



A Continuous High-Resolution Profile of the Riverbed and Water Surface for 460-km of the Colorado River in Grand Canyon

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Project B: Sandbar and Sediment Storage Monitoring and Research

- Project Elements and Objectives
 - B.3 Control Network and Survey Support
 - In support of Remote Sensing Overflight (Project L)
- Cooperators: Northern Arizona University
- LTEMP Resource Goals:
 - Sediment: "Increase and retain fine sediment volume, area, and distribution in the Glen, Marble, and Grand Canyon reaches above the elevation of the average base flow for ecological, cultural, and recreational purposes"

This information is preliminary and is subject to revision. It is being provided to meet the need for timely best science. The information is provided on the condition that neither the U.S. Geological Survey nor the US. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the information

Acknowledgements

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Katie Chapman
Northern Arizona University

Trip Participants:
Jeremy Swindlehurst, Bryan Smith,
Chris Louderback, Karen Koestner,
Sinjin Eberle, Bryan Cooperrider,
John O'Brien, Maggie Ryan



BUREAU OF
RECLAMATION



USGS

2021 Survey Overview

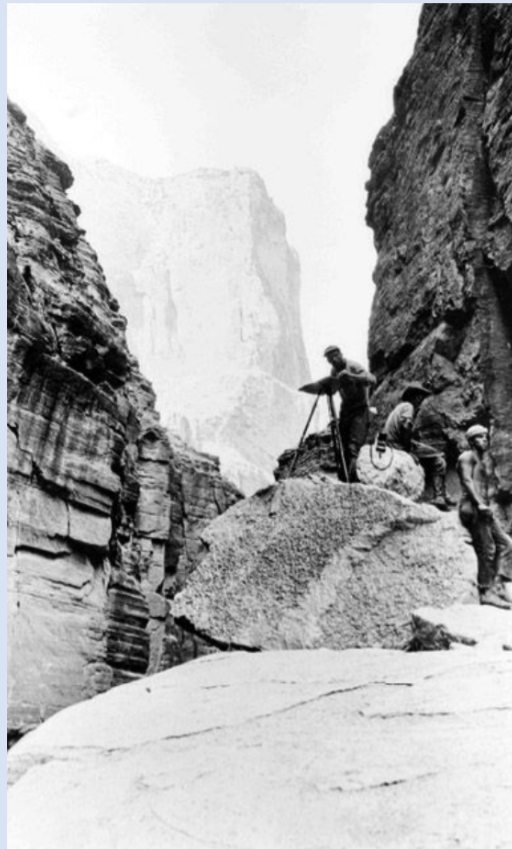
- Surveys conducted May 29th through June 5th, 2021, concurrent with overflight
- Glen Canyon Dam releases held steady at 8,000 cfs (227 cms)
- Elevations of the **water surface** and the **riverbed** collected from Lees Ferry to Pearce Ferry
 - River miles 0 to 280

Water Surface Elevation



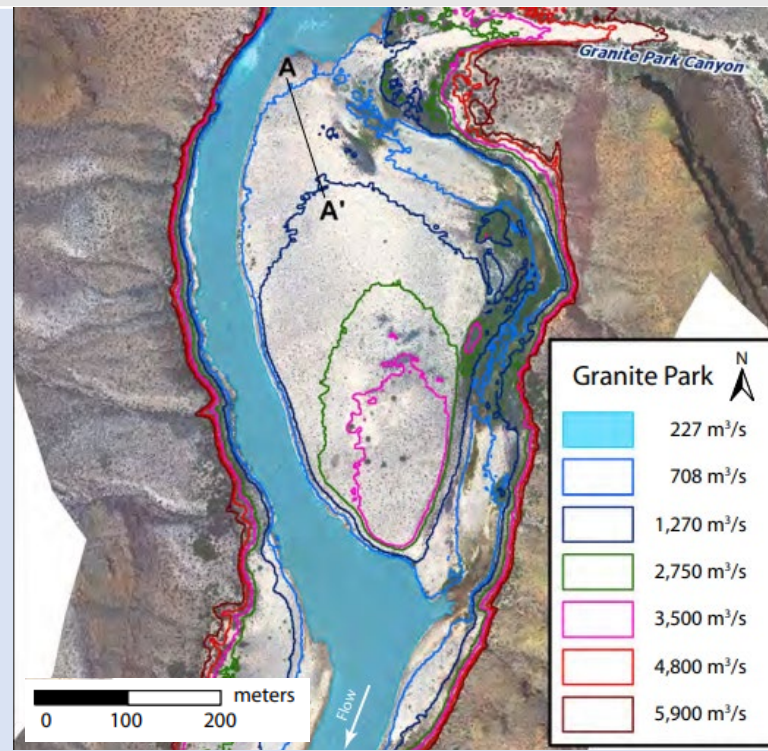
Previous water surface surveys

Year	Reference	Discharge	Method	Vertical Accuracy
1923	Birdseye and Burchard (1924)	15,000 to 30,000 cfs, spike of ~115,000 cfs	Spirit level, stadia rod	± 1.4 m



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Magirl et al.
(2008)



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2021	This study	8,000 cfs	GPS (boat) + total station survey	± 0.1 m*

*Vertical accuracy is spatially variable based on GPS quality. 10 cm vertical accuracy applies to ~245 of 280 river miles

Water Surface Elevation – Data Collection

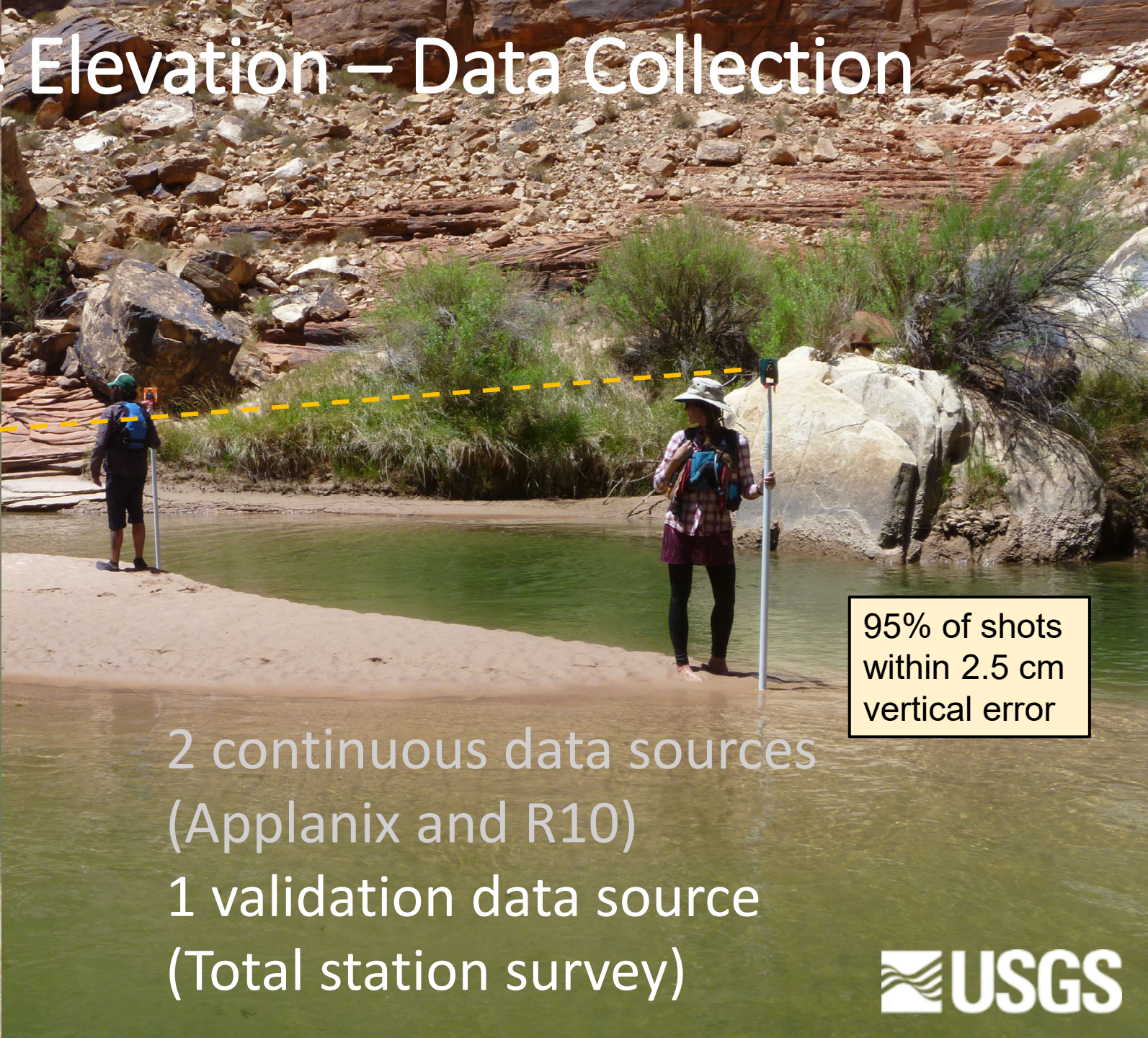
2 continuous data sources
(Applanix and R10)

Applanix
Antennae

R10
Antenna

- Applanix system did not run during rapids
- Both systems post-processed with GNSS base stations on the rim
- Each Applanix and R10 point have an associated **vertical error**

Water Surface Elevation – Data Collection

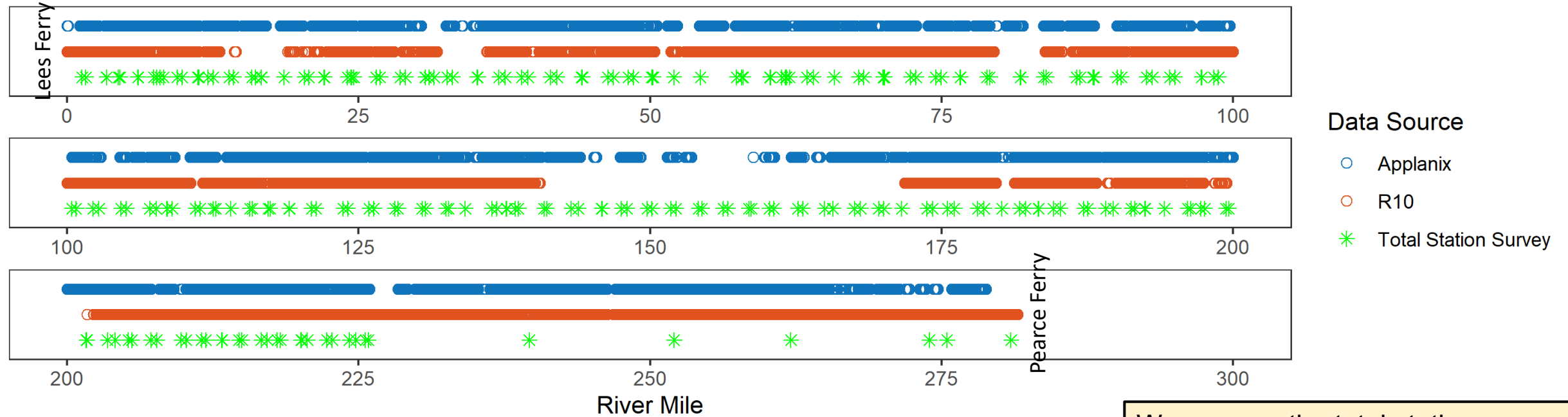


95% of shots
within 2.5 cm
vertical error

2 continuous data sources
(Applanix and R10)
1 validation data source
(Total station survey)

Water Surface Elevation – Data Collection

High Quality Data Available (Applanix and R10 Vertical Error < 10 cm)

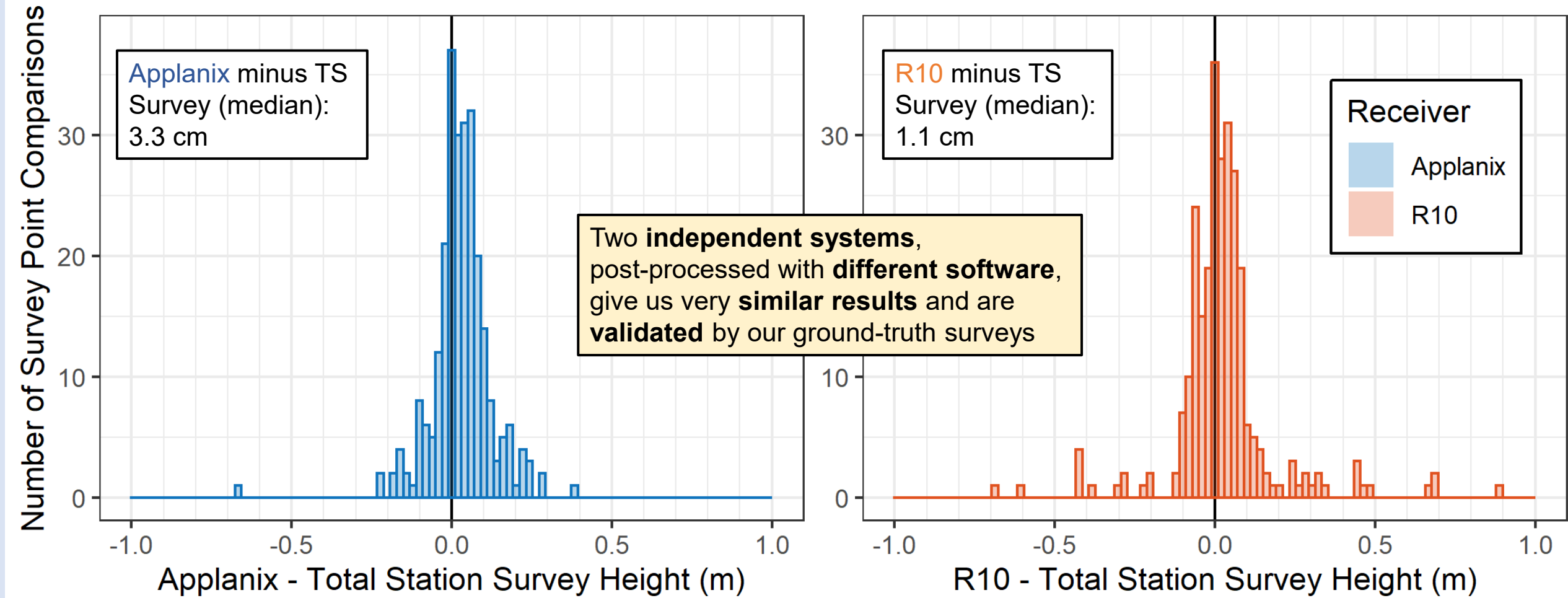


We can use the total station survey points to **validate** the Applanix and R10 points by **comparing their elevations** for the same river mile

- 201.5 miles of high quality Applanix Data (VE < 10cm)
- 211.3 miles of high quality R10 data (VE < 10cm)
- 578 total station survey points at 316 unique river hundredth-miles



Water Surface Elevation – Data Validation



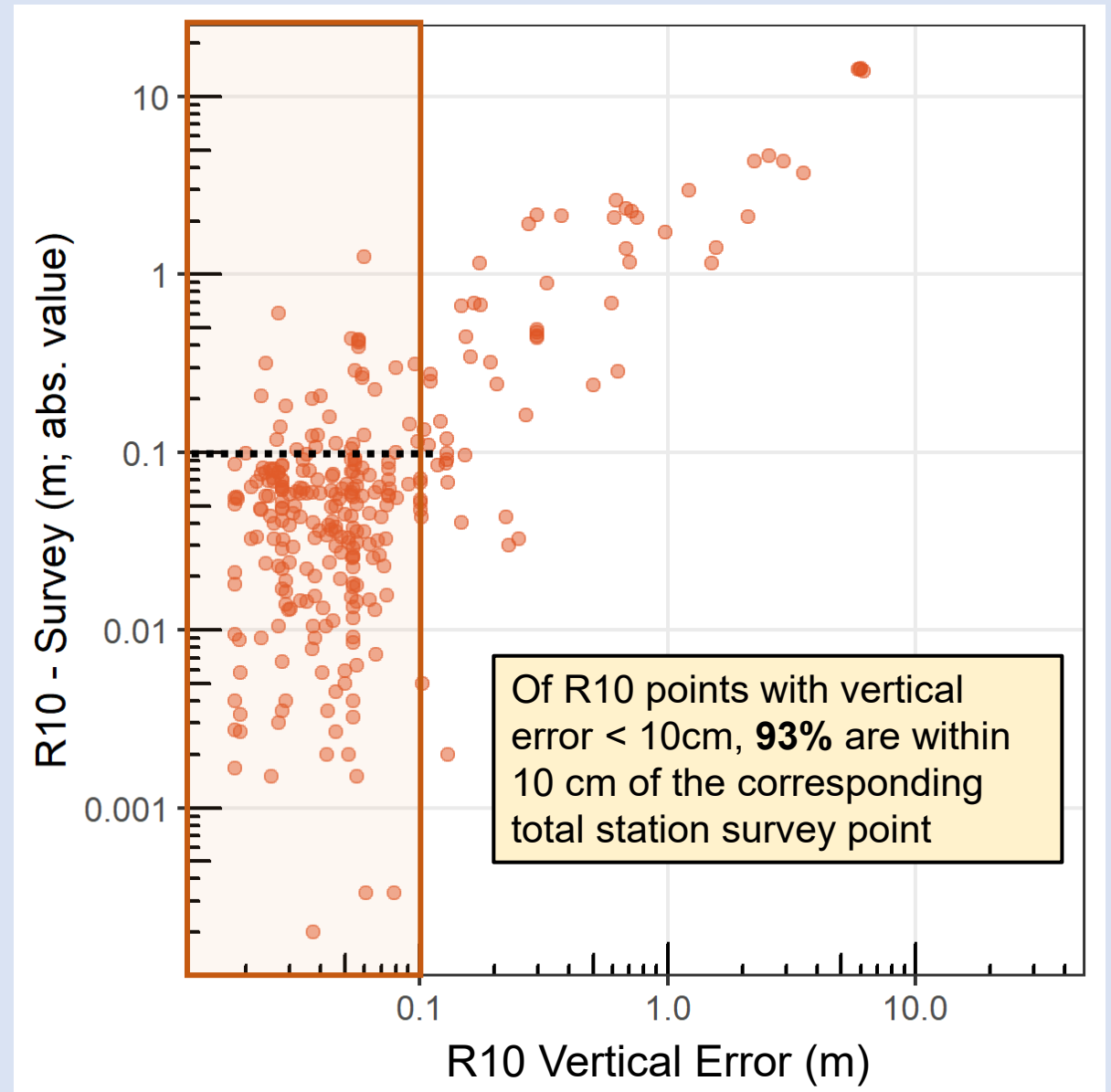
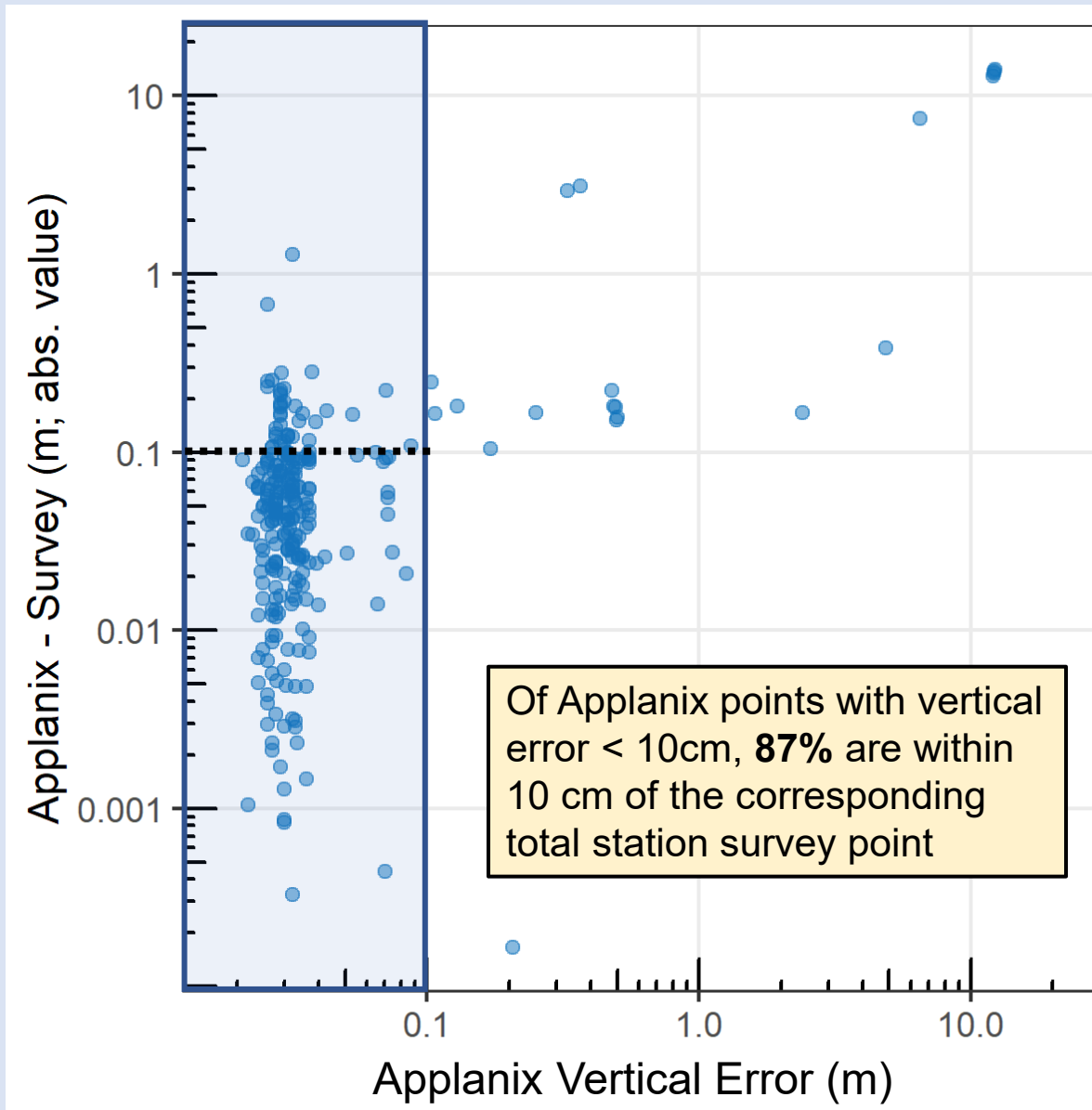
*only data from -1.0 to +1.0 m are shown

261/269 (97%) Applanix comparisons shown

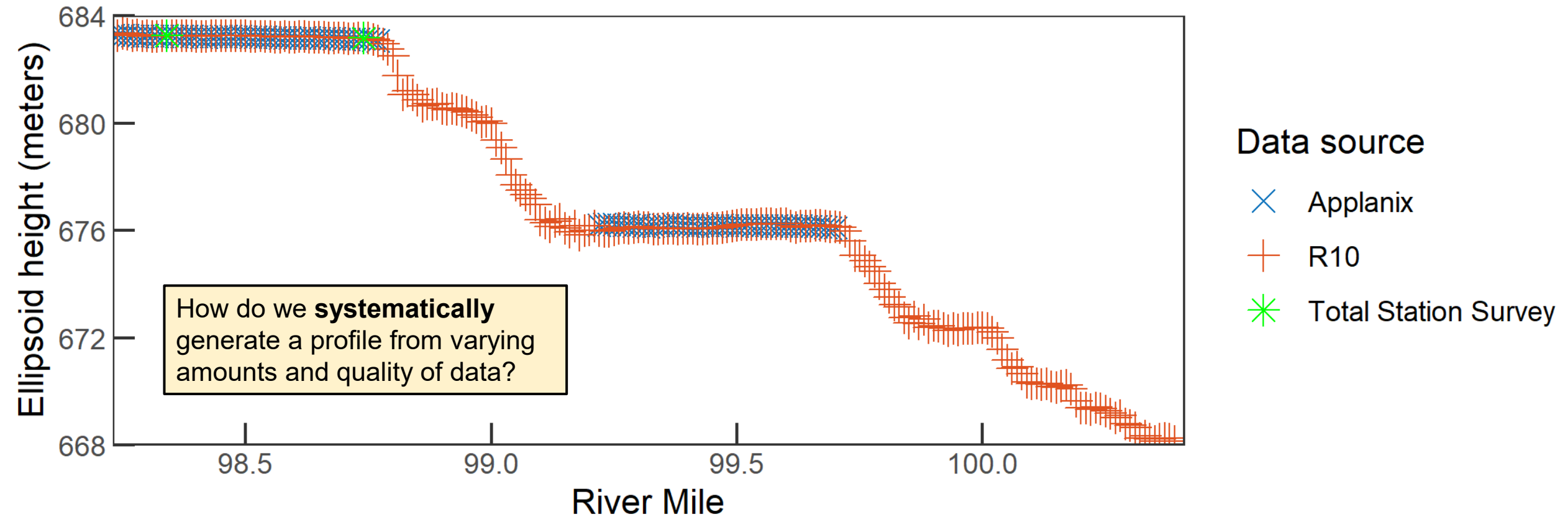
269/294 (91%) R10 comparisons shown



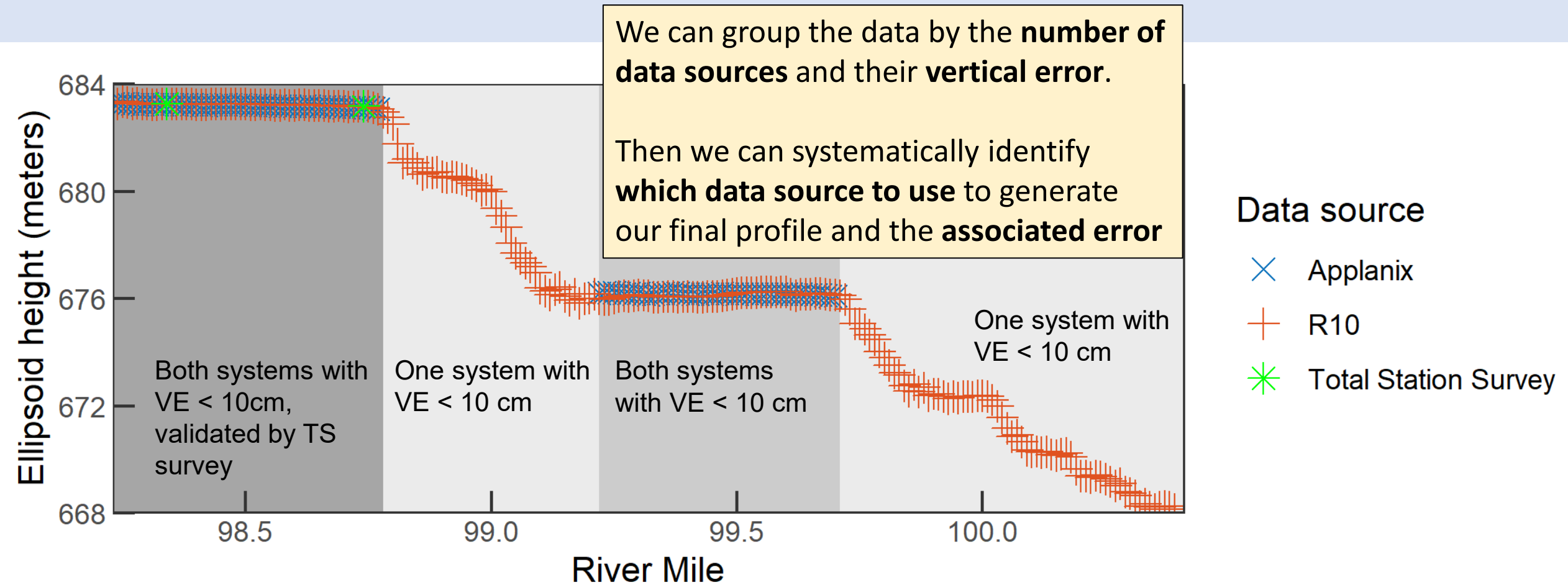
Water Surface Elevation – Data Validation



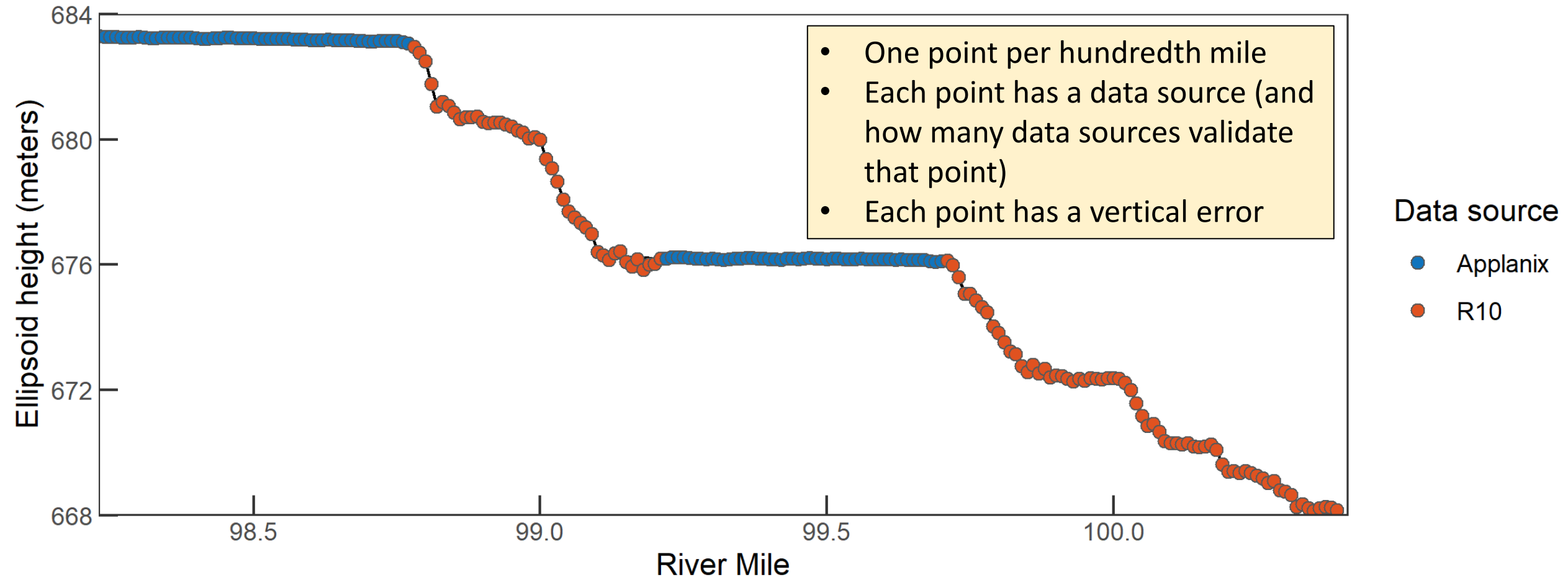
Water Surface Elevation – Profile Creation



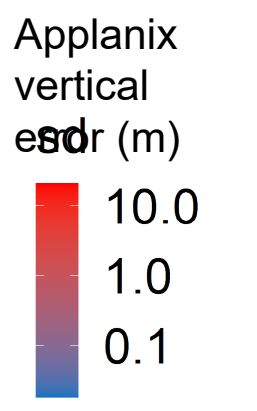
Water Surface Elevation – Profile Creation



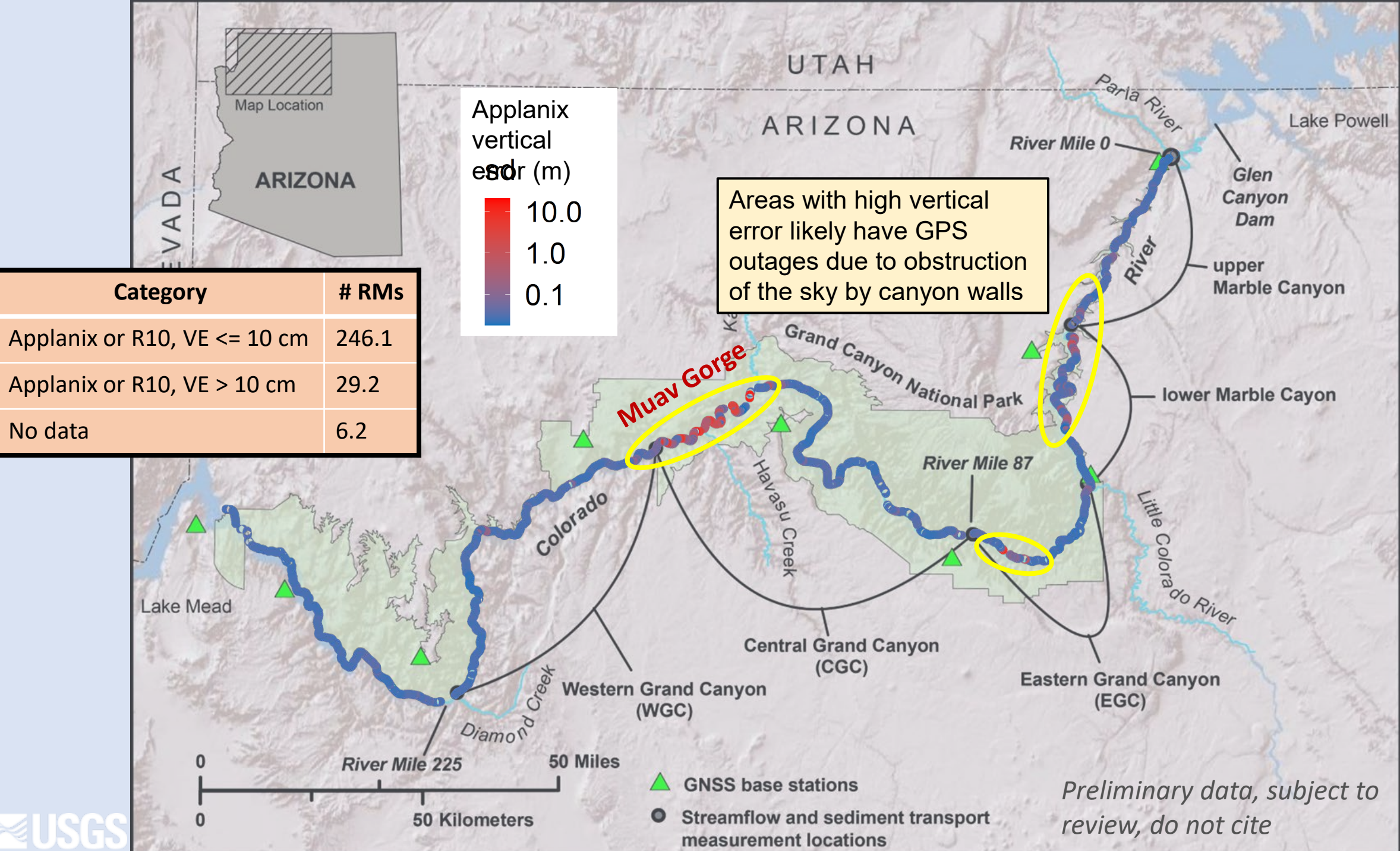
Water Surface Elevation – Profile Creation



Category	# RMs
Applanix or R10, VE <= 10 cm	246.1
Applanix or R10, VE > 10 cm	29.2
No data	6.2



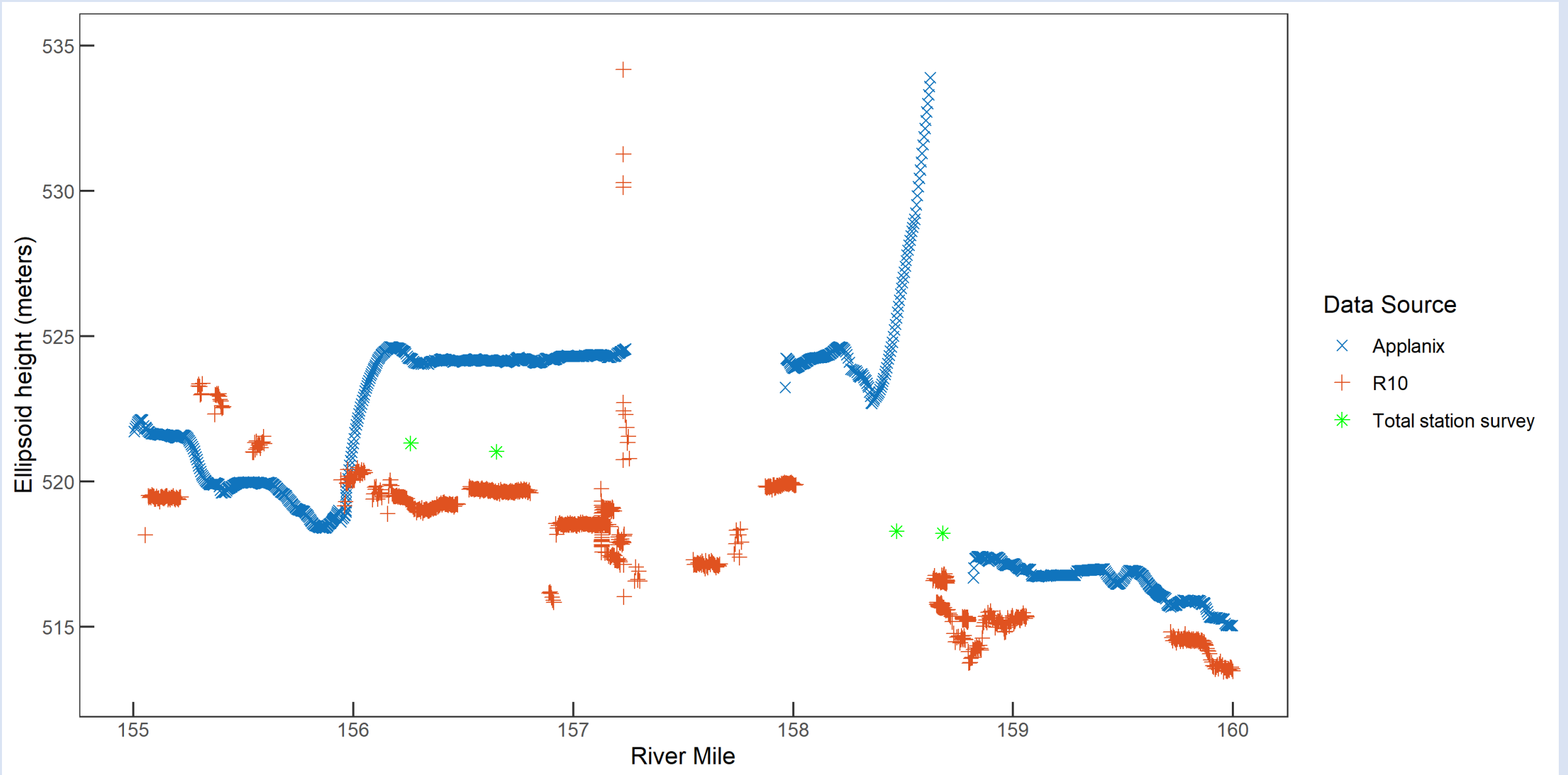
Areas with high vertical error likely have GPS outages due to obstruction of the sky by canyon walls



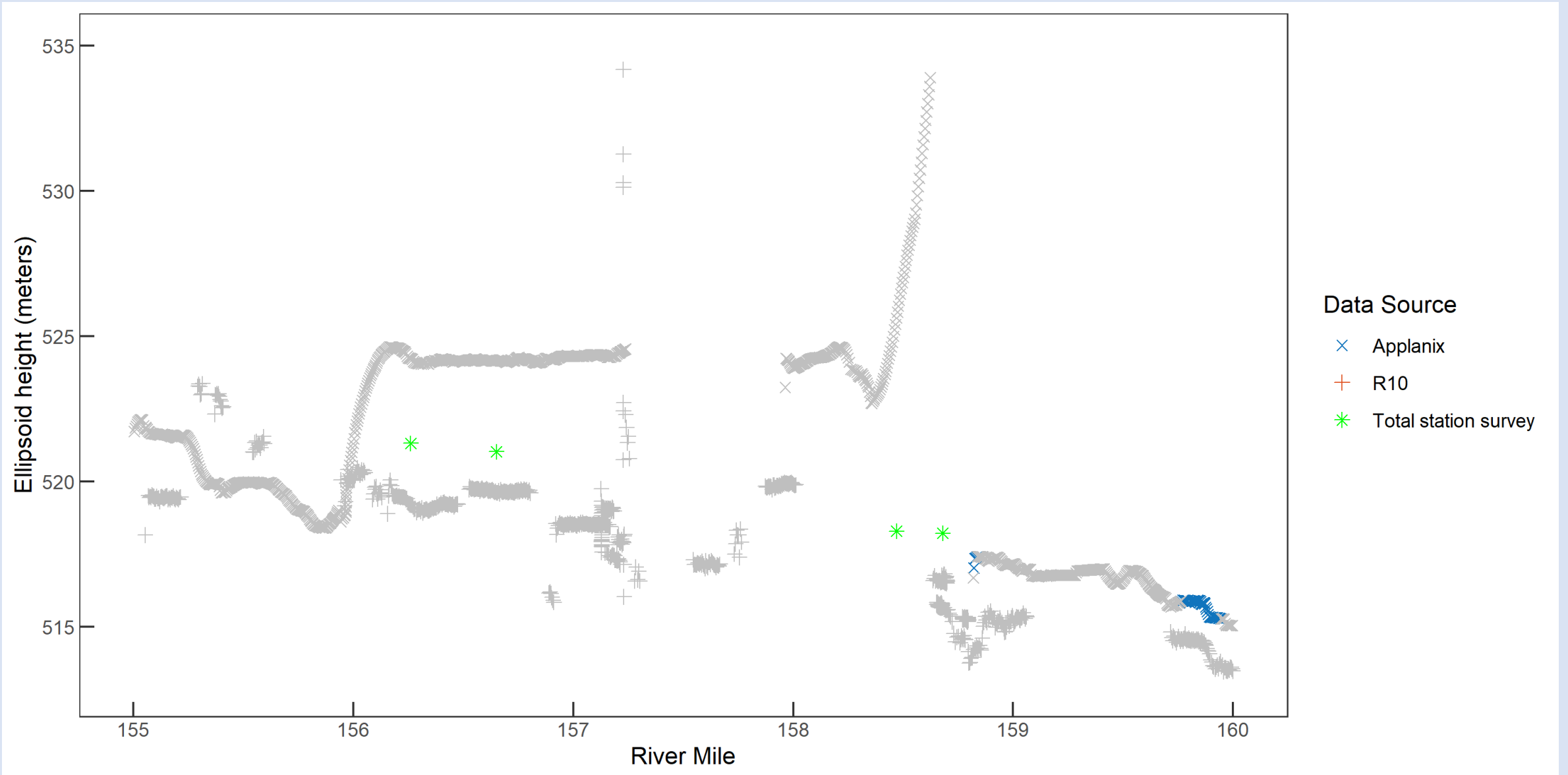
Preliminary data, subject to review, do not cite



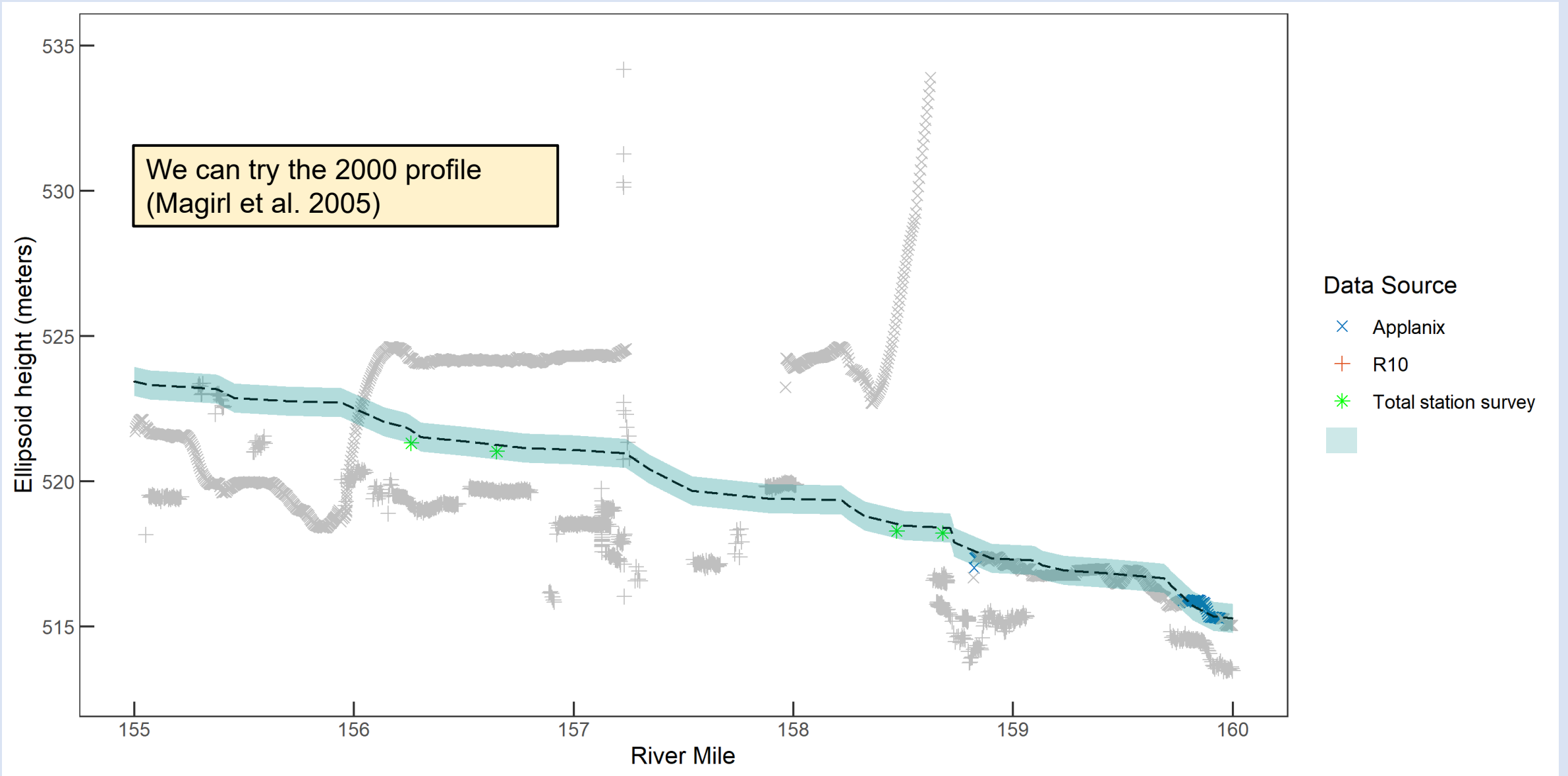
Water Surface Elevation – Profile Creation



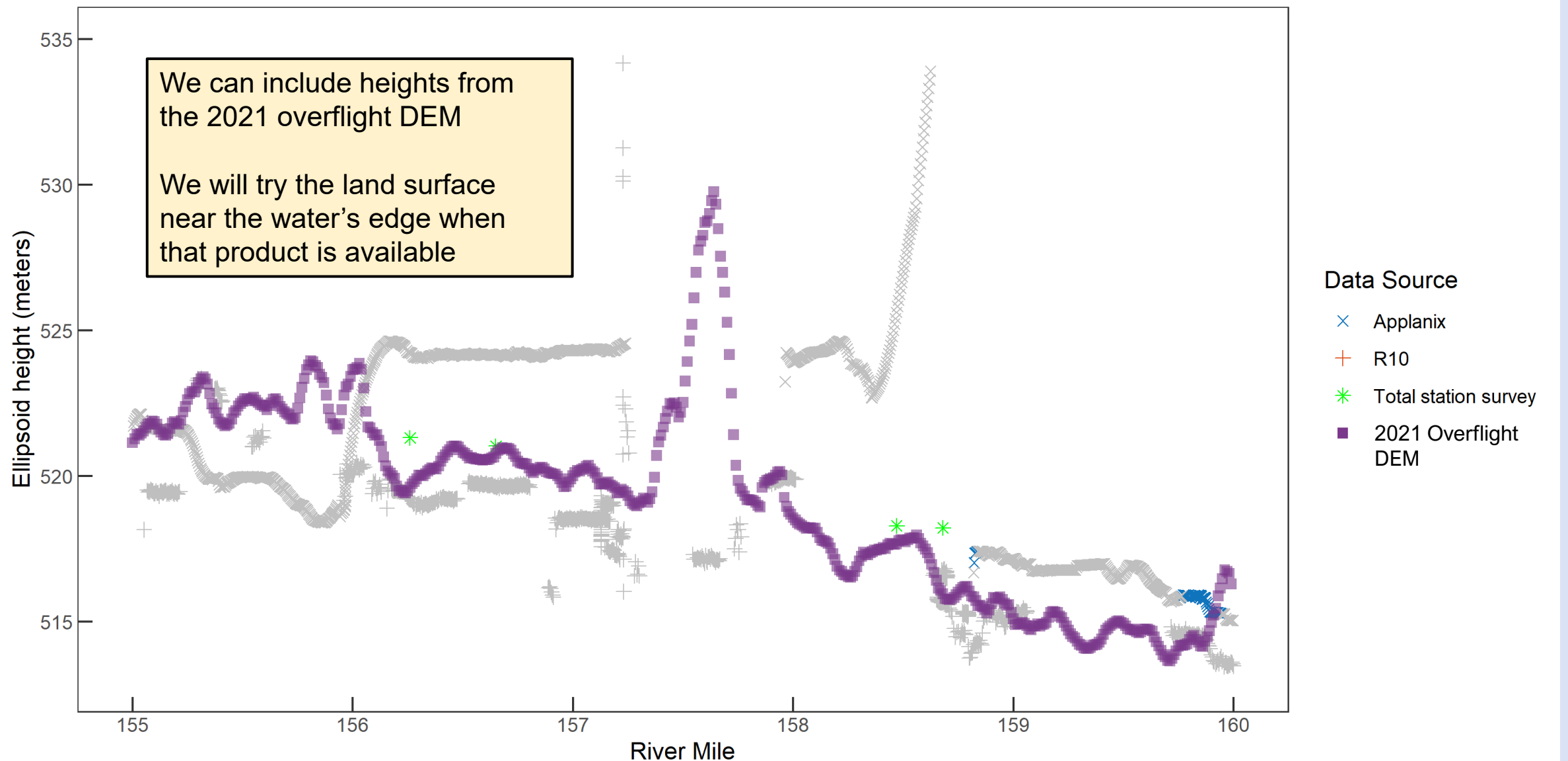
Water Surface Elevation – Profile Creation



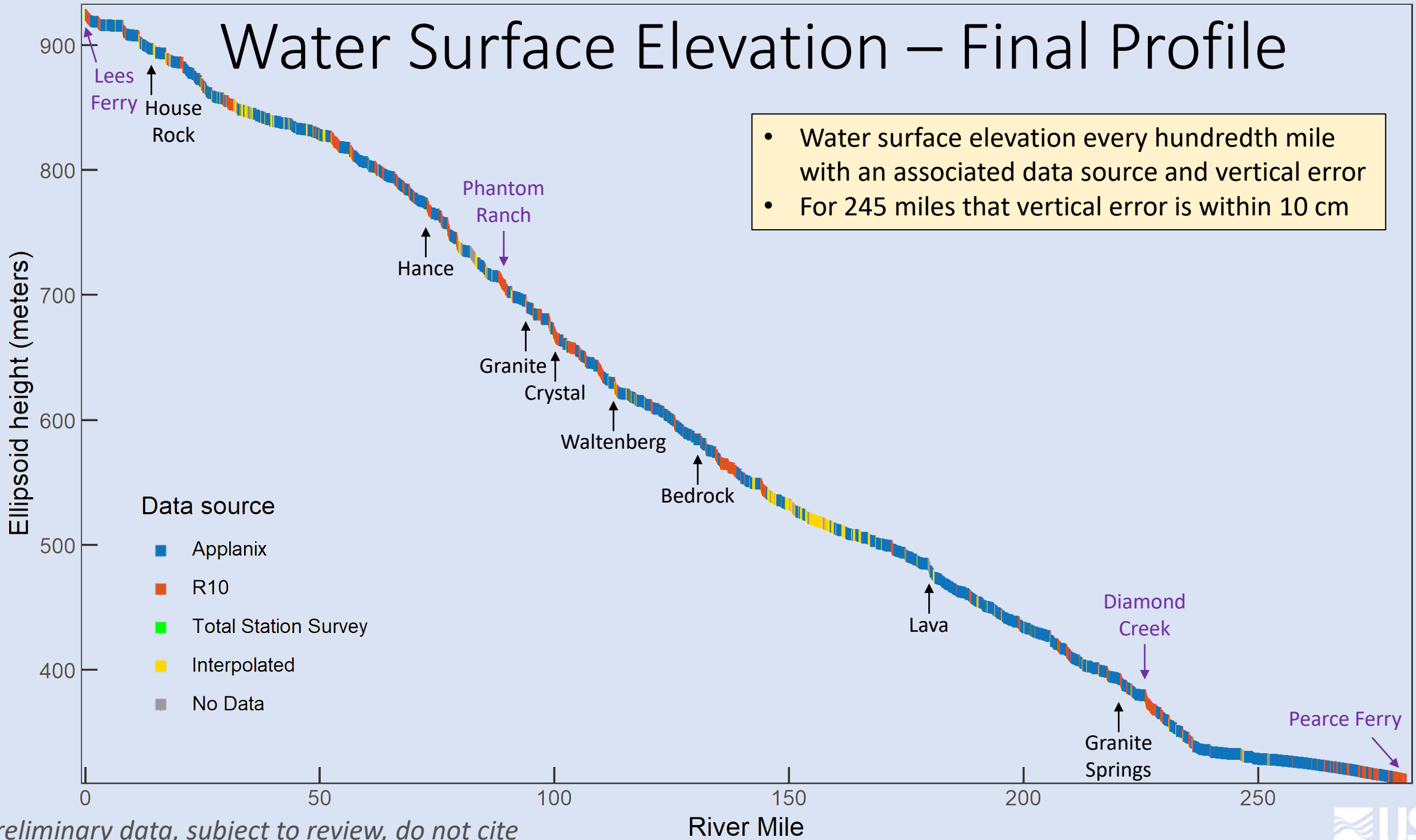
Water Surface Elevation – Profile Creation



Water Surface Elevation – Profile Creation



Water Surface Elevation – Final Profile



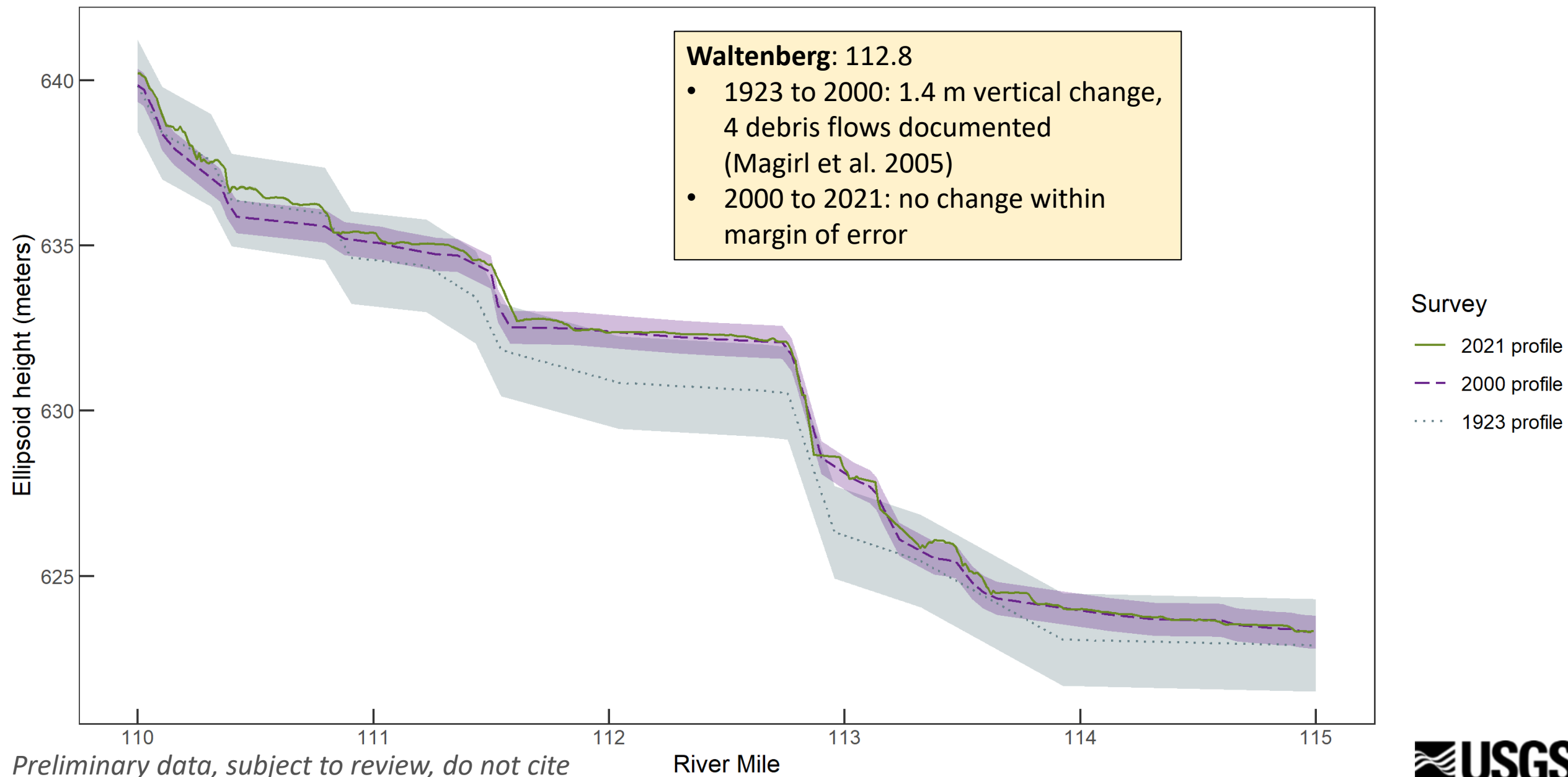
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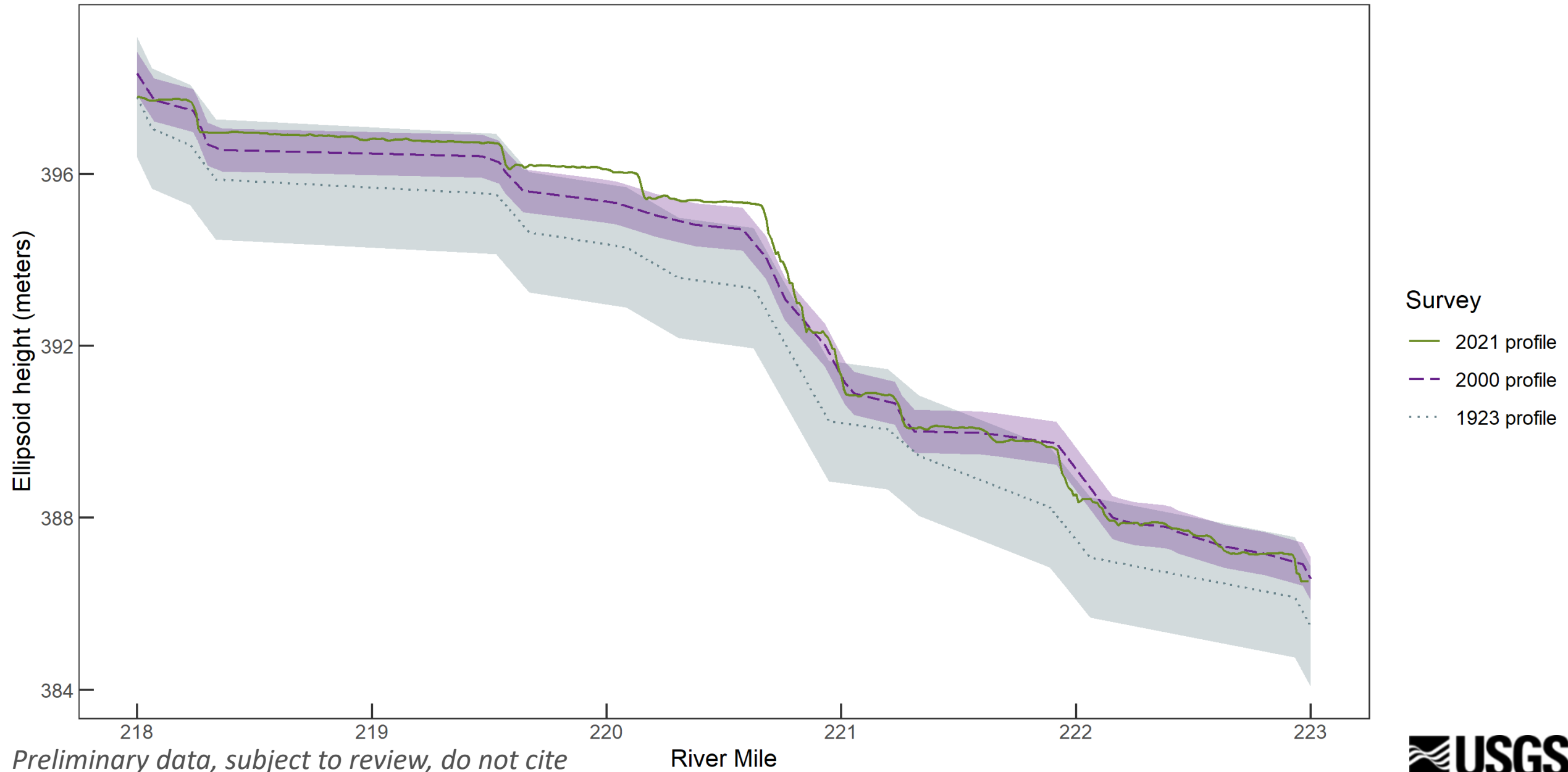
Water Surface Elevation: Comparison of Profiles



Water Surface Elevation: Comparison of Profiles



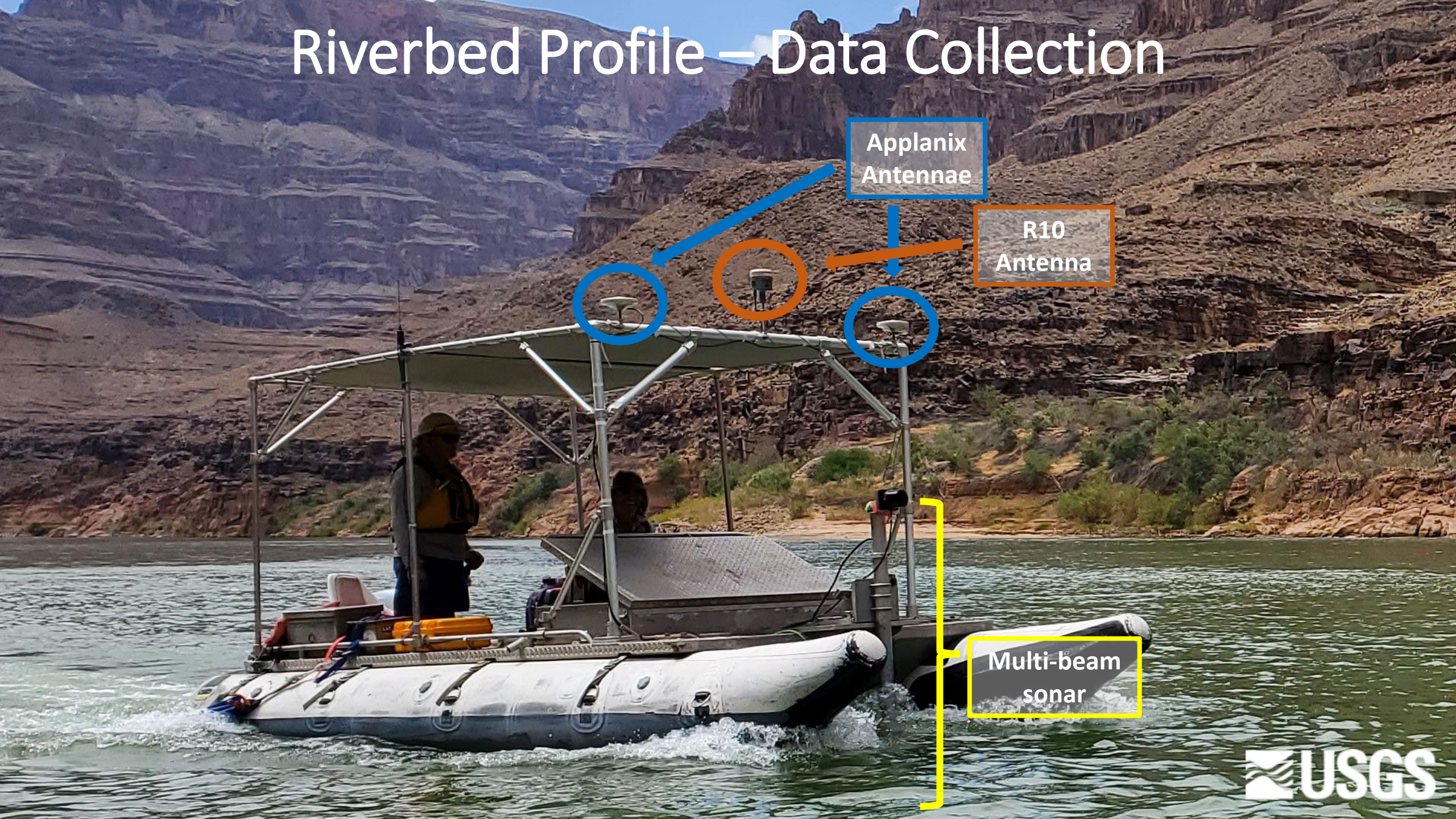
Water Surface Elevation: Comparison of Profiles



Riverbed Profile



Riverbed Profile – Data Collection



Applanix
Antennae

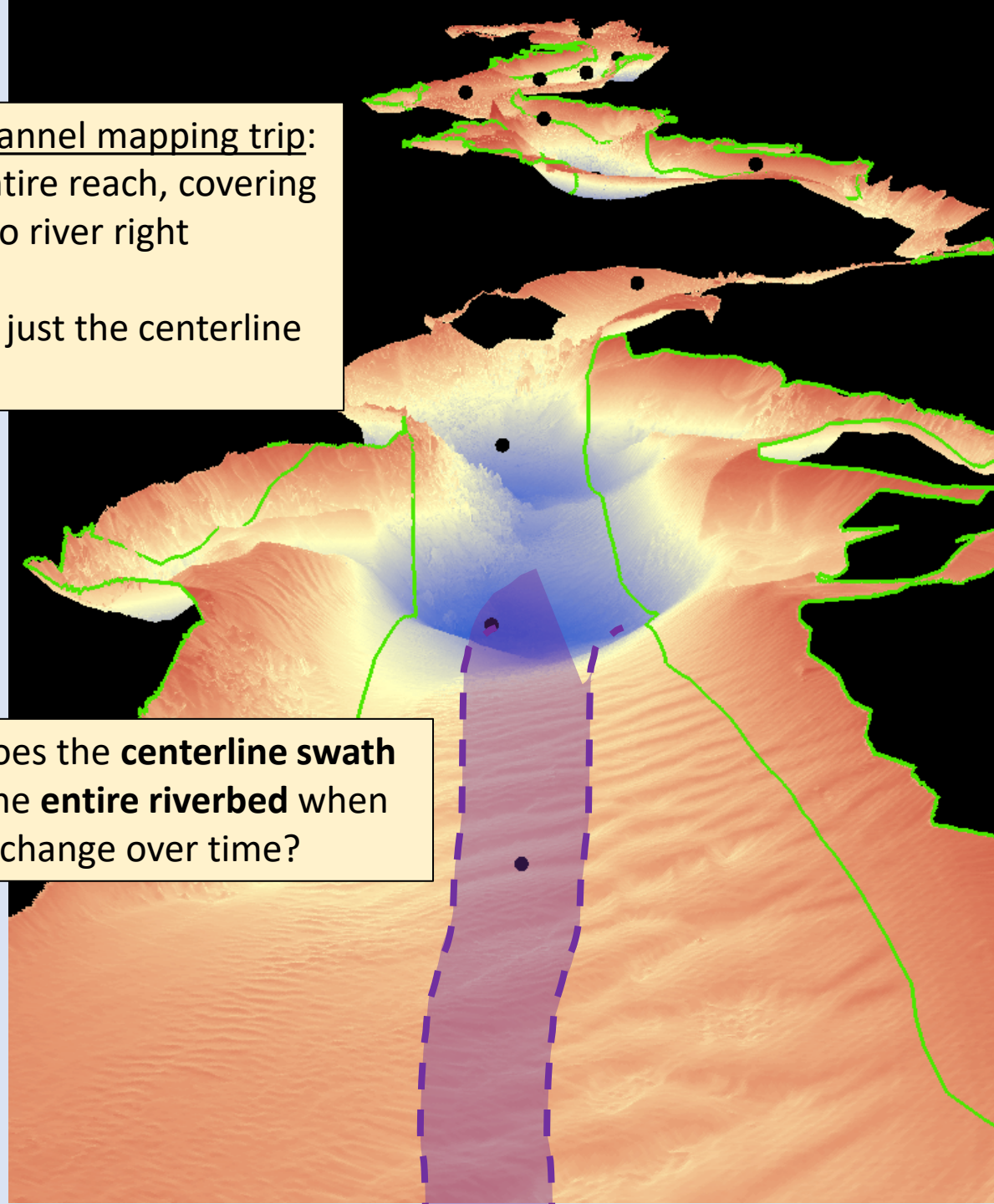
R10
Antenna

Multi-beam
sonar

Typical channel mapping trip:
map of entire reach, covering
river left to river right

2021 trip: just the centerline
swath

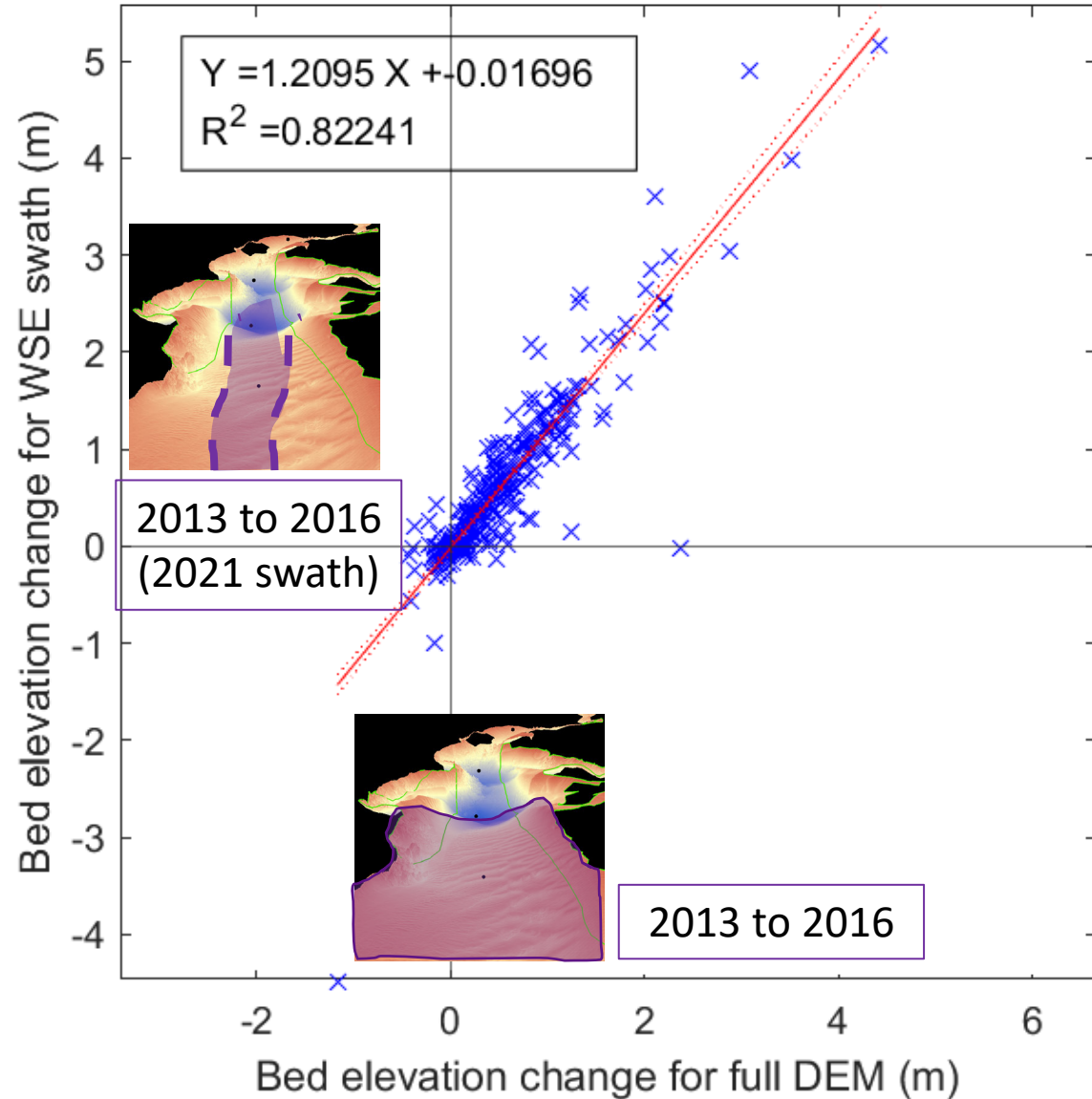
How well does the **centerline swath**
represent the **entire riverbed** when
it comes to change over time?



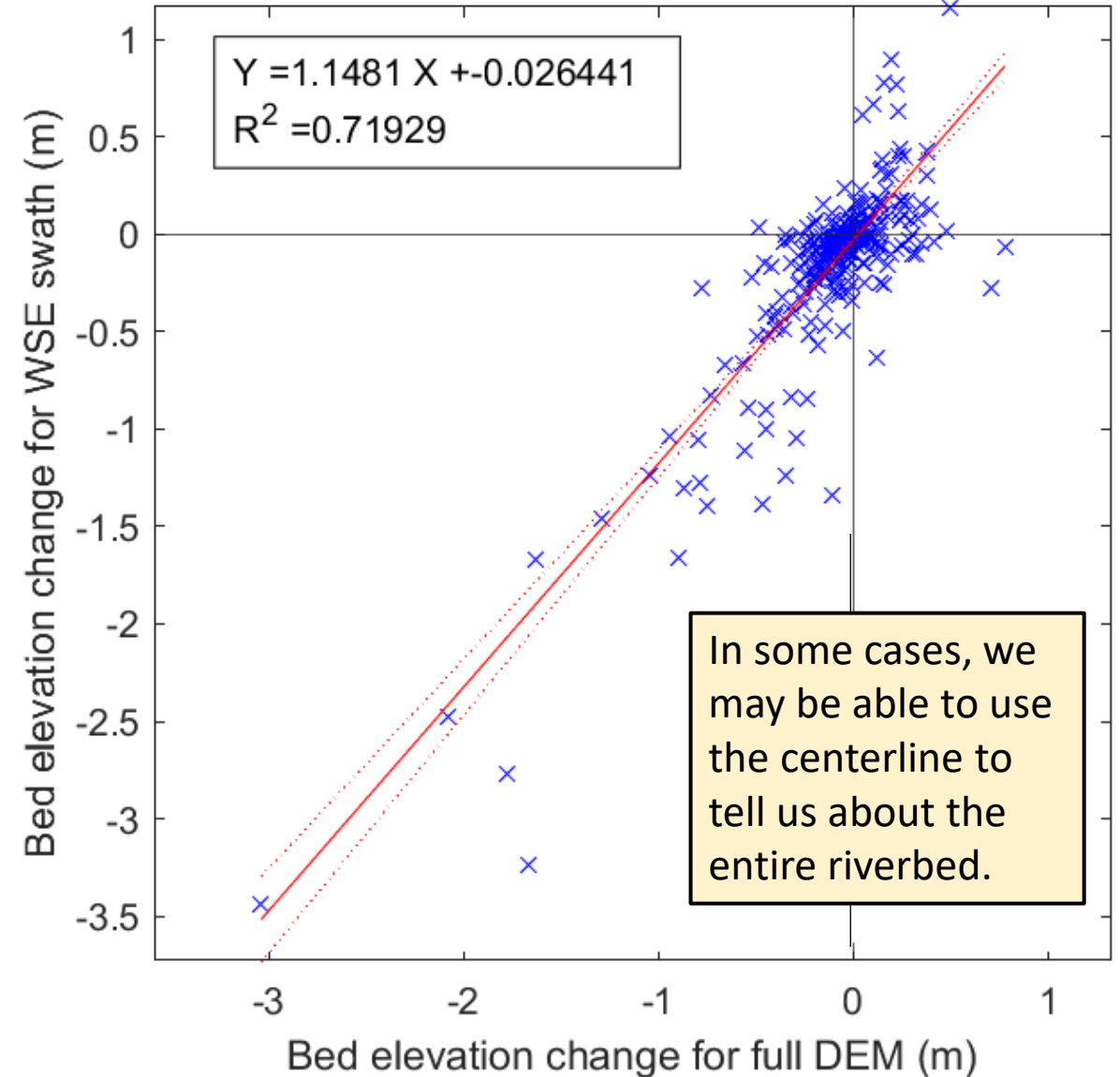
Riverbed Profile – Data Collection

Riverbed Profile – Analysis

Change in mean bed elevation in Upper Marble Canyon

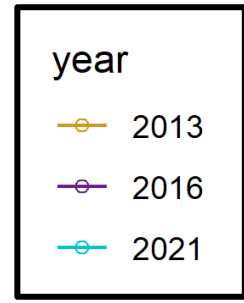
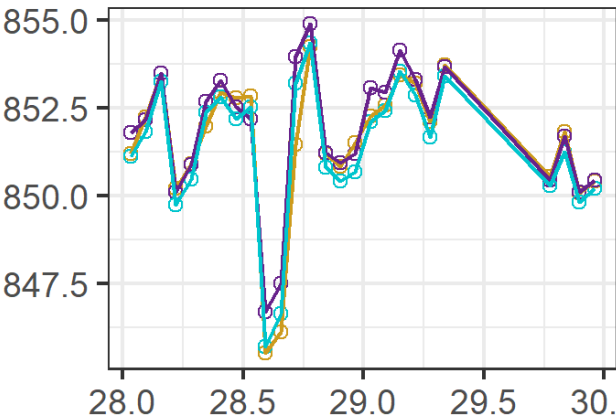
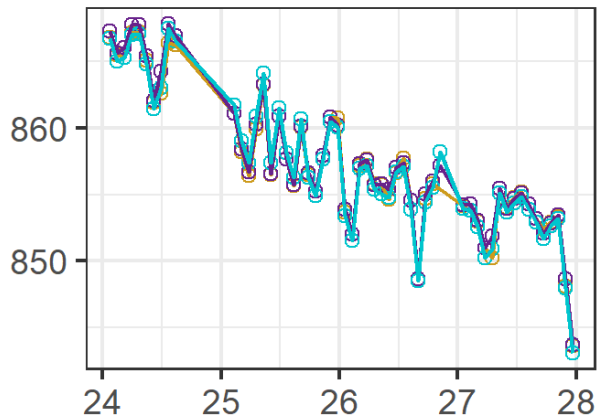
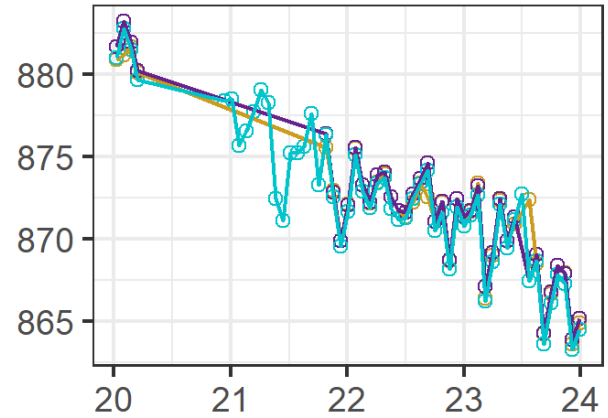
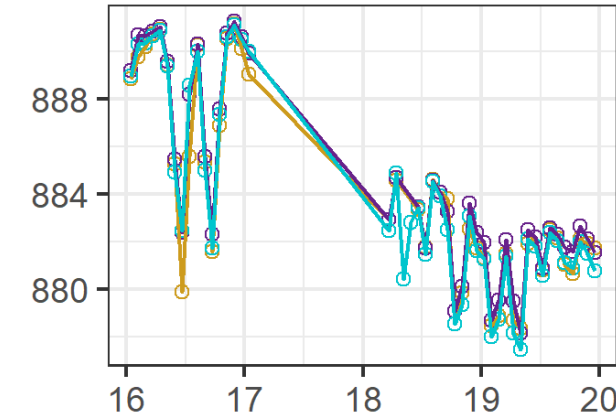
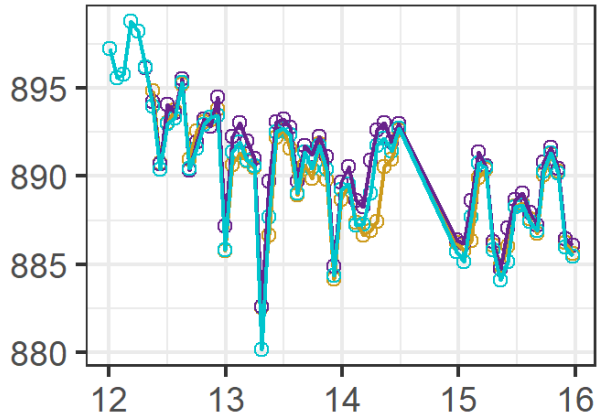
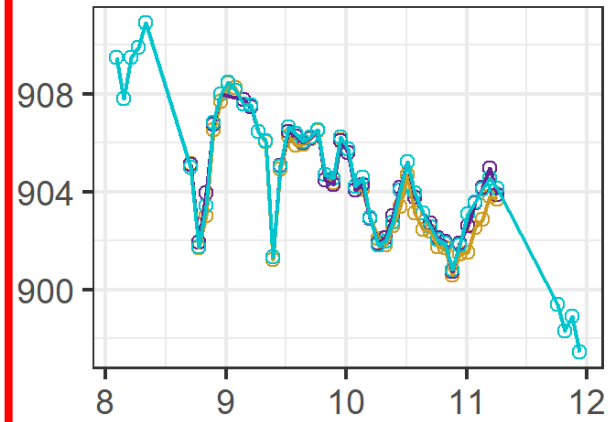
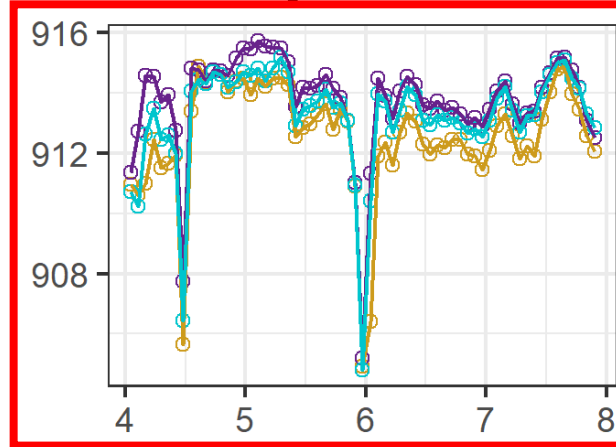
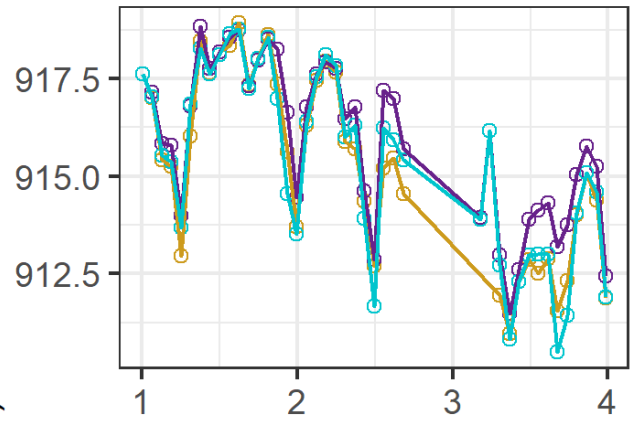


Change in mean bed elevation in Lower Marble Canyon



Mean bed elevation of centerline swath by river mile in Upper Marble Canyon

Mean bed elevation (m)



Preliminary data, subject to review, do not cite

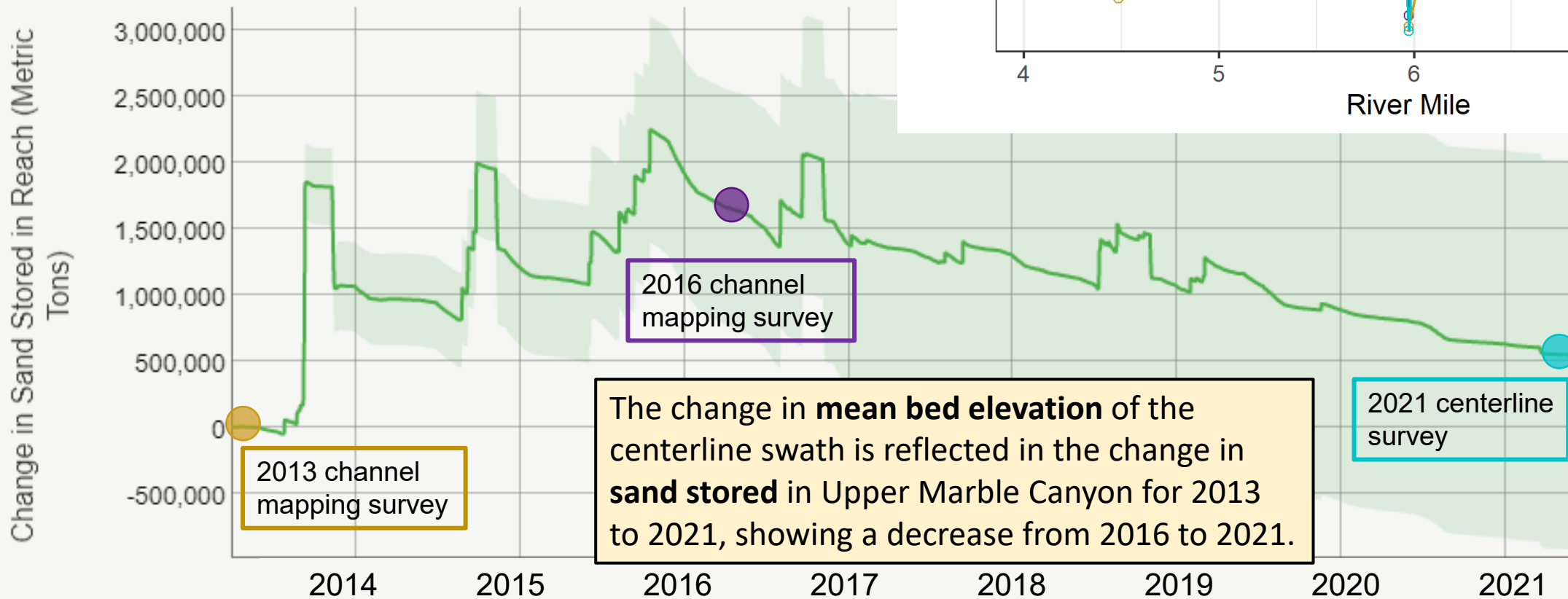
Riverbed Profile – Analysis



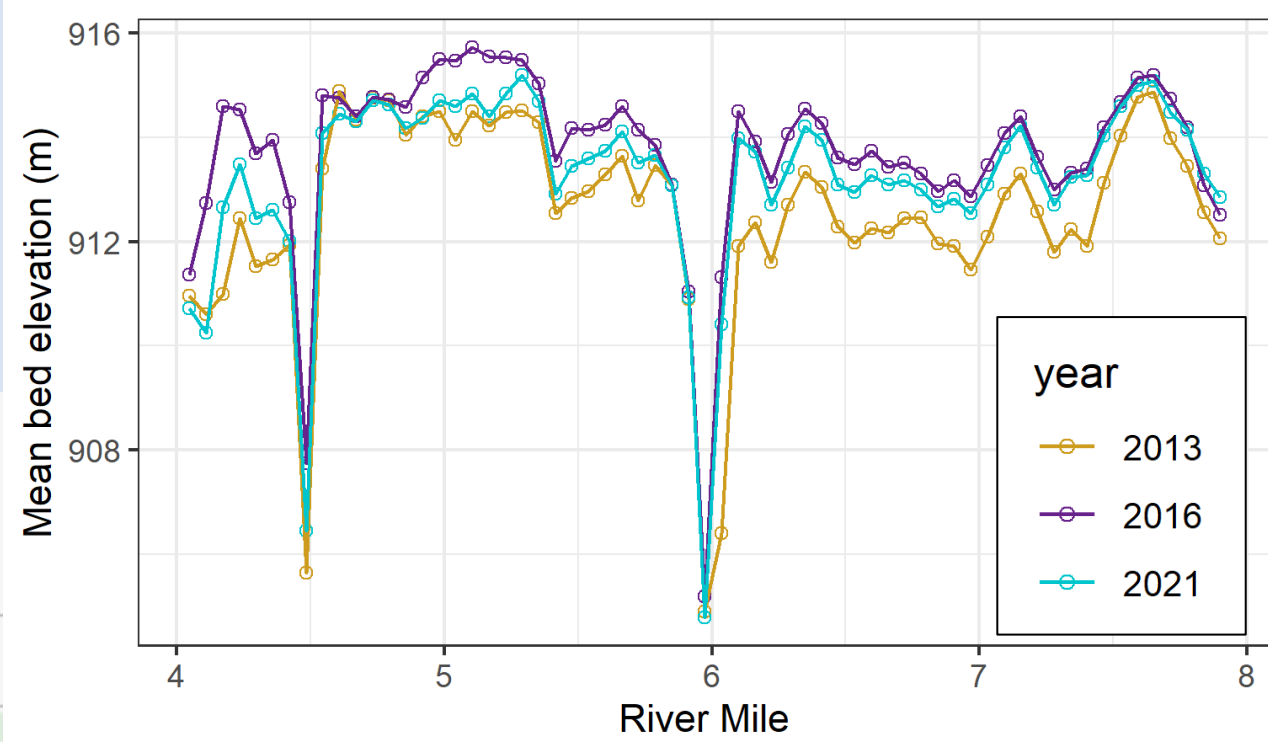
Riverbed Profile – Analysis

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Change in Sand Mass for River Miles 0 – 30 Measured via Sediment Gaging Stations

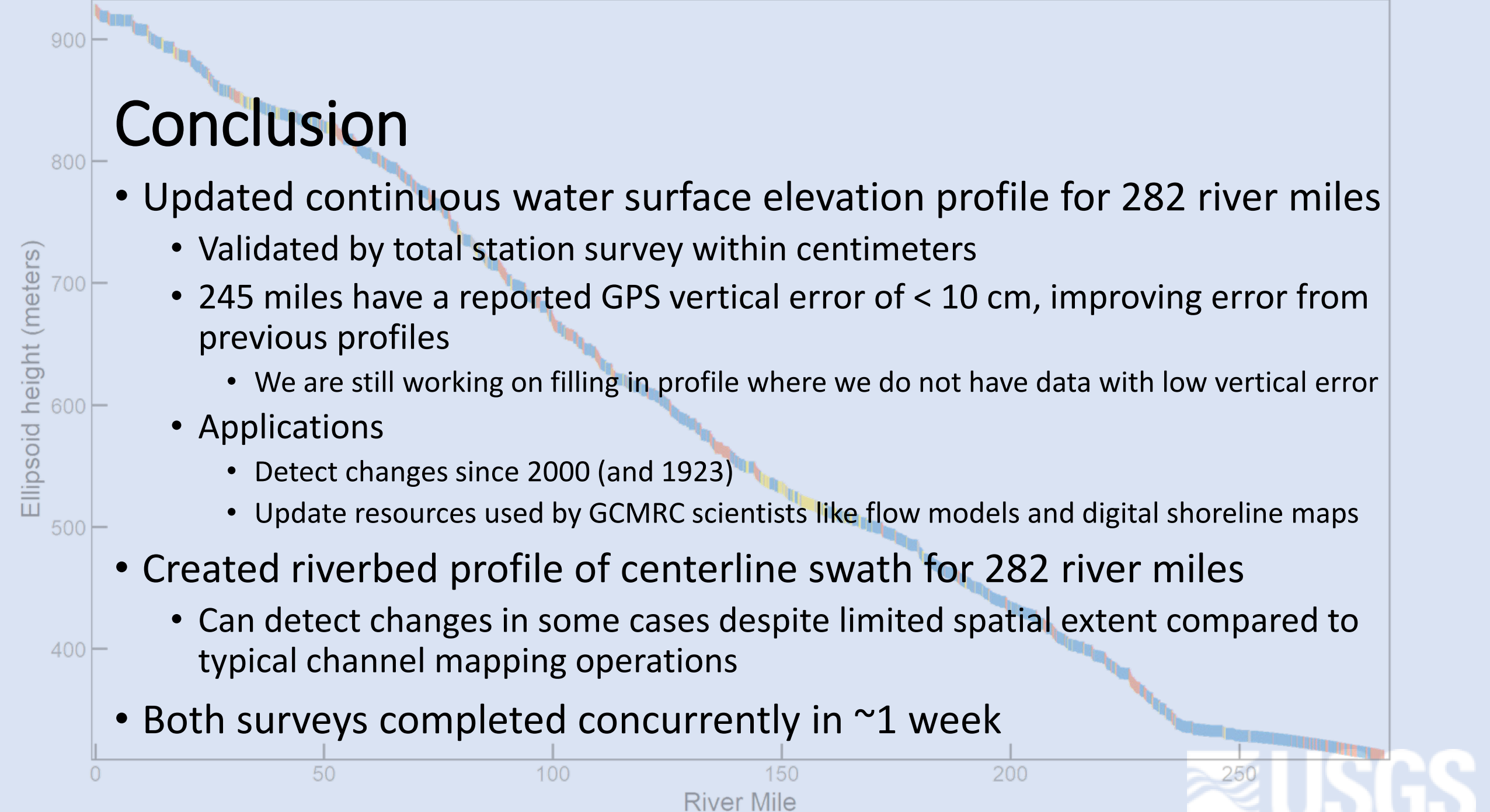


The change in **mean bed elevation** of the centerline swath is reflected in the change in **sand stored** in Upper Marble Canyon for 2013 to 2021, showing a decrease from 2016 to 2021.



Conclusion

- Updated continuous water surface elevation profile for 282 river miles
 - Validated by total station survey within centimeters
 - 245 miles have a reported GPS vertical error of < 10 cm, improving error from previous profiles
 - We are still working on filling in profile where we do not have data with low vertical error
- Applications
 - Detect changes since 2000 (and 1923)
 - Update resources used by GCMRC scientists like flow models and digital shoreline maps
- Created riverbed profile of centerline swath for 282 river miles
 - Can detect changes in some cases despite limited spatial extent compared to typical channel mapping operations
- Both surveys completed concurrently in ~1 week



Thank you!

