Determining the Accuracy of SWOT Water Elevation Data at Mono Lake, California

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Background

- Mono Lake, located on the eastern side of the Sierra Nevada in California, is a part of the Great Basin Lakes[1]. Its elevation was at an all-time low in 1982, standing at 1,942 meters due to water being diverted to Los Angeles[2]. The elevation has stabilized since then; however, it's still slowly decreasing because of evaporation.
- Surface Water and Ocean Topography (SWOT), is a project by NASA to examine Earth's surface water topography of all bodies of water in a span of 21 days, allowing for the first global survey of such data[3].
- Our goal is to determine the accuracy of SWOT's data by comparing on-site elevation data through Global Navigation Satellite System (GNSS) imaging to SWOT's elevation data from Mono Lake. This data can provide us with insights into the accuracy and dependability of SWOT when regarding Earth's surface water.

Methods

- Chose two access points on the perimeter of Mono Lake to collect on-site elevation data through the GNSS survey: the Mono Lake Navy Beach (37°56'27.700", 119°1'13.6106"), and the Mono Lake Boat Launch (37°58'50.5513", 119°6'29.0439").
- At our locations, we raised and positioned our tripod into a shallow area, and measured three offsets before and after the data collection to account for the height of the tripod and antenna.
- After obtaining the SWOT elevation data, we gathered and averaged the ellipsoid elevation of the 15 closest pixel cloud elevation points to our two GNSS survey sites for both SWOT flyovers.
- We established the accuracy of SWOT's elevation data by generating a buffer around the GNSS survey points and collecting approximately 2000 elevation points from each location for both satellite flyovers.

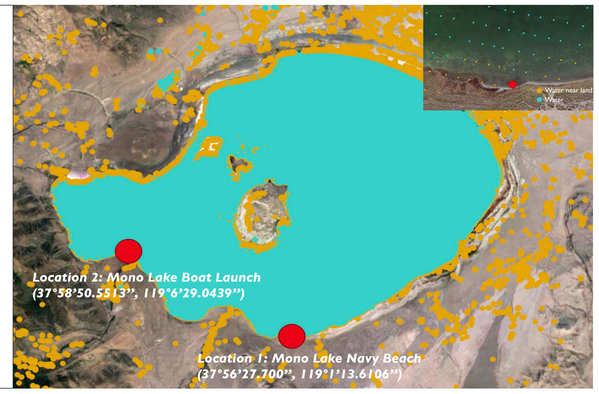

Figure 1. Locations at which GNSS Data was recorded at Mono Lake, California

Research Question

To what extent can the surface elevation of Mono Lake be accurately measured by the SWOT satellite?

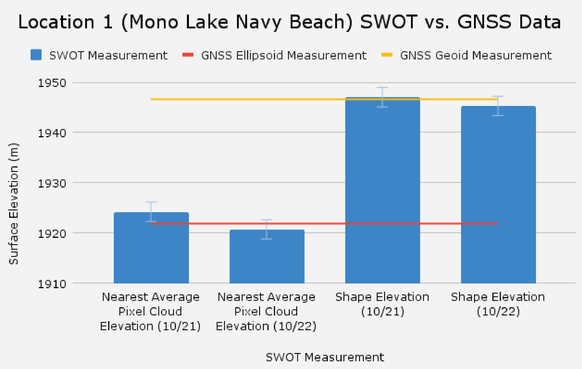

Figure 2. Comparing SWOT vs. GNSS Data at Location One

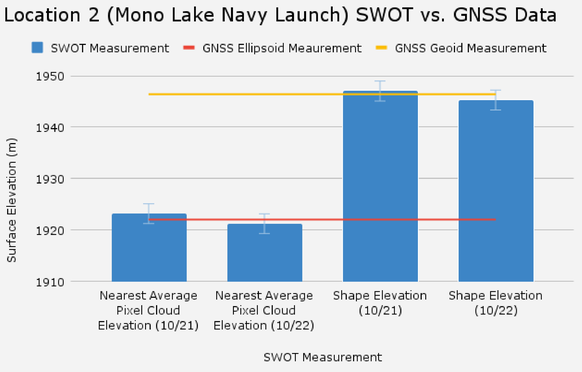

Figure 3. Comparing SWOT vs. GNSS Data at Location Two

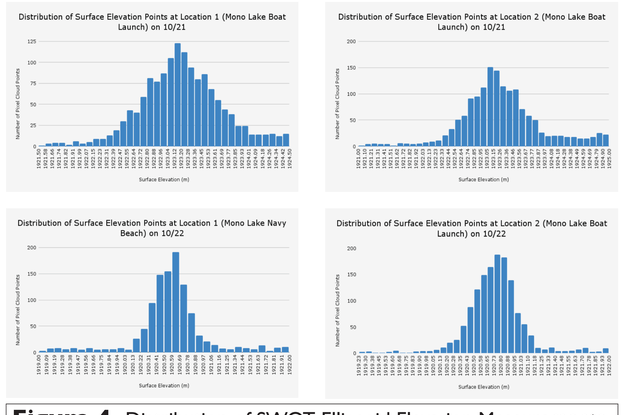

Figure 4. Distribution of SWOT Ellipsoid Elevation Measurements

Results

- Location 1: GNSS ellipsoid measurement of 1922.0302m, geoid measurement of 1946.4093m (± 0.0005m). Location 2: Ellipsoid measurement of 1921.8431m, geoid measurement of 1946.4093m (± 0.0005m). GNSS error was thinner than the line on Figures 2 & 3.
- SWOT pixel cloud/ellipsoid elevation on 10/21 at location 1 was 1923.1906m and on 10/22 was 1921.2401m. SWOT elevation on 10/21 for location two was 1924.2030 m, and on 10/22 was 1920.7252m.
- SWOT's shape/geoid elevation on 10/21 was 1947.032m and on 10/22 was 1945.294 meters.

Discussion

- Pixel cloud data differed by 1.9505m and 3.4777m at each location respectively on different days, while shape elevation differed by 1.738m, possibly due to satellite wobble, a phenomenon where a satellite may not be the same pitch relative to the surface elevation of the earth at all times.
- The first flyover produced higher elevation values compared to GNSS data, while the second flyover had lower elevation values. Overall, SWOT's geoid data was more accurate than its ellipsoid data. Furthermore, data from 10/22 was more accurate, perhaps because the flyover on 10/22 had a satellite path with greater visibility to accurately measure Mono Lake. Averaging ellipsoid data from both days at location two gives us a value of 1922.2153m, only 37 cm different from the GNSS survey at the location. Overall, SWOT's flyover on 10/22 was more precise and accurate although still not within the error of the GNSS data or SWOT's accuracy requirements for a lake for the size of Mono Lake (± 10cm)[5].
- To account for differences between the days between the GNSS survey (10/19) and SWOT's flyovers, external factors like wind and weather conditions were observed to determine differences, although archival data showed almost no difference in these conditions[4]. However, the collection of this data always involves uncertainty, especially when it comes from a new satellite. SWOT's geoid elevation measurement is more accurate than its ellipsoid or pixel cloud data due to specific algorithms. Using similar algorithms to process SWOT's ellipsoid data might produce more accurate results. Lastly, human error in setting up the GNSS survey, such as recording incorrect offsets, may have led to slightly inaccurate data.

Conclusion

- SWOT's ellipsoid and geoid elevation data doesn't fit NASA's performance specifications of a lake the size of Mono Lake (~10 cm of error); however, SWOT's elevation data provides promising perspective for measuring the elevation of water bodies across the globe.
- This information can enhance SWOT's survey capabilities and rectify its processing methods to accurately represent surface elevation data, especially for obscure bodies of water.
- Our findings suggest that averaging data from multiple flyovers may yield more precise results by accounting for any discrepancies that may have possibly been due to wobble.

Citations

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