# G51C-0360 Advancing Water Level Measurements through GNSS Interferometry:

## Experiences, Challenges, and Innovations from JOA Surveys LLC

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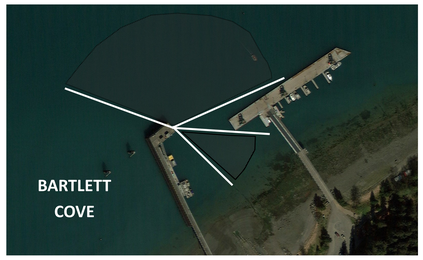
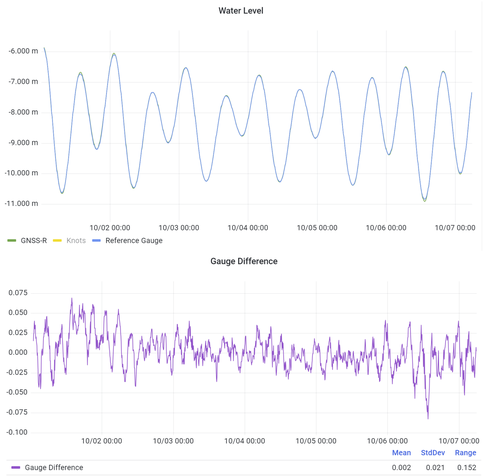
JOA Surveys, LLC
At the boundary between land and sea

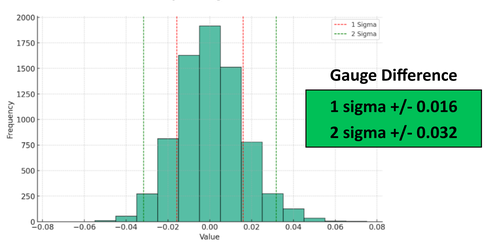
## GLBX




**Example 6 Days of Data vs. Traditional Tide Gauge**




**Comparing 14 months of data**



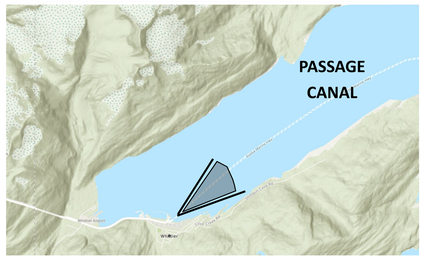

**Gauge Difference**

**1 sigma +/- 0.016**
**2 sigma +/- 0.032**

| | GNSS-R | Radar | Diff |
|---|---|---|---|
| HWL | -4.237 | -4.175 | -0.062 |
| MHHW | -5.251 | -5.259 | 0.008 |
| MHW | -5.548 | -5.556 | 0.008 |
| DTL | -7.487 | -7.489 | 0.002 |
| MTL | -7.412 | -7.414 | 0.002 |
| MSL | -7.42 | -7.420 | 0.000 |
| MLW | -9.276 | -9.272 | -0.004 |
| MLLW | -9.756 | -9.753 | -0.003 |
| DHQ | 0.297 | 0.297 | 0.000 |
| DLQ | 0.48 | 0.481 | -0.001 |
| GT | 4.51 | 4.499 | 0.011 |
| MN | 3.728 | 3.716 | 0.012 |
| LWL | -11.346 | -11.332 | -0.014 |

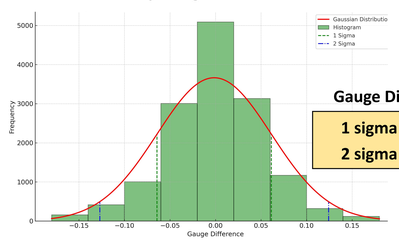
**A Trimble Alloy GNSS and a radar water level sensor at the Glacier Bay National Park fuel dock in Bartlett Cove, Alaska. Excellent results were achieved from an adequate footprint in protected waters.**

## WHTR




**Example 6 Days of Data vs. Traditional Tide Gauge**


**Comparing 2 months of data**



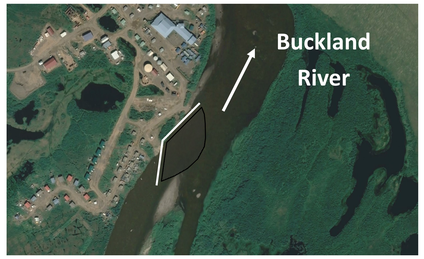

**Gauge Difference**

**1 sigma +/- 0.06**
**2 sigma +/- 0.12**

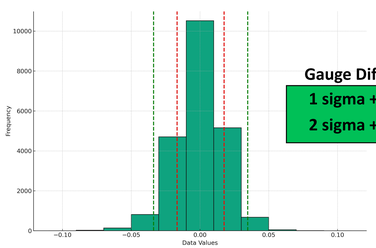
| | GNSS-R | MWWL | Diff |
|---|---|---|---|
| **HWL** | 10.630 | 10.769 | 0.139 |
| **MHHW** | 9.917 | 9.928 | 0.011 |
| **MHW** | 9.392 | 9.397 | 0.005 |
| **DTL** | 8.008 | 8.040 | 0.032 |
| **MTL** | 7.878 | 7.900 | 0.022 |
| **MSL** | 7.846 | 7.846 | 0.000 |
| **MLW** | 6.365 | 6.403 | 0.038 |
| **MLLW** | 6.123 | 6.177 | 0.054 |
| **DHQ** | 0.525 | 0.531 | 0.006 |
| **DLQ** | 0.242 | 0.225 | -0.017 |
| **GT** | 3.753 | 3.707 | -0.046 |
| **MN** | 3.027 | 2.994 | -0.033 |
| **LWL** | 5.010 | 5.065 | 0.055 |

**A Trimble Alloy GNSS receiver and a radar water level sensor were installed at the Alaska Marine Highway terminal in Whittier Alaska. What at first appears to be an adequate GNSS-R footprint is seriously reduced by the mountainous terrain in Passage Canal. The limited footprint produced usable results with limited precision.**


## BUCK




**3 Months of Data vs. Traditional Tide Gauge**


**Gauge Difference**

**1 sigma +/- 0.011**
**2 sigma +/- 0.022**

**A Septentrio Mosaic Go and a bubbler/pressure based water level sensor were installed on the left bank of the river at Buckland, Alaska for 3 summer months. The river has a tide signal but is also affected by upstream influences and experienced multiple high water events. The site shows the technique can successfully capture irregular water level variations on a river. The large footprint, calm water, and the three meter bank produced excellent results.**

## GNSS-R at JOA

JOA Surveys was founded in 2003 with an ambition to provide the highest quality water level data service in Alaska and beyond. To meet the unique environmental challenges of Alaska we are continually conducting research and development of novel water level measurement techniques. GNSS reflectometry (interferometry) offers unique advantages over traditional pressure or radar based tide gauges that makes it particularly attractive in Alaska. The primary benefit is that the system is capable of measuring water level obliquely and so it can be installed in areas that experience heavy winter sea ice and not get damaged. It also has the unique quality of measuring water level directly relative to a global reference frame.

As the GNSS-R technique and the GNSS constellations have grown JOA has been working to operationalize and validate the technique for real-world use. JOA's first exposure to GNSS-R was the processing of AT01 and PBAY, two UNAVCO permanent GNSS sites in Alaska, using a spectral analysis algorithm. Currently we are developing inhouse an improved processing algorithm based largely on the inverse modeling technique developed by Joakim Strandberg (Strandberg et al. 2016).

In the past three years we have deployed over a dozen temporary and permanent GNSS-R sites. Along the way we have learned that each deployment presents unique challenges and requires a carefully adjusted set of processing parameters to achieve the best results.

The next steps include the development of a set of QA/QC tools, refinement of our processing algorithm, and developing automation to provide water level data in near real time.

## Acknowledgements

- Alaska Continuously Operating Reference Network (ACORN) **WHTR**
- National Park Service **GLBX**
- Alaska Ocean Observing System (AOOS) **WHTR MWWL**
- Special thanks to Kristine Larson, Joakim Strandberg , Dave Parnell, and the whole open source GNSS-IR community.
- Strandberg, J., T. Hobiger, and R. Haas (2016), Improving GNSS-R sea level determination through inverse modeling of SNR data, Radio Sci., 51, 1286–1296, doi:10.1002/2016RS006057