SWOT: Pushing the Boundaries Beyond What's Possible

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What is SWOT

•SWOT (Surface Water and Ocean Topography) measures the height of nearly all water surfaces worldwide.
•Made up of two antennas about 10 meters apart, the satellite collects data by transmitting radar pulses from one antenna and receiving the signal with both (JPL, n.d.).
•Studying SWOT is important as it provides insight into preventing depletion of drinking water, understanding irrigation and discharge, making predictions for short and long-term weather changes, etc (JPL, n.d.).

Statement of Problem

•Located in eastern California, the Owens River begins in the Sierra Nevada mountain range and flows about 120 miles west to Owens Lake, which is now dry. The Los Angeles Department of Water diverts the river's flow into the L.A. Aqueduct (Danskin, 2017).
•In addition to being a vital freshwater source for humans, the Owens River sustains diverse landforms and habitats (e.g., provides habitat for threatened Yosemite toad) (National Wild and Scenic Rivers System, n.d.). Due to it being a critical river, gaining more information on its elevation, slope, storage, and discharge would be especially valuable. SWOT aims to provide this groundbreaking data.
•A successful survey of the Owens River may prove SWOT's unexpected, more advanced accuracy. SWOT is expected to **ID rivers and streams 30 meters or wider** (SWORD, 2022), and the Owens River has an average width of **about 6 to 15 meters** (Danskin, 2017)**.** The difference in width allows us to test the validity of SWOT. We determined the surface elevation of the river at three locations and compared these data with SWOT.

Methods

Methods of Data Collection:
•Took data from 3 locations along the Owens River: Pleasant Valley, Poleta Bridge, and Warm Springs Road.
•Set up tripod with **Global Navigation Satellite System (GNSS)** receiver in ~10 cm of water.
•Measured antenna offsets of tripod legs before and after data collection and let system collect data for ~1 hour.

Methods of Data Analysis:
•Captured SWOT data points in and along the river (**49.95-meter buffer**) from Pleasant Valley to Poleta Bridge to Warm Springs for **10/21/23** and **10/22/23**.
•Converted SWOT points from coordinates to meters (Pleasant Valley GNSS at 0m). Analyzed points that had nearly the exact same location as GNSS points (off by 0.1 meters at most), points within 45 meters of GNSS, and points within 100 meters of GNSS.
•**Only data for 10/22 could be used** because no points on 10/21 were within 100 meters of GNSS.
•Determined **average height** for each set (exact location, within 45 m, and within 100 m) for each location as well as **standard deviation**, height **range** within each set, and **difference** between GNSS-determined height and average SWOT height.
•SWOT points 2 standard deviations from the mean were removed from each set.
•All points were graphed in comparison with GNSS points, and the approximate latitudinal slope (change from Poleta to Warm Springs) of the river was calculated from trend lines.

Discussion & Conclusion

The average water surface elevation for each location displays SWOT's accuracy for collecting data on the Owens River. It likely has potential to collect data for similarly narrow rivers in open valleys. The average height of SWOT points with nearly the same location as GNSS at Poleta and Warm Springs had **a discrepancy of less than a meter**, and for Pleasant Valley, SWOT had **a discrepancy of three meters**. **Likewise, SWOT can accurately approximate the slope of the Owens River (0.1 m/km discrepancy).** That said, more data need to be collected to determine SWOT's capabilities. More GNSS points along the river should be collected. Additionally, while 54 and 38 SWOT points were within 100 meters of GNSS for Pleasant Valley and Warm Springs, only 12 points could be analyzed for Poleta Bridge, making it difficult to comment on SWOT's precision at that location. Further, data from 10/21 was essentially unusable and had relatively inaccurate heights. Some discrepancies in SWOT may be due to tree coverage and cable interference, which were noted at some of our locations. Interestingly, SWOT collected points in "clumps" near GNSS (i.e., picked up sets of points with the same location rather than more continuously). **While much more data need to be collected, our findings support SWOT's potential ground-breaking ability to capture data for narrow rivers.**

Results

1. Pleasant Valley Campground
Point 1: 37° 24' 23'' N, 118° 30' 9'' W, (Figure 3)
2. Poleta Bridge
Point 2: 37° 361' 65'' N, 118° 338' 69'' W, (Figure 4)
3. Warm Springs Road
Point 3: 37° 32' 574'' N, 118° 31' 390'' W, (Figure 5)

Percent Error of Heights
(average height vs GNSS):
Pleasant Valley (0m)
Exact: -0.256% Within 45m: -0.206%
Poleta Bridge (45171m)
Exact: -0.0607% Within 45m: -0.0822%
Warm Springs (58510m)
Exact:-0.0000970% Within 45m: -0.0199%

Latitudinal Slope

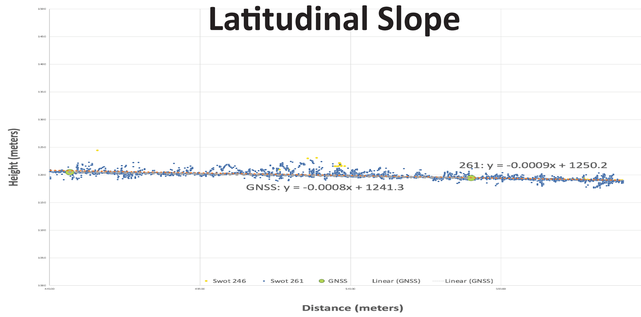


Figure 2: Water surface elevation (m) vs distance (m) from Poleta to Warm Springs (representing latitudinal distance). Latitudinal slope calculated from trend lines. Green dots represent GNSS points. Yellow dots represent data from 10/21. Blue dots represent data from 10/22.

GNSS: -0.8 m/km
SWOT: -0.9 m/km

Water Surface Elevations vs Distance for ALL POINTS

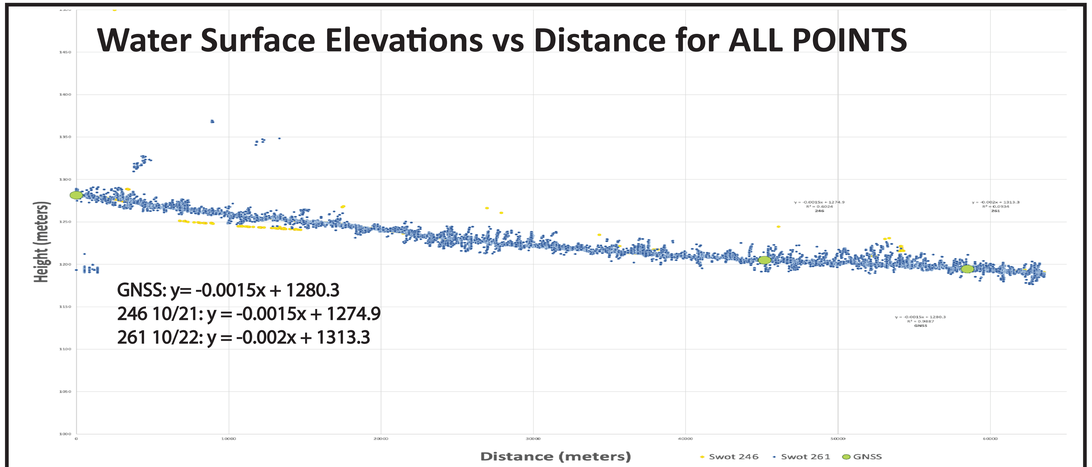


Figure 1: Water surface elevation (height) in meters vs position of points (distance) in meters. Green dots represent GNSS. Yellow dots represent SWOT points from 10/21. Blue dots represent SWOT points from 10/22.

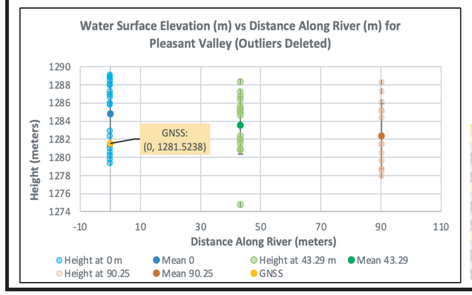


Figure 3

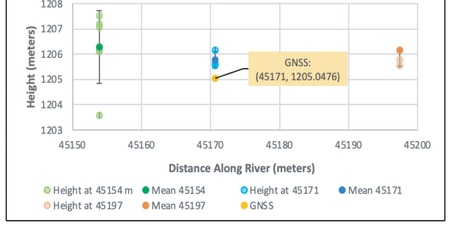
Height vs distance for 3 sets of data for Pleasant Valley. All distances given as river distance from Pleasant Valley here and for all other locations. 1st set: same position as GNSS (all at 0m); 2nd set: ~45m away (all at 43.29m); 3rd set: ~100 meters away (all at 90.25m). Outliers have been deleted and error bars shown.

Pleasant Valley GNSS Height:	1281.523839	
Exact Location (0m)	Outliers included	Outliers deleted
Average	1272.32152	1284.804989
STDEV	32.3258924	3.581046461
Range	95.888916	9.73023
Diff. GNSS - SWOTavg	9.202322443	-3.281150474
W/in 45 (0-43.29m)	Outliers included	Outliers deleted
Average	1277.511868	1284.163369
STDEV	24.18912919	3.409948117
Range	95.888916	14.26746
Diff. GNSS - SWOTavg	4.011971195	2.639529947
W/in 100 (0-90.25m)	Outliers included	Outliers deleted
Average	1278.745774	1283.677673
STDEV	21.00046512	3.504940484
Range	95.888916	14.26746
Diff. GNSS - SWOTavg	2.778064818	-2.153834462

Figure 4

Height vs distance for 3 sets of data for Poleta Bridge (those that have the same position as GNSS (all at 45171m), those that are about 20m north of GNSS (all at 45154m), and those that are about 20m south of GNSS (all at 45197m). Outliers have been deleted and error bars are shown.

Poleta Bridge GNSS Height:	1205.04758	
Exact Location (45171m)	Outliers included	Outliers deleted
Average	1205.77885	1205.77885
STDEV	0.336505876	0.336505876
Range	0.61486	0.61486
Diff. GNSS - SWOTavg	-0.73127	-0.73127
W/in 45 (45154-45197m)	Outliers included	Outliers deleted
Average	1205.397987	1206.038554
STDEV	2.507308653	1.019279727
Range	9.81494	3.95398
Diff. GNSS - SWOTavg	-0.350406923	-0.990974167



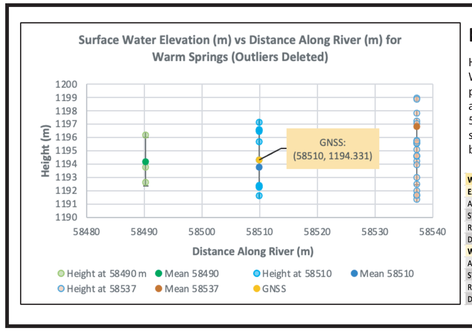


Figure 5

Height vs distance for 3 sets of data for Warm Springs (those that have the same position as GNSS (all at 58510m), those that are about 20m north of GNSS (all at 58490m), and those that are about 20m south of GNSS (all at 58537m). Outliers have been deleted and error bars are shown.

Warm Springs GNSS Height:	1194.331039	
Exact Location (58510m)	Outliers included	Outliers deleted
Average	1194.332198	1194.332198
STDEV	2.171579945	2.171579945
Range	5.50036621	5.50036621
Diff. GNSS - SWOTavg	-0.001159182	-0.001159182
W/in 45 (58490-58537m)	Outliers included	Outliers deleted
Average	1195.415809	1194.568584
STDEV	4.260401427	2.184836591
Range	19.81054	7.61963
Diff. GNSS - SWOTavg	-1.084769718	-0.237544514

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