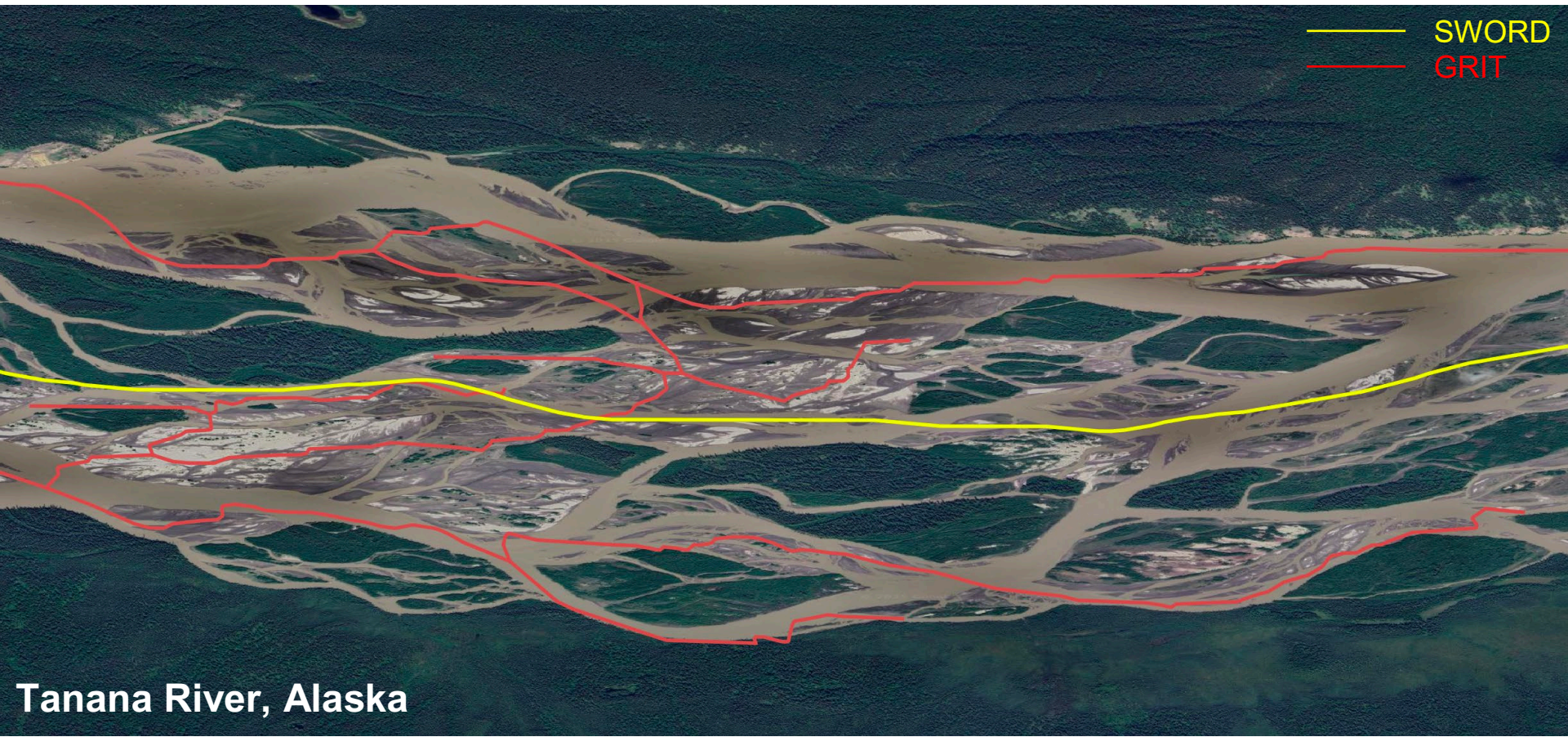Example Centerline Updates

Tanana River, AK

Summary

- SWORD v17b represents relatively large rivers globally including bifurcations in some places (but not all) and with fairly accurate topology.

- SWORD v17c will provide updates to some key fields, but not to reach geometry.

- SWORD v18 will include more rivers, reduced location errors, and better representation of deltas

- SWORD v18 also will improve representation of multichannel rivers, but we're still working on exactly how. Collaborations welcome!
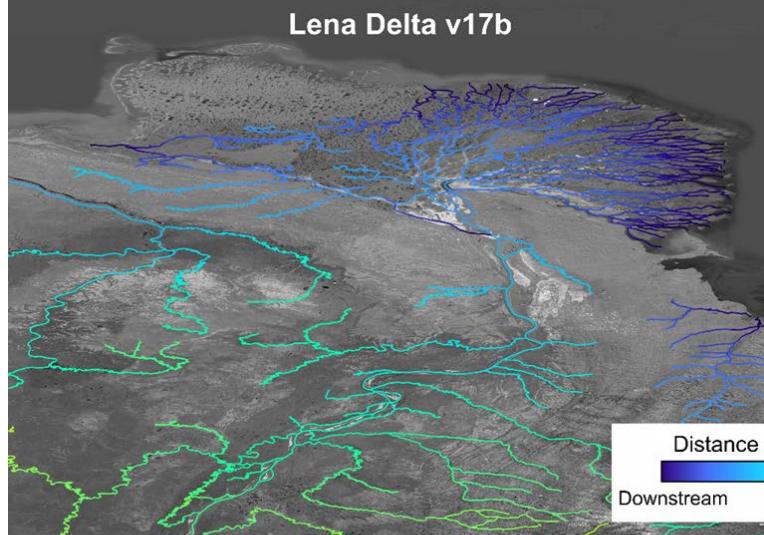
Why Not Just Use GRIT?

Tanana River, Alaska

Lena Delta v17b | Lena Delta v18

Distance from Outlet
Downstream — Upstream

Number of Reaches Accumulated
Lower — Higher