US Geological Survey SWOT Agency Perspective

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SWOT
SURFACE WATER & OCEAN TOPOGRAPHY

USGS
science for a changing world

Overview

Background

Agency Perspective

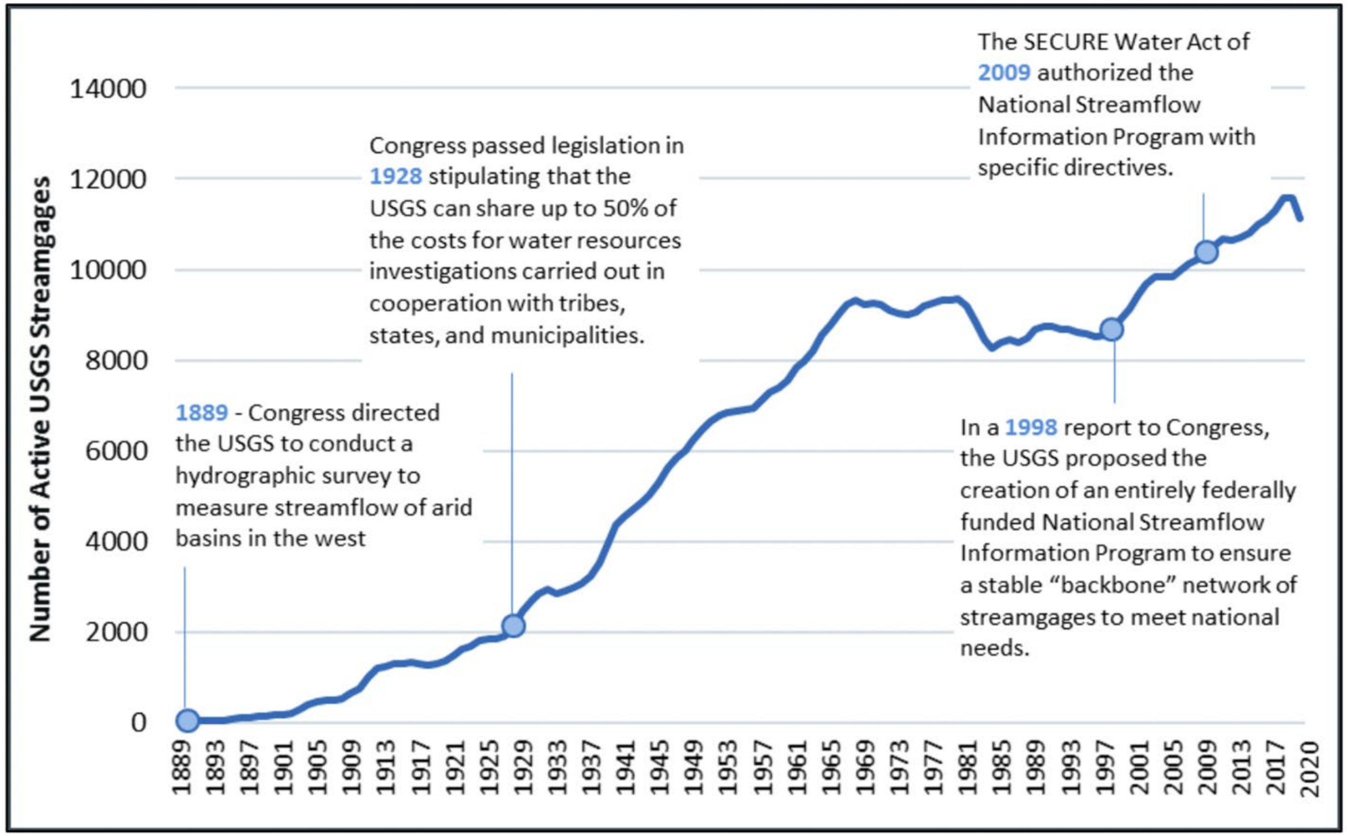
Current SWOT involvement

Moving forward

USGS discharge data

US has > ~250,000 rivers, 30 million stream reaches

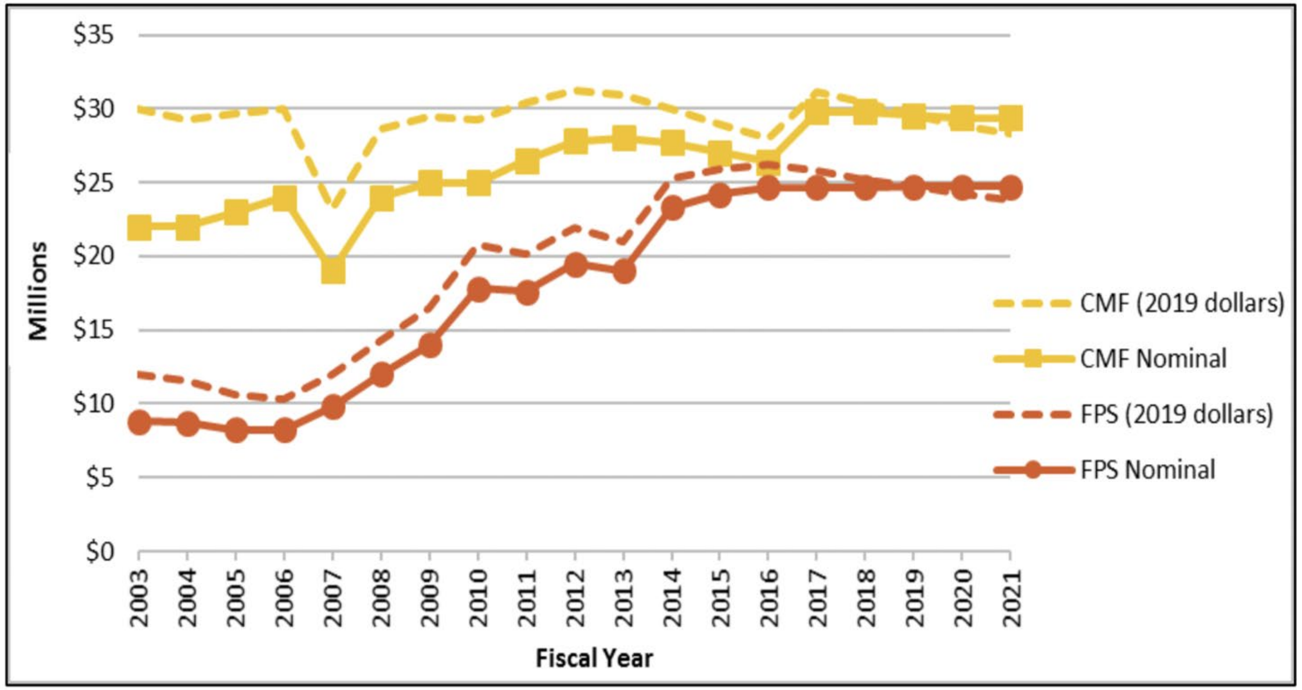
Figure 6. Number of USGS Streamgages and Policy Changes over Time



March 2, 2021 Report:
[*"U.S. Geological Survey (USGS) Streamgaging Network: Overview and Issues for Congress"*]

USGS discharge data

Figure 8. USGS Funding for the Streamgaging Network



Approximate Cost of USGS Streamgages

Capital costs for equipment and installation:

- $25,000 - $40,000 for a standard streamgage depending on the site conditions.
- $35,000 - $110,000 for a supergage depending on sensors and the site conditions.
- $15,000 for RDGs.

Annual costs for operation and maintenance:

- $16,500 - $32,000 for continuous streamflow measurements with a standard streamgage depending on site conditions. Costs decrease by half if measuring stream stage height only and proportionally if measuring seasonally.
- $26,000 and $135,000 for supergages depending on site conditions and the type and number of sensors.
- $4,000 per event for RDGs.

FPS: Federal Priority stream gauge
CMF: Cooperative Matching Funds
RDG: rapid deployment gauge

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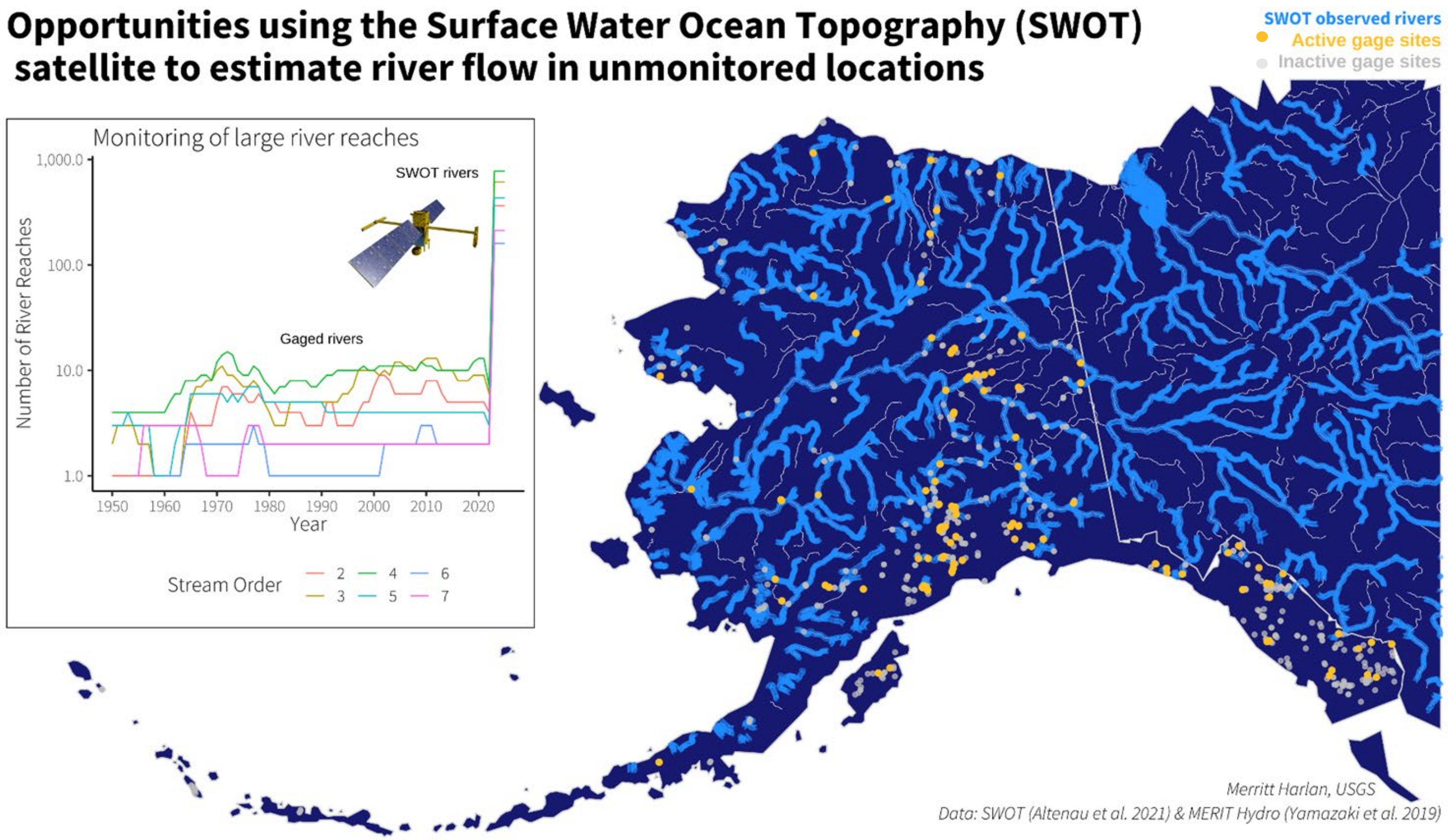
USGS monitoring- SWOT perspective



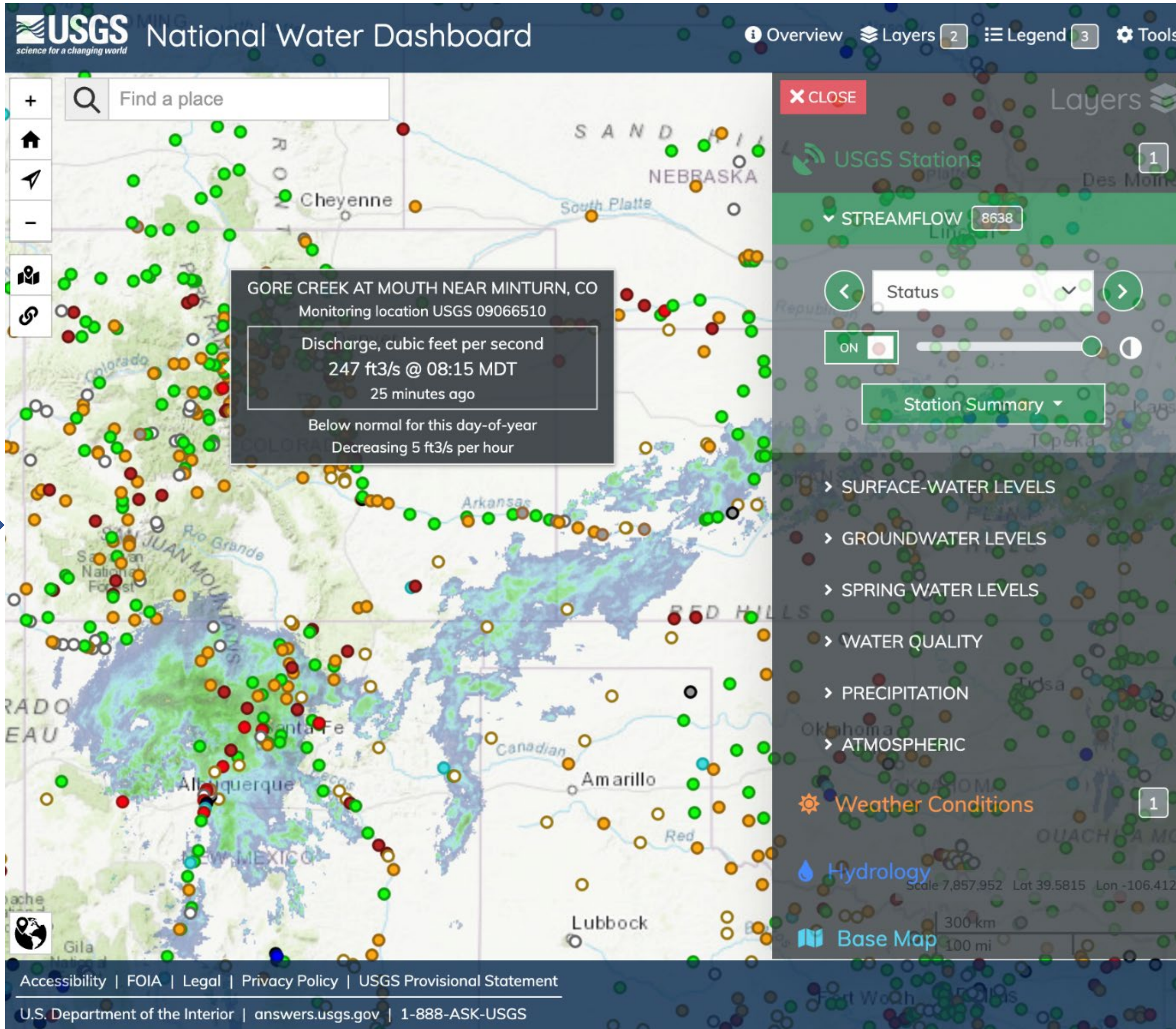
Possible SWOT linkages USGS Water Mission Area Priorities

Observe	**Next Generation Water Observing System (NGWOS)** NGWOS collects real-time data on water quantity and quality in more affordable, rapid, and widespread ways than has previously been possible. The flexible monitoring approach enables USGS networks to evolve with new technology and emerging trends.
Assess	**Integrated Water Availability Assessments (IWAA)** IWAAs examine the supply, use, and availability of the Nation's water. These regional and national assessments evaluate water quantity and quality in both surface and groundwater, as related to human and ecosystem needs and as affected by human and natural influences.
Predict	**Integrated Water Prediction (IWP)** IWP builds a powerful set of modeling tools to predict the amount and quality of surface and groundwater, now and into the future. These models use the best available science to provide information for more rivers and aquifers than can be directly monitored.
Deliver	**National Water Information System (NWIS) Modernization** NWIS data systems that house USGS water information are being modernized to maximize data integrity, simplify data delivery to the general public, and automate early warning to enable faster response times during water emergencies.

Possible SWOT linkages USGS Water Mission Area Priorities

Next Generation Water Observing System: NGWOS

Possible SWOT linkages USGS Water Mission Area Priorities



Agency needs & opportunities

USGS has interest in SWOT data, but recognizes stakeholder need for accuracy and accessibility

Interest in leveraging USGS measurements with SWOT observations to provide more accurate end user data

- calibrating satellite measurements to gauge discharge (MOMMA)
- focusing on regions in remote locations (Alaska remote sensing discharge)
- building relations between inactive gauge sites with current satellite observations to extend time series backwards (and forward) in time

Agency challenges & questions

SWOT awareness/interest

How accurate will SWOT data products be?

How accessible will SWOT data be?

How can we at USGS best prepare for SWOT launch and SWOT data?

Current SWOT involvement/ related projects

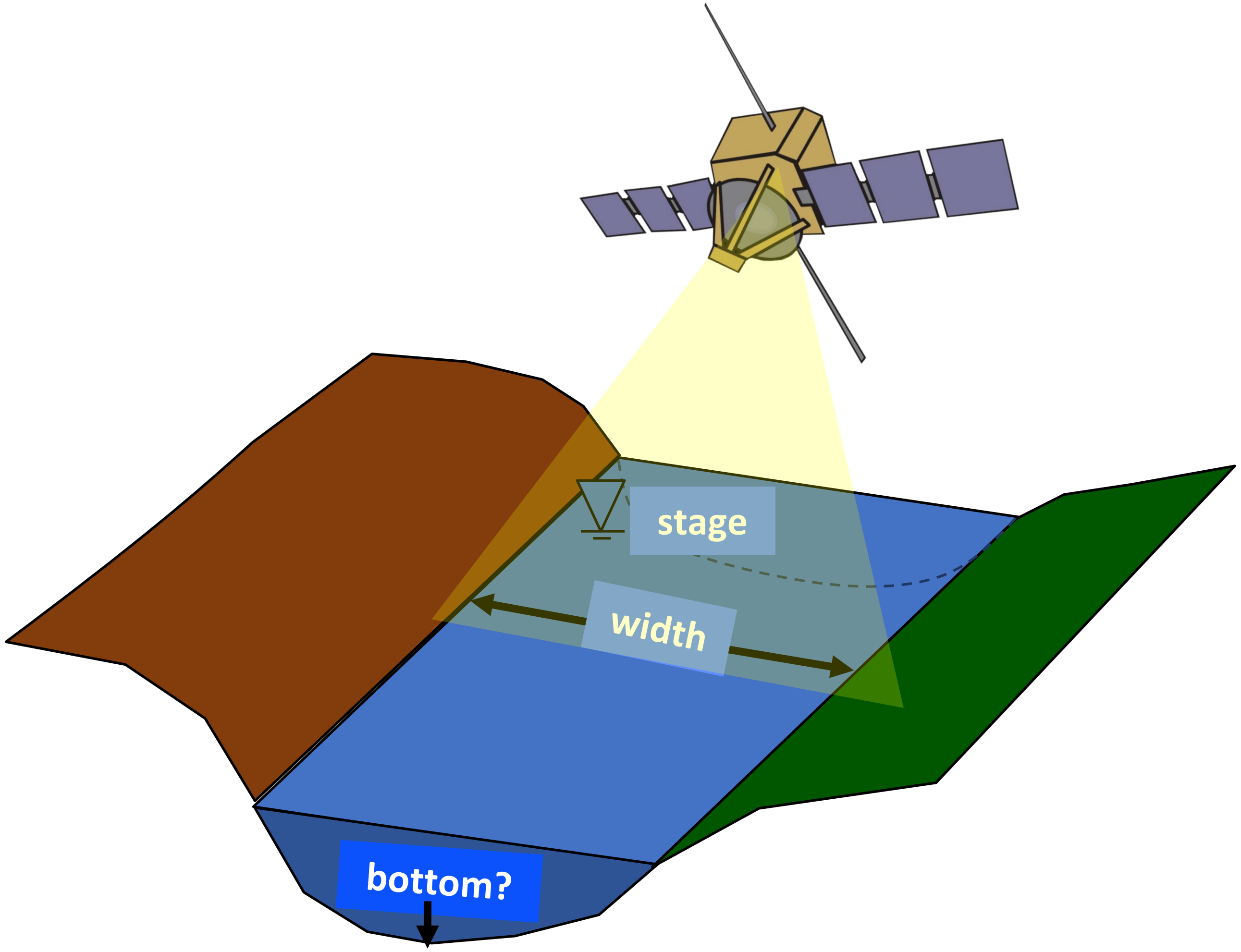
Two examples

1) Operational remote sensing stream gaging system in Alaska
2) Uncertainty from Modified Manning's equation

Alaska Remote Sensing of Discharge Objectives

- Produce river stage and flow data using satellite data and flow-law algorithms (SatRSQ)
- Integrate SatRSQ into the USGS national water information system (NWIS) for dissemination
- End-users integrate SatRSQ into their existing operations to improve water resource decision making

Satellite Remote Sensing of Discharge (SatRSQ) Challenge



Flow = Velocity x Area

Area = Width x Depth

RSQ Algorithm

Modified Manning's Equation with stage-varying resistance

$$Q = \frac{\left[W * \left((h - B) * \left(1 - \left(\frac{1}{1+r}\right)\right) \right)^{1.67} * S^{0.5} \right]}{n}$$

$$n = n_b * \left(\frac{(H - B)}{(h - B)} \right)^{x}$$

Bjerklie et al., 2018, Satellite remote sensing estimation of river discharge: Application to the Yukon River Alaska: *J. Hydrology*, 561, p.1000-1018. https://doi.org/10.1016/j.jhydrol.2018.04.005.

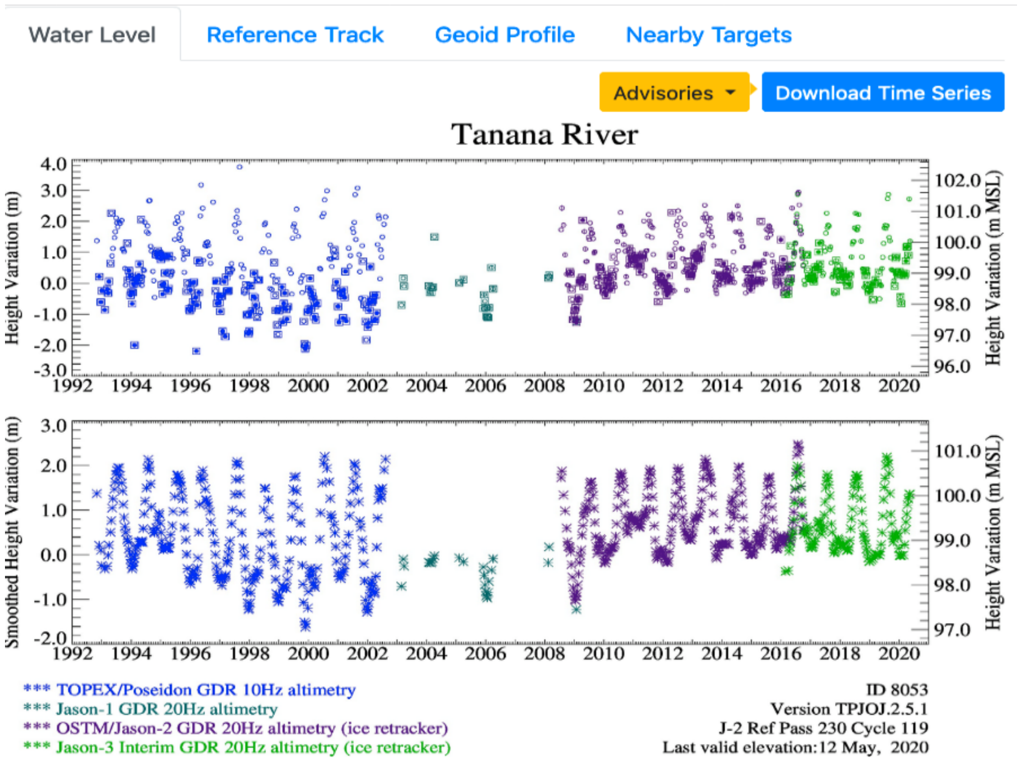
Equations 1 and 15

Variable	Observation	Data Source
Water surface heights (h, H, S)	Elevation	Altimetry
Reach averaged geometry (W)	Surface water area	DSWE/other
Channel roughness and invert (n_b, x, B)	Flow measurements	Field (calibration)

Data Sources: Satellite Altimetry

- Primary data record
- Produced by Charon Birkett (NASA-GSFC) accessed through the Global Water Monitor website

https://blueice.gsfc.nasa.gov/gwm



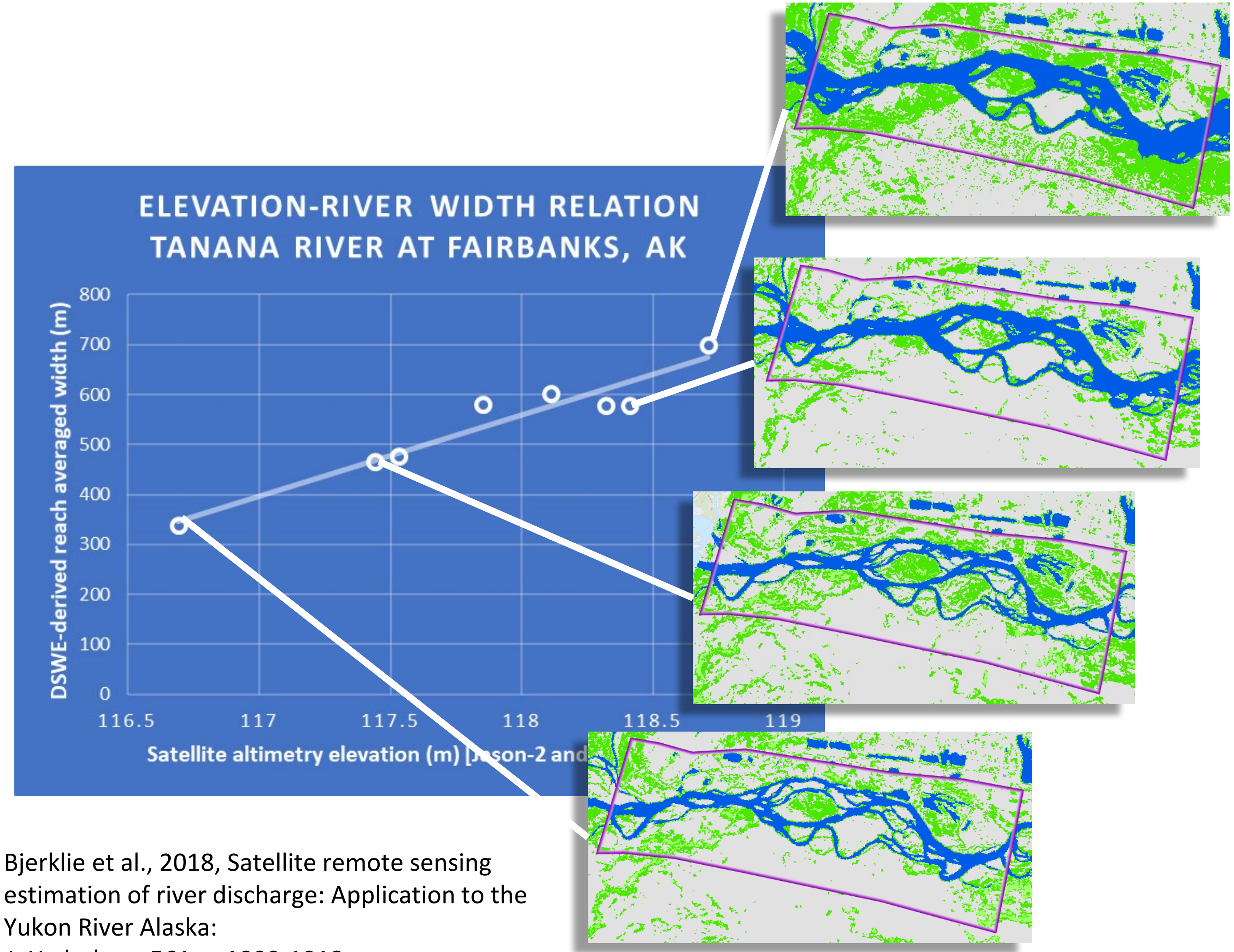
10-day temporal resolution
1992 to the present day

Determining river width through rating curve

DSWE used to compute reach-averaged widths and paired with altimetry elevation data

USGS Dynamic Surface Water Extent (DSWE)

Derived from Landsat and Sentinel-2 (soon SAR)



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Data Sources: Field observations

Satellite discharge measurements (RSQ) calibrated to ground observations

Heather Best, USGS, making a wading measurement at Birch Creek gage 15392000.
Photo credit: Derek Frohbeiter, USGS

Study Sites: Stage and Discharge

- 6 Tier I sites
  - Gaged
- 4 Tier II sites
  - Formerly gaged
- 5 Tier III sites
  - Not gaged

Remotely Sensed Discharge Produced Operationally

USGS 15485500 TANANA R AT FAIRBANKS AK

PROVISIONAL DATA SUBJECT TO REVISION

Available data for this site

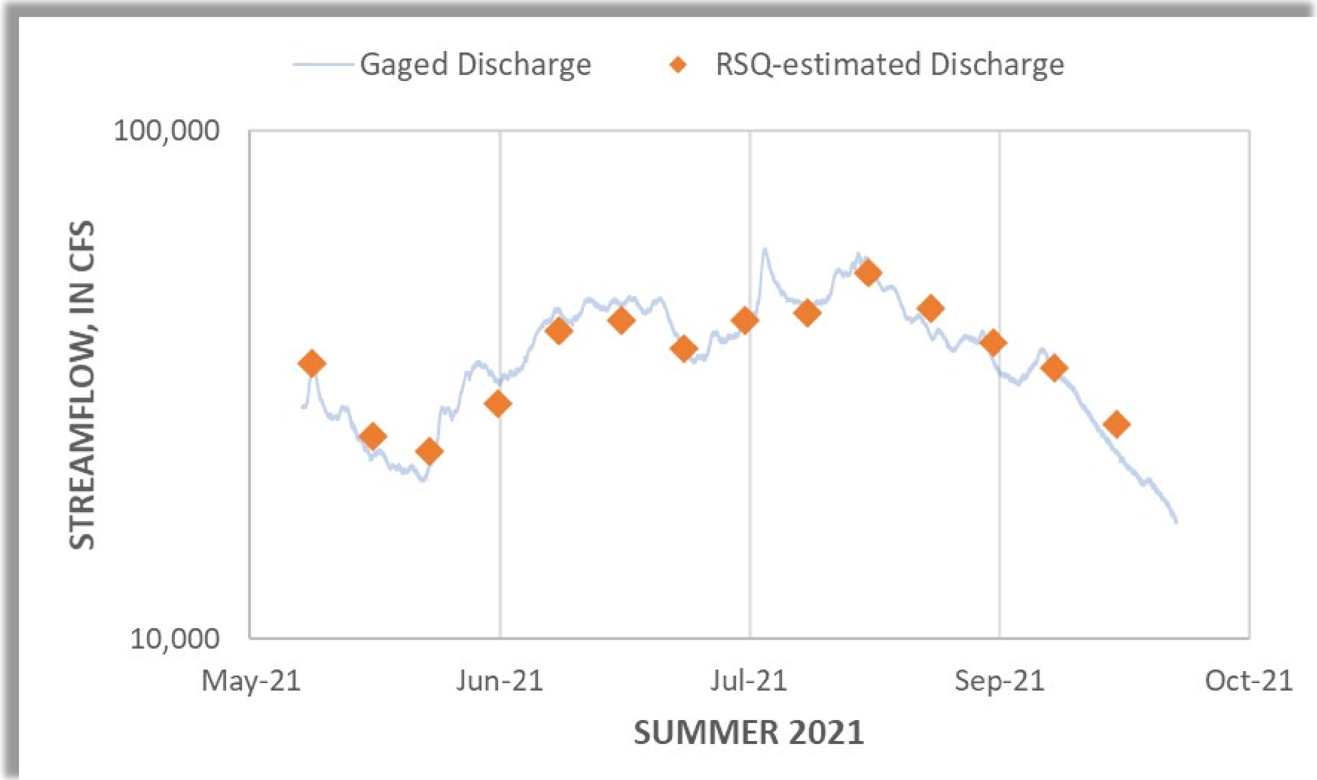
Click for station-specific text

This station managed by the Fairbanks Field Office.

Available Parameters	Available Period	
All 6 Available Parameters for this site		
00060 Discharge	1989-10-01	2021-09-29
00060 Discharge [RSQ cfs]	2018-10-04	2021-09-19
00065 Gage height	2007-10-01	2021-09-29
70969 DCP battery voltage	2021-06-01	2021-09-29
72333 Reach-avg water-surface elev [RSQ m]	2018-10-04	2021-09-19
72397 Reach-avg water-surface elev [RSQ ft]	2018-10-04	2021-09-19

Summary of all available data for this site

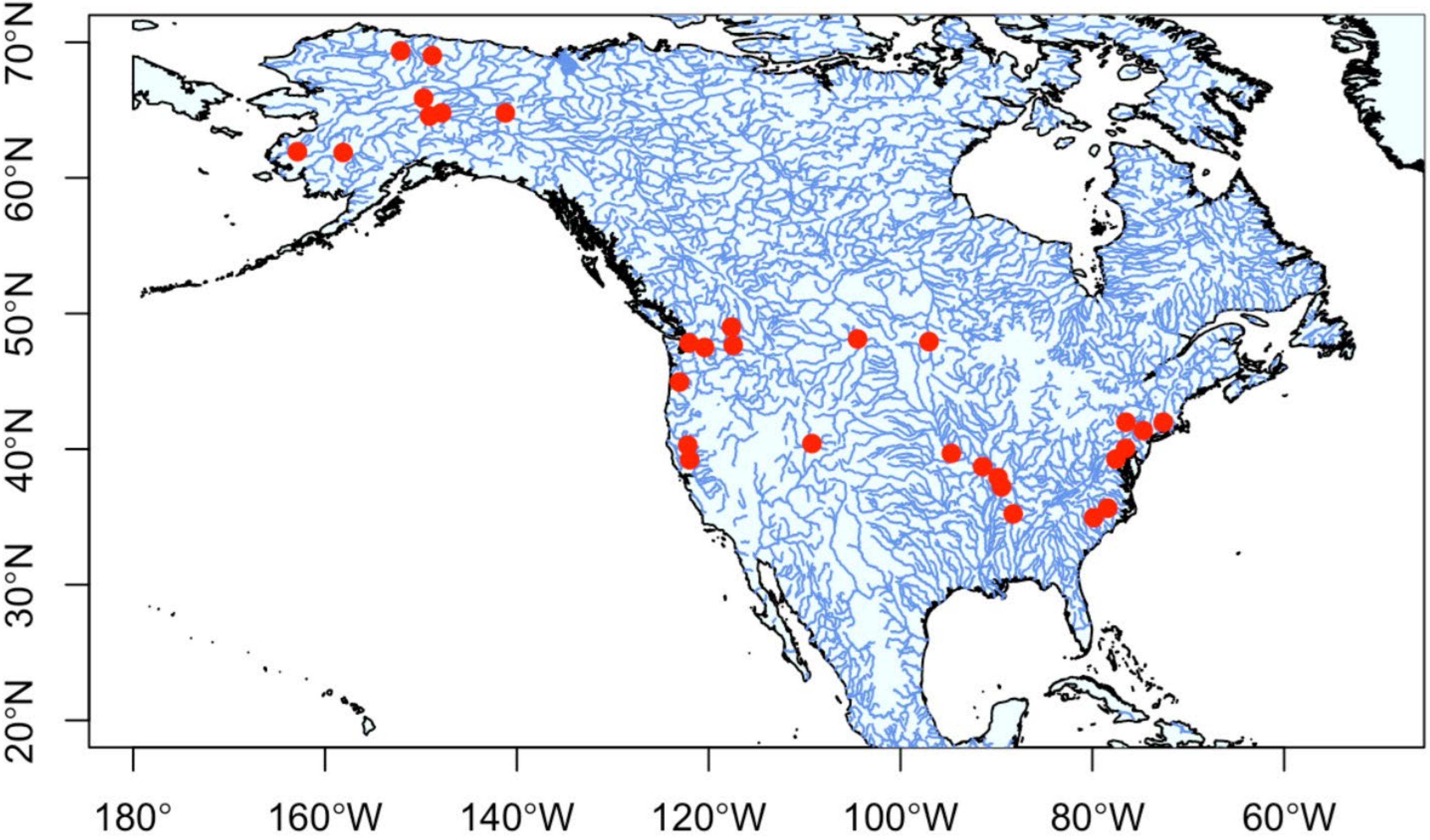
Instantaneous-data availability statement



Data access presently limited to project cooperators and internal

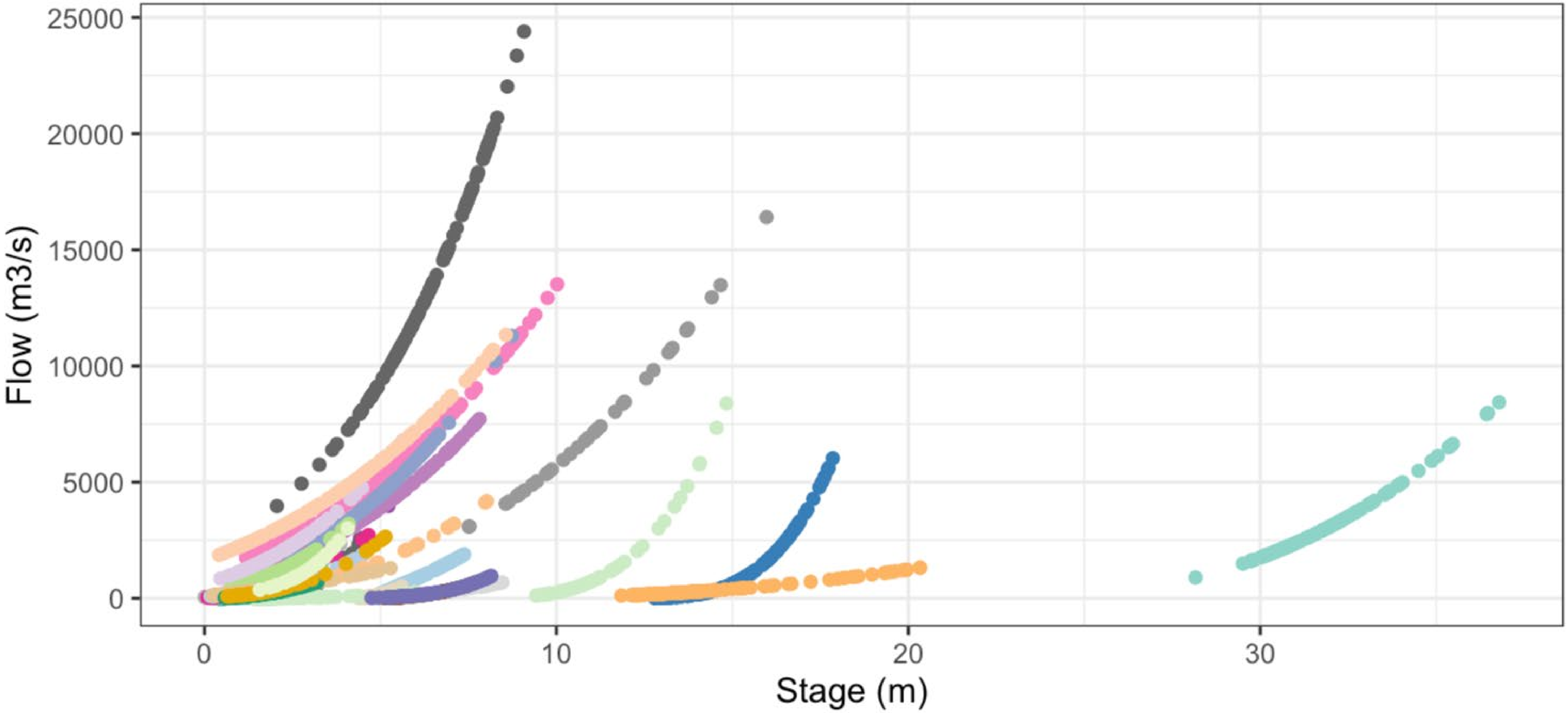
PROVISIONAL DATA SUBJECT TO CHANGE

Uncertainty in Modified Manning's Equation

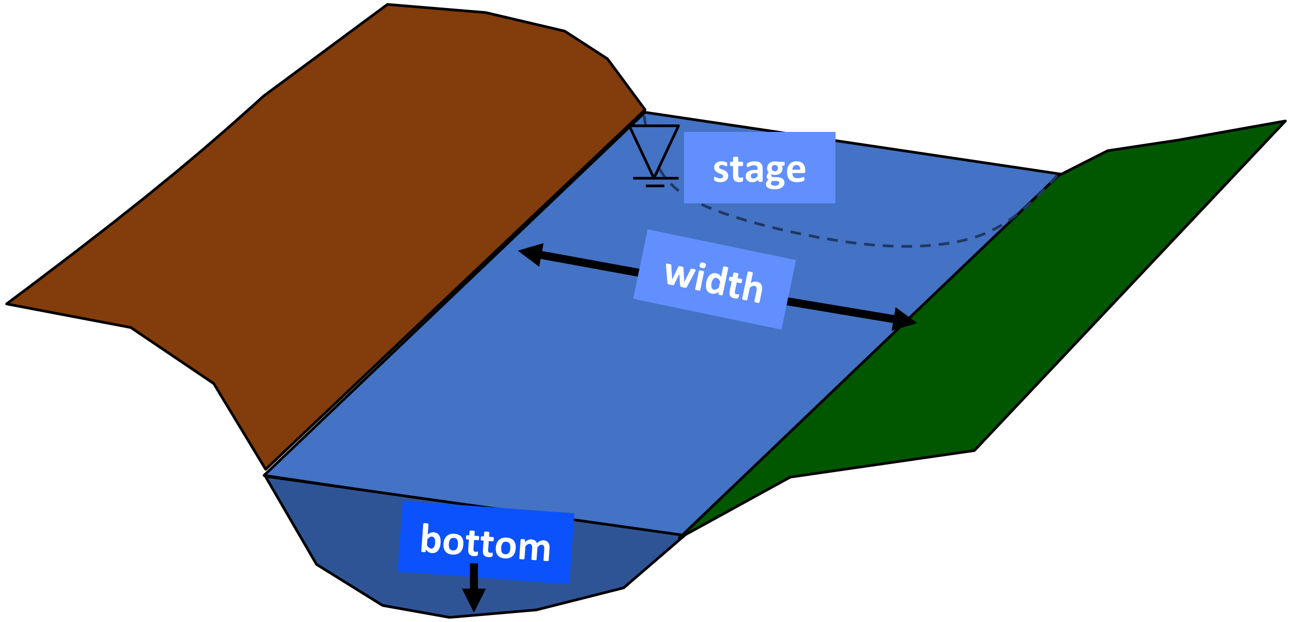


Compared estimating discharge using modified Manning's equation to an ADCP in 30 rivers throughout the US

Uncertainty in Modified Manning's Equation



Uncertainty in Modified Manning's Equation



Measured width and stage → Discharge through Modified Manning's equation

How uncertain is discharge estimation through a modified Manning's equation with in situ measurements?

- ~10-20% error

How many measurements are needed to calibrate a modified Manning's approach?

- 10 – 20 discharge measurements

What flow regimes are poorly represented by this approach?

- Discharge < 1000 m3/s and mean flow depth < 3m
- Widely varying Froude numbers (or varying flow conditions)
- High baseflow index
- Obstructed reaches

Moving forward

Calibration and validation

- Resurveying
- ADCP measurements/training courses

Internal USGS database creation

Model ingestion (National Water Model, deep learning)

Multi-sensor fusion (Hydrologic Remote Sensing Branch)