GNSS-R

Drew Lindow
Jim Mitchell
Nathan Wardwell

GNSS-R History

* **1988: Georgiadou and Kleusberg** “On carrier signal multipath effects in relative GPS positioning”
* “extreme multipath interference can render useless GPS observations for precise positioning applications”

GNSS-R *Interference patterns from a planar surface below an antenna had a **distinct frequency** related to the height of the antenna above the surface.*

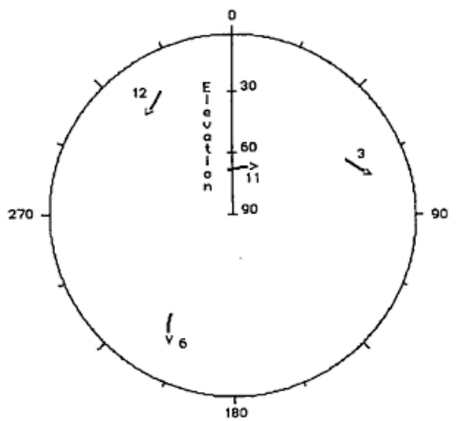

Figure 2: Satellite polar plot, Dec. 14, 1986, 13:30-13:40 UT

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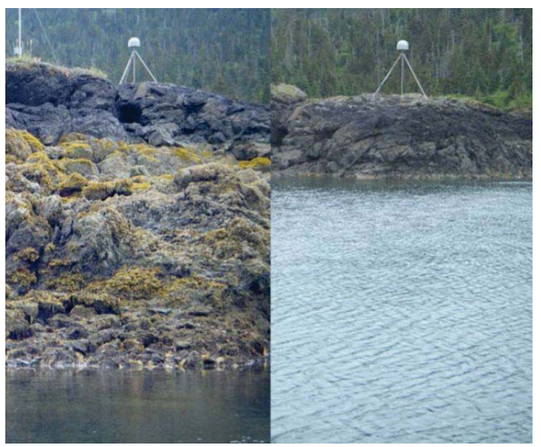
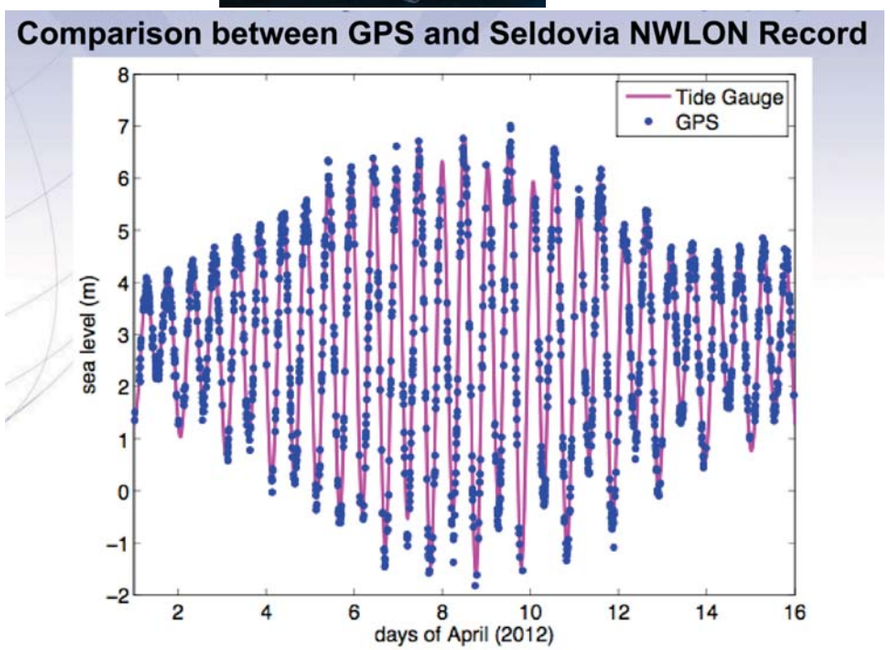
GNSS-R History

* **2013**: Larson et al. **First demonstration of water levels** GPS-IR SNR measurements
*

  Petersen Bay, AK



Onsala, Sweden



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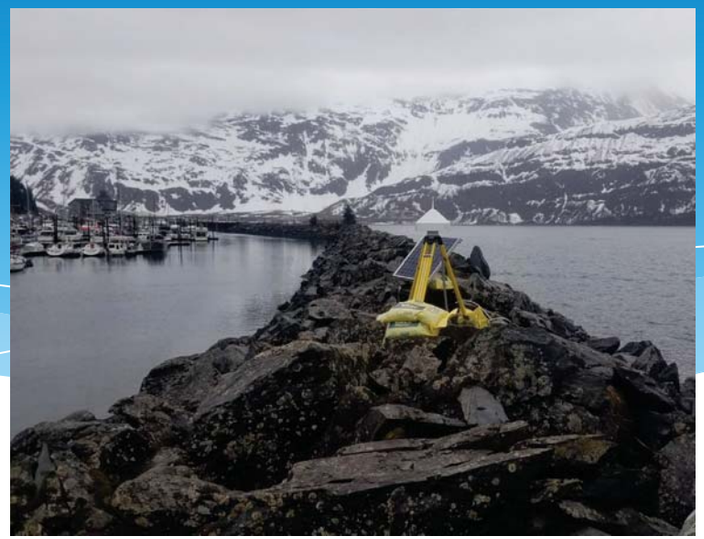
GNSS-R History

* 2017: Larson et al. 10-year comparison at Friday Harbor, Washington, between a GPS-IR analysis and collocated tide gauge (350 m SE) **showed daily averages** to be in agreement at the 2-cm level

SC02 (Friday Harbor) GPS

GNSS-R at JOA

* AT01 & PBAY GNSS-R @ JOASurveys.com
* 2020 Whittier Deployed Pressure Gauge, GNSS Buoy, GNSS-R
* 2021 Wainwright Egegik



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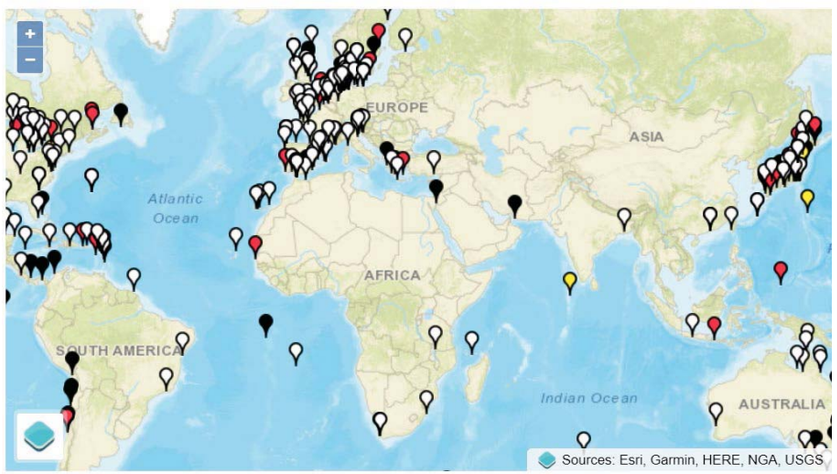
Permanent Service for Mean Sea Level https://psmsl.org

* 275 Sites around the world

GNSS-IR Site Map



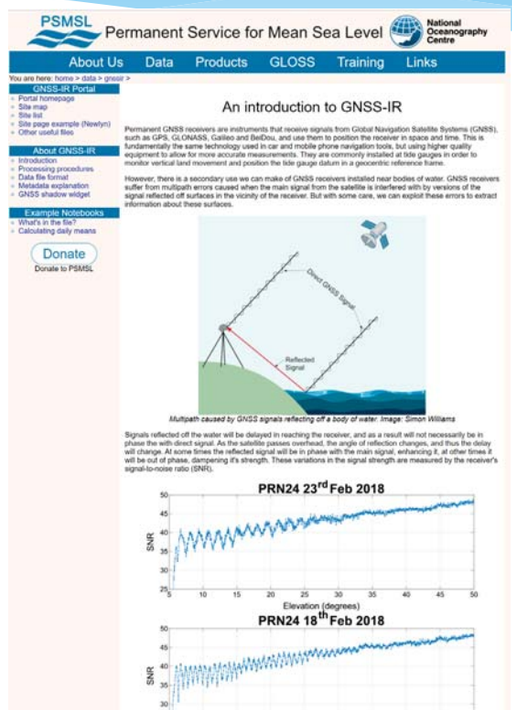
- Good site - reflectometry works well and data is available
- Decommissioned - reflectometry works well, data is available, but site is no longer operating
- Questionable - reflectometry works sometimes or the signal is very weak probably due to location
- Bad - no data available at the site, either due to positioning of the sensor, lack of signal to noise ratio data, or data sampling is inadequate for the height of the sensor

GNSS-IR Portal
- Portal homepage
- Site map
- Site list
- Site page example (Newlyn)
- Other useful files

About GNSS-IR
- Introduction
- Processing procedures
- Data file format
- Metadata explanation
- GNSS shadow widget

Example Notebooks
- What's in the file?
- Calculating daily means

Excellent Introduction



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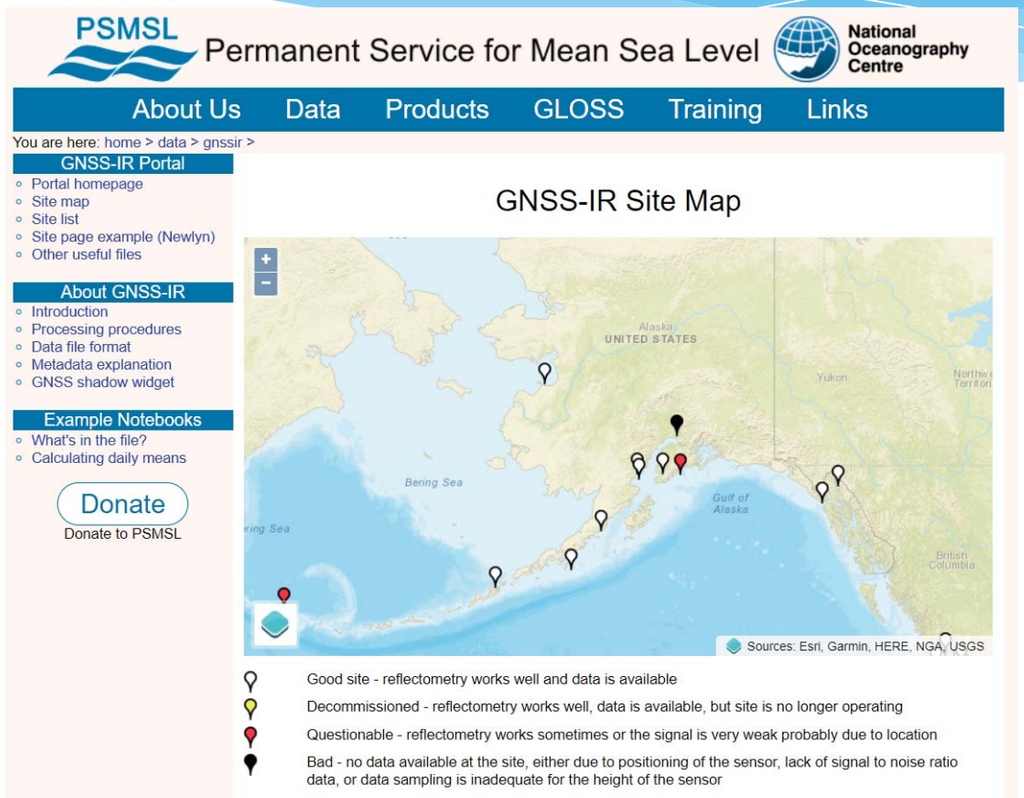
https://psmsl.org

* 10 sites in Alaska

CODE	Site	GNSS Data
ELDC	Eldred Rock	1/5/2022
AB43	**Cape Spencer**	**current**
AC43	Seal Rocks	9/10/2021
PBAY*	**Peterson Bay**	**current**
AC59	**Ursus Head**	**current**
AV02	Augustine Volcano	1/16/2023
UGAI	Ugaiushak Island	6/21/2022
AC12	Chernabura	1/21/2023
AV09	**Unalaska**	**current**
AT01	**St. Michael**	**current**
* GPS Only		



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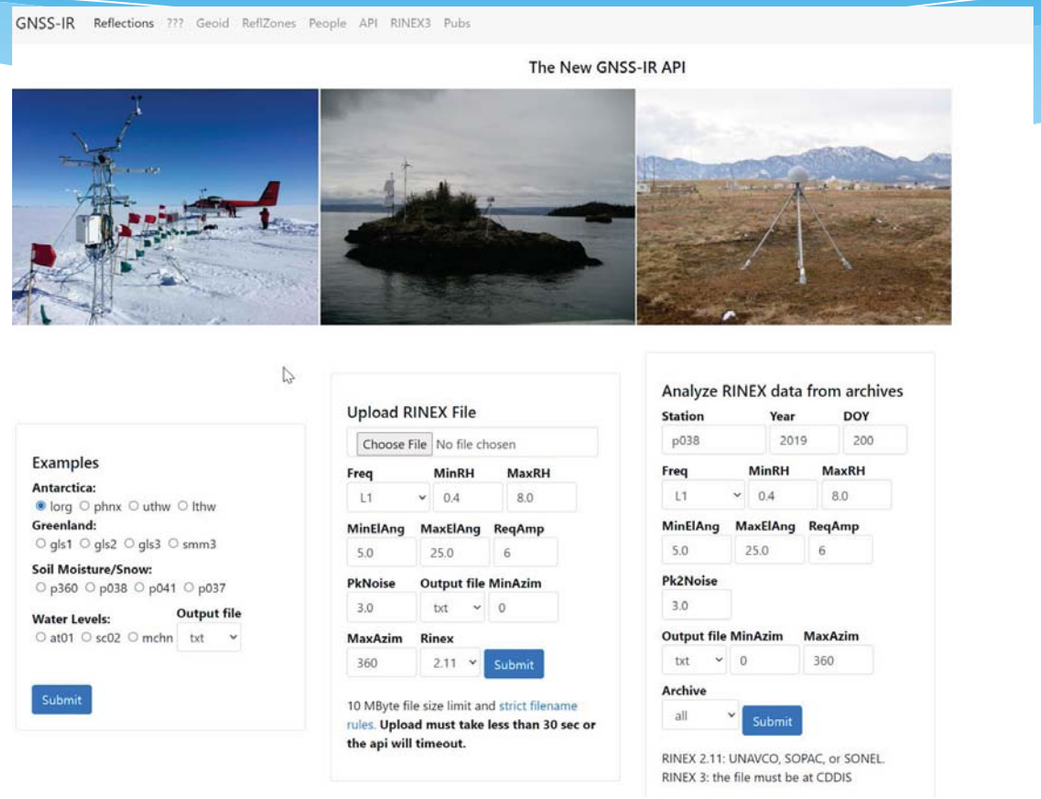
https://gnss-reflections.org/

* Kristine Larson
  Git Hub –
  https://github.com/kristinemlarson

* YouTube Videos Webinars …
* Short Course May 2- May 5, 2023



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Kristine M. Larson

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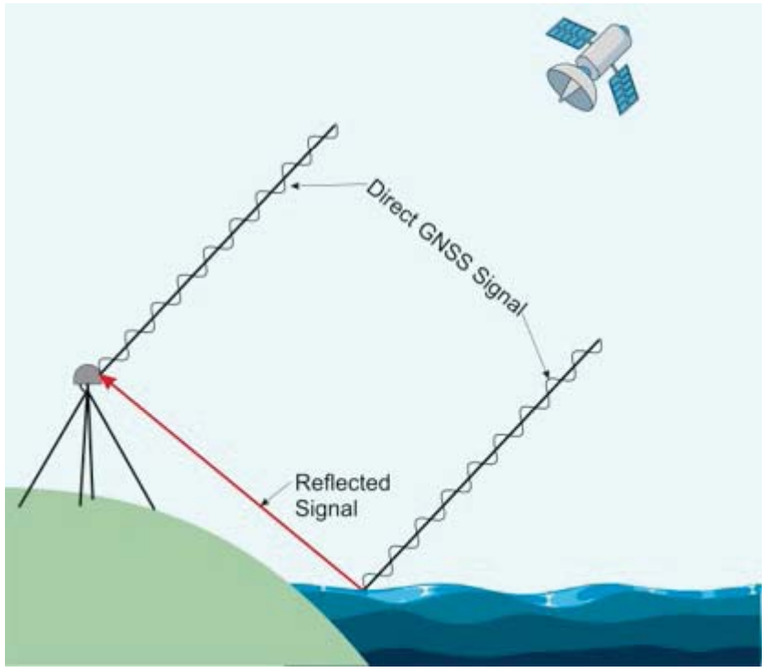
Measuring Water Levels with GPS

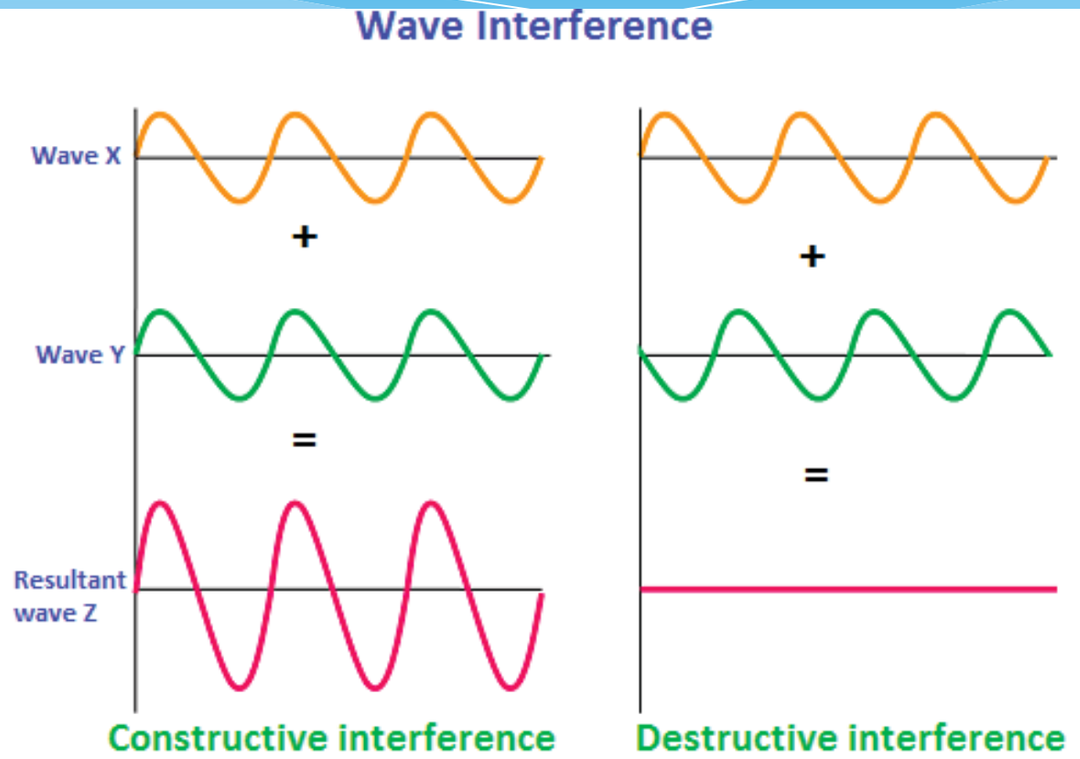
Posted
November 8, 2015

Category
GPS Reflections

GNSS signals reflect off water surfaces. Unlike for soil moisture and snow depth, which varies most dynamically only on the day that it rains or snows, water levels vary throughout the day. This adds a bit of complexity for using the GPS/GNSS Interferometric Reflectometry (GPS-IR or GNSS-IR) technique to measure tidal variations for example. The advantage of using GNSS-IR with a standard geodetic receiver is that you can simultaneously measure the three-dimensional position of the GNSS antenna in the International Terrestrial Reference Frame.

Reflected Signal Interference





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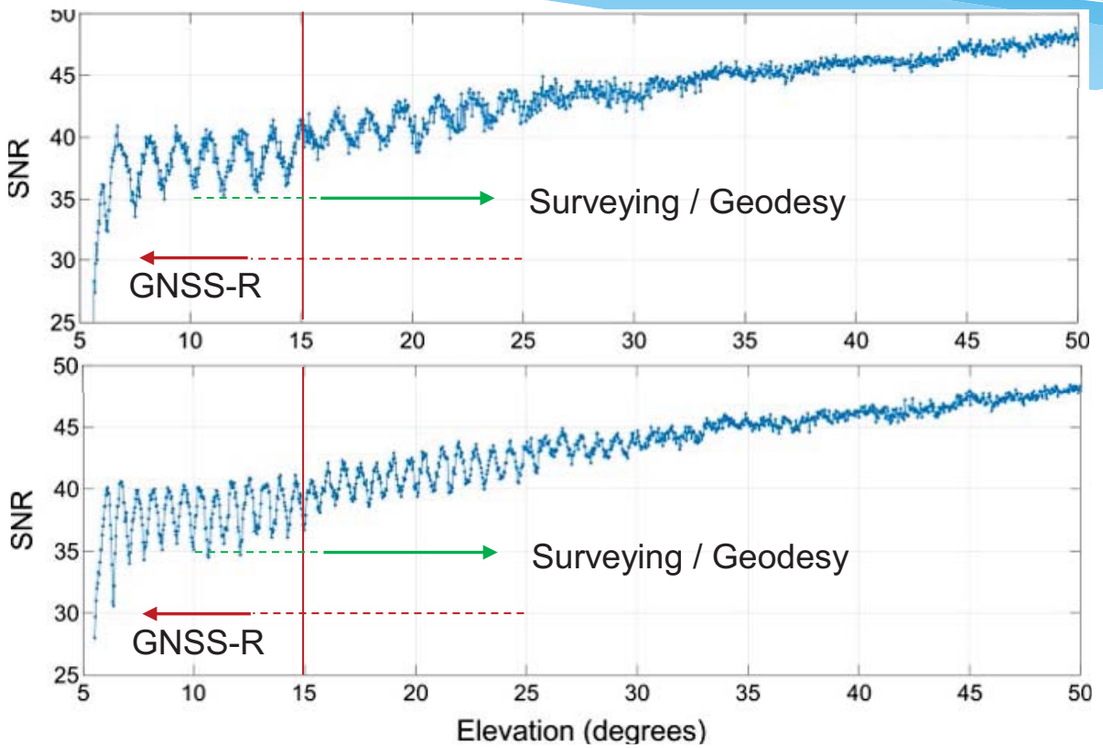
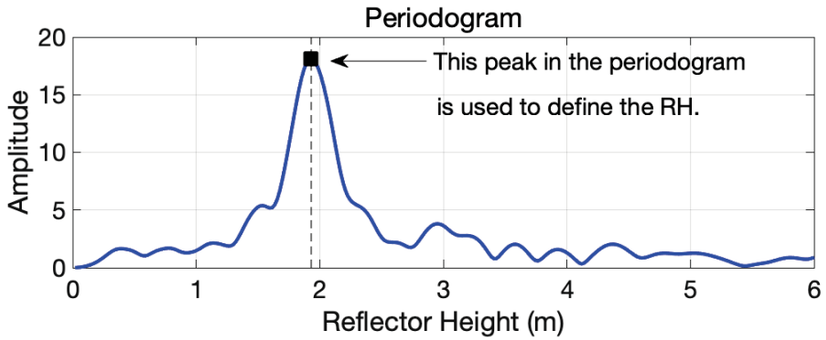
SNR Oscillation Frequency

High Tide

Low Tide





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My Start with GNSS-R
Shelter Cove, CA RECON
December 1-4, 2022

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Shelter Cove, CA

BACK336a00.22_.gz	3,841,784	GZip File	12/1/2022 3:15:39 PM
BACK336a15.22_.gz	4,147,418	GZip File	12/1/2022 3:30:25 PM
BACK336a30.22_.gz	4,239,622	GZip File	12/1/2022 3:45:49 PM
BACK336a45.22_.gz	4,424,211	GZip File	12/1/2022 4:00:32 PM
BACK336b00.22_.gz	4,260,002	GZip File	12/1/2022 4:16:36 PM
BACK336b15.22_.gz	4,124,577	GZip File	12/1/2022 4:30:24 PM
BACK336b30.22_.gz	3,918,243	GZip File	12/1/2022 4:46:06 PM
BACK336b45.22_.gz	3,834,197	GZip File	12/1/2022 5:01:29 PM
BACK336c00.22_.gz	3,789,097	GZip File	12/1/2022 5:15:47 PM
BACK336c15.22_.gz	3,864,674	GZip File	12/1/2022 5:30:28 PM
BACK336c30.22_.gz	3,837,553	GZip File	12/1/2022 5:45:38 PM
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BACK336d00.22_.gz	4,129,858	GZip File	12/1/2022 6:15:38 PM
BACK336d15.22_.gz	3,887,867	GZip File	12/1/2022 6:30:16 PM
BACK336d30.22_.gz	3,433,531	GZip File	12/1/2022 6:45:50 PM
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BACK336e00.22_.gz	3,436,760	GZip File	12/1/2022 7:15:22 PM

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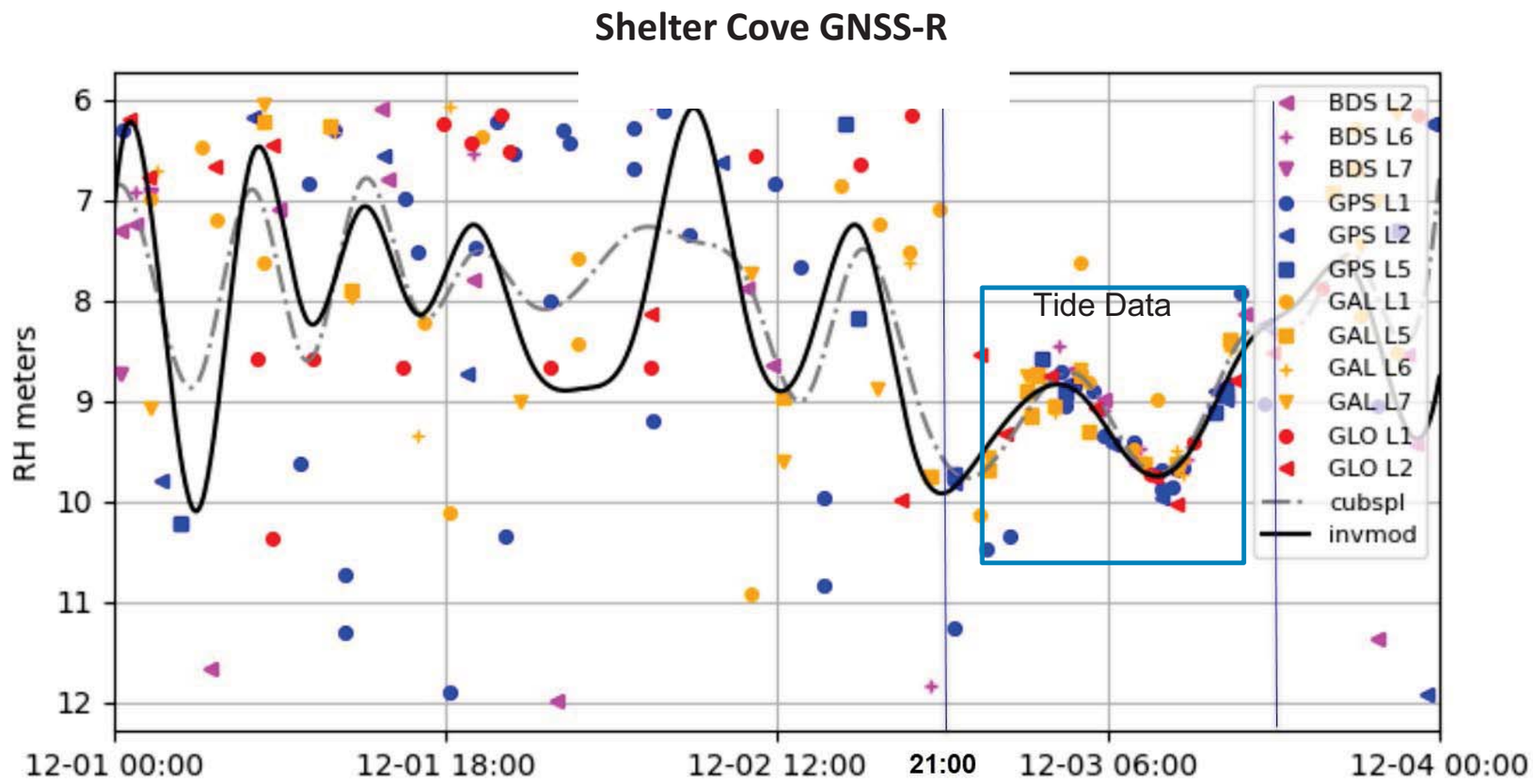
Shelter Cove GNSS-R Data



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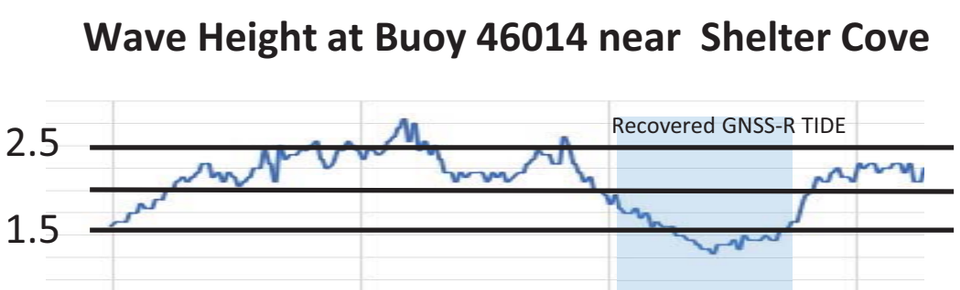
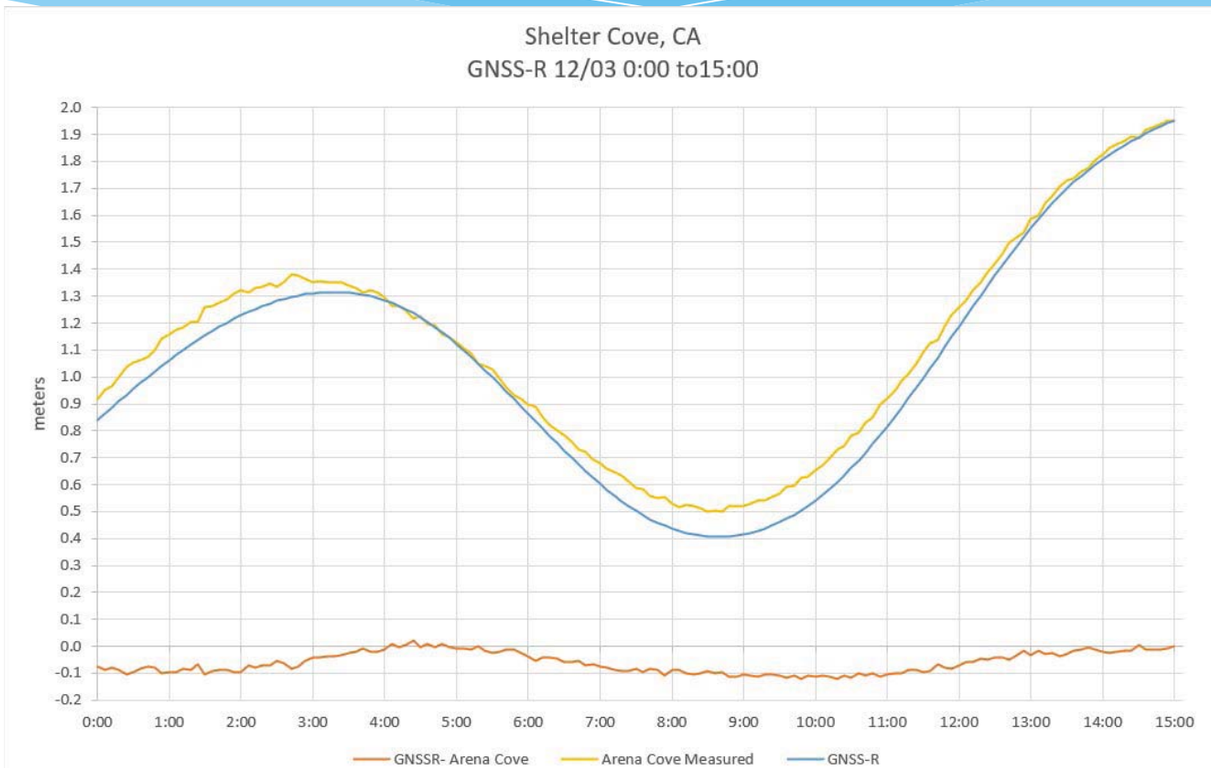
Shelter Cove GNSS-R Comparison with Arena Cove NWLON





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Measuring Water Levels with GPS

Posted
November 8, 2015

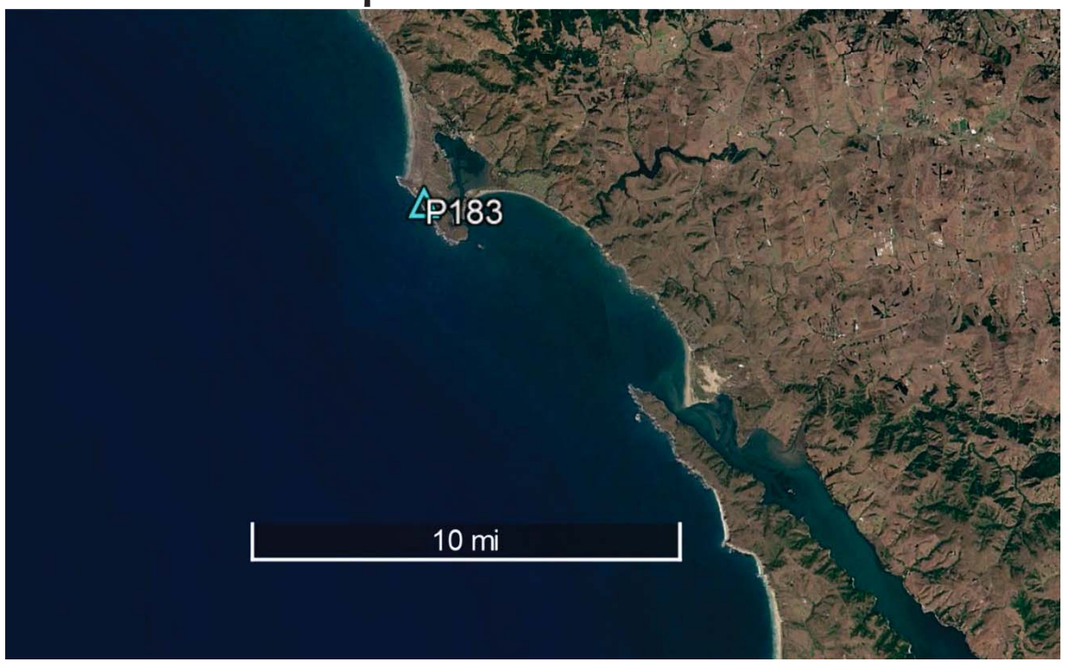
Category
GPS Reflections

If the surface isn't too rough, GNSS signals reflect off water surfaces. Unlike for soil moisture and snow depth, which varies most dynamically only on the day that it rains or snows, water levels vary throughout the day. This adds a bit of complexity for using the GPS/GNSS Interferometric Reflectometry (GPS-IR or GNSS-IR) technique to measure tidal variations for example. The advantage of using GNSS-IR with a standard geodetic receiver is that you can simultaneously measure the three-dimensional position of the GNSS antenna in the International Terrestrial Reference Frame.

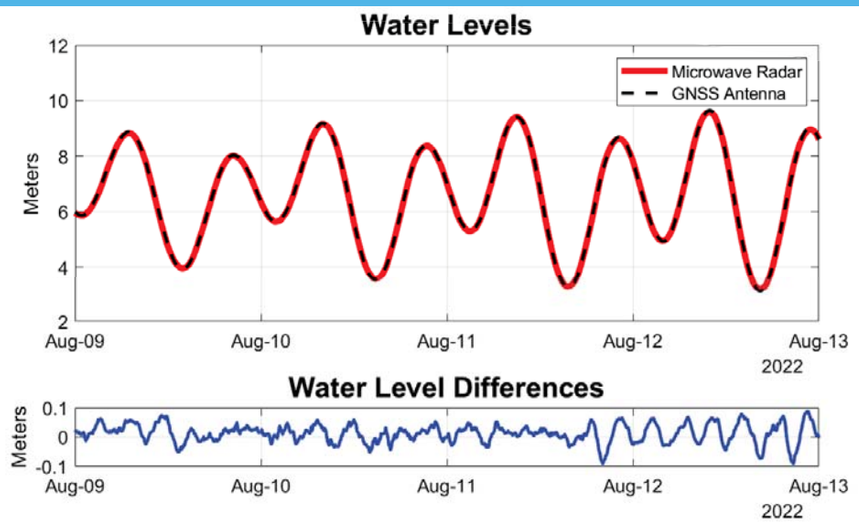
GNSS-R Where Does it Work?

Bartlett Cove, Alaska – Protected Waters

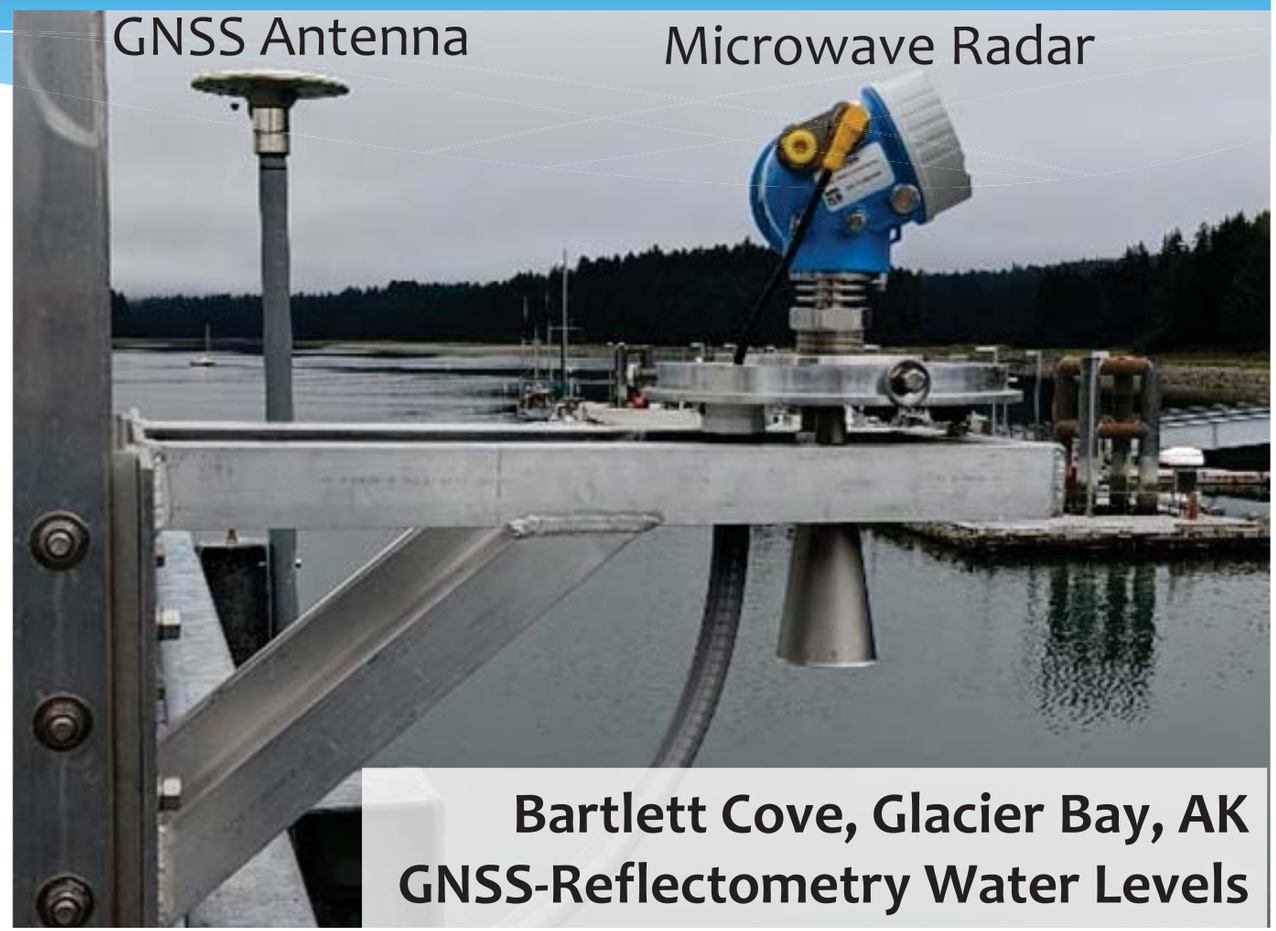
P183 Pacific Coast at Bodega Bay, California
Open Ocean



Bartlett Cove - GLBX



The GNSS antenna is next to a radar sensor. Both are in a protected area.



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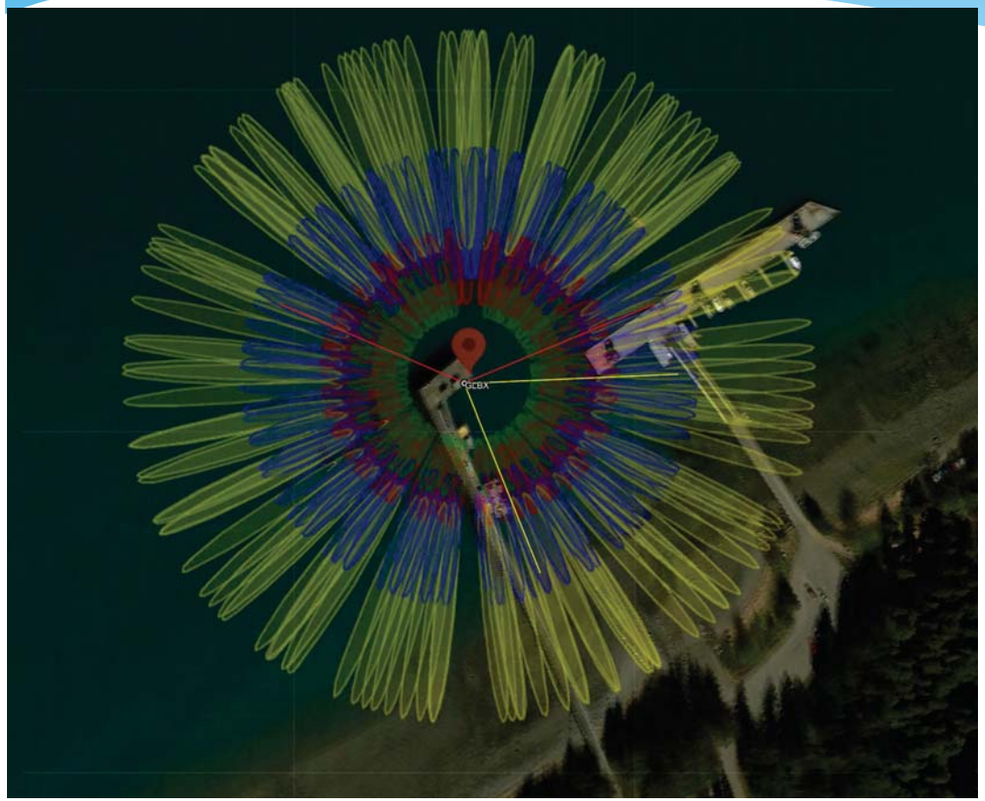
Processed using: github.com/kristinemlarson

Bartlett Cove - GLBX



Current Processing Parameters
Azimuth 293 to 068 (red line)
Elev. Angle 5 (yellow) ,7 (blue), 10 (red) , 12 (green)
Reflector Height 3-17 meters

To Do
1) AZ 88 – 158 Elev. Angle 8 -12 (5 - 7 go dry)
2) AZ 180 - 293 Elev. Angle 5 -9 (9 – 12 hit dock)

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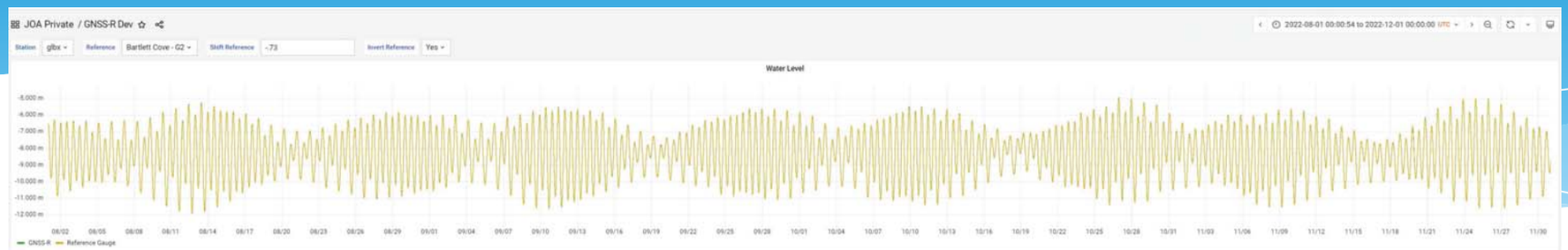
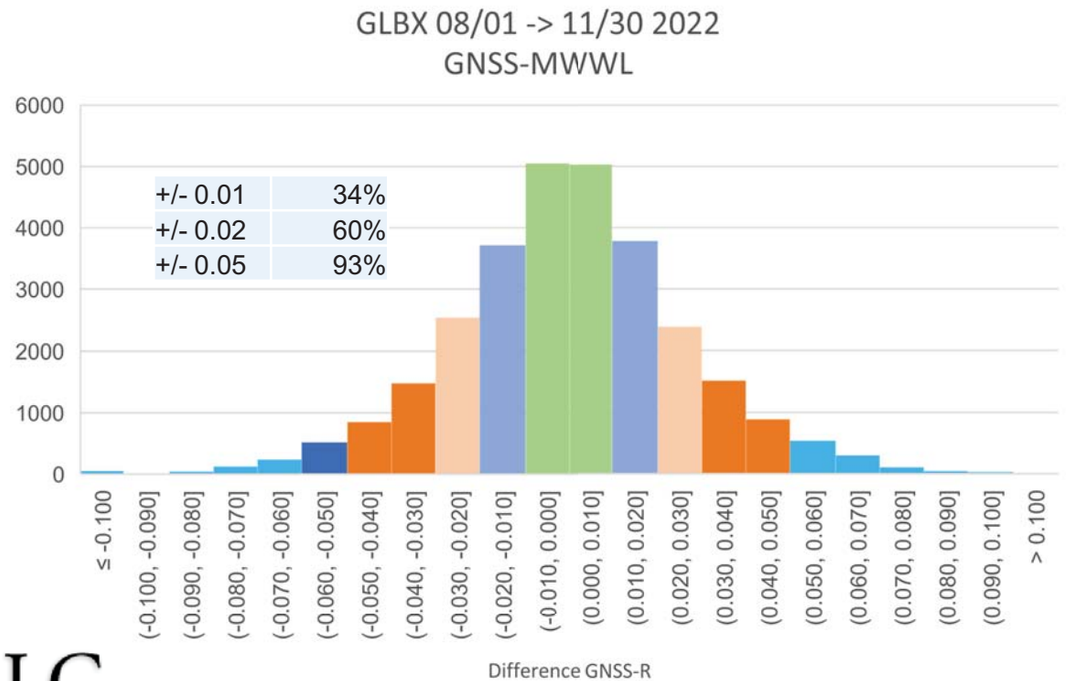
Bartlett Cove - GLBX





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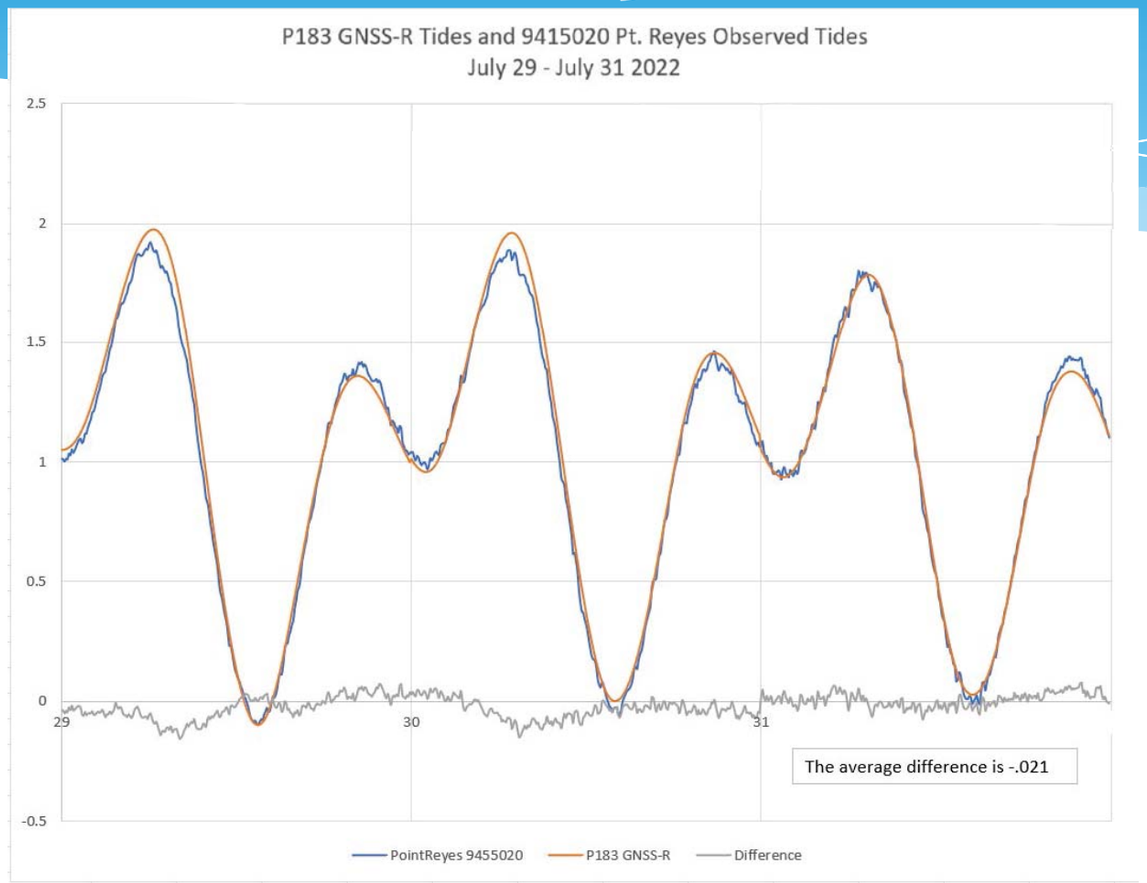
P183



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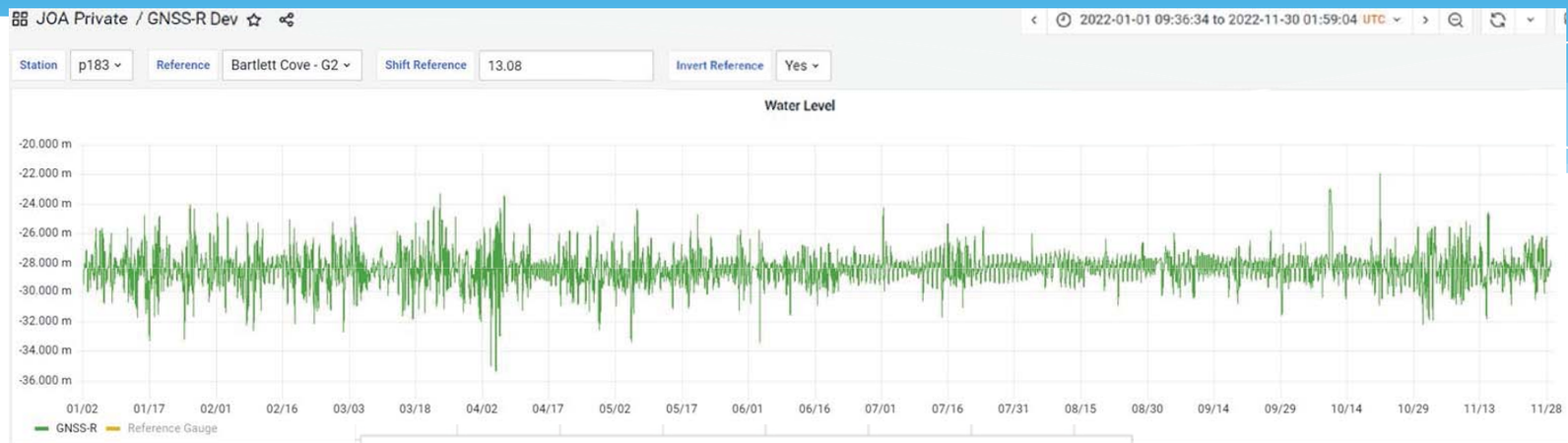
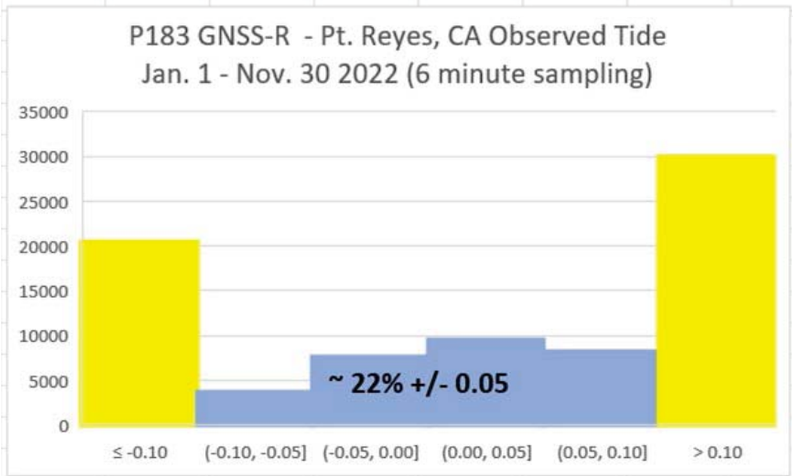
P183





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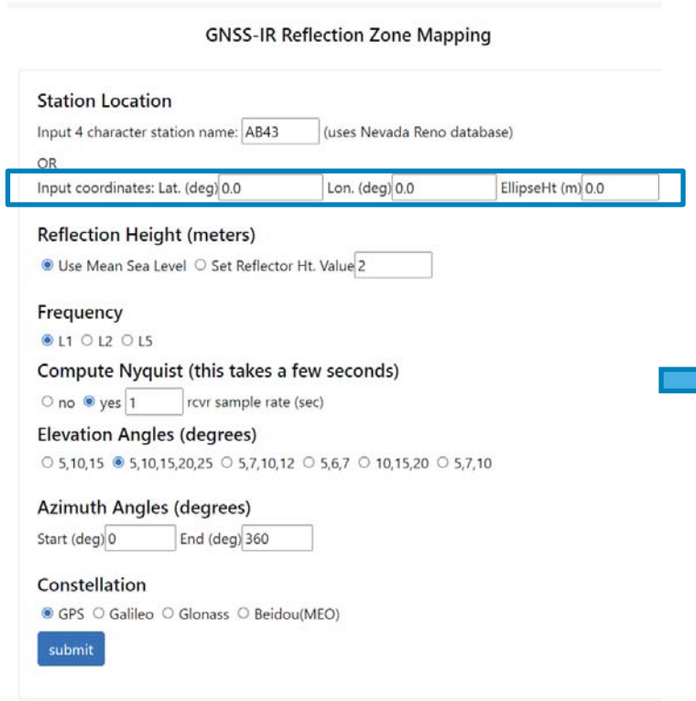
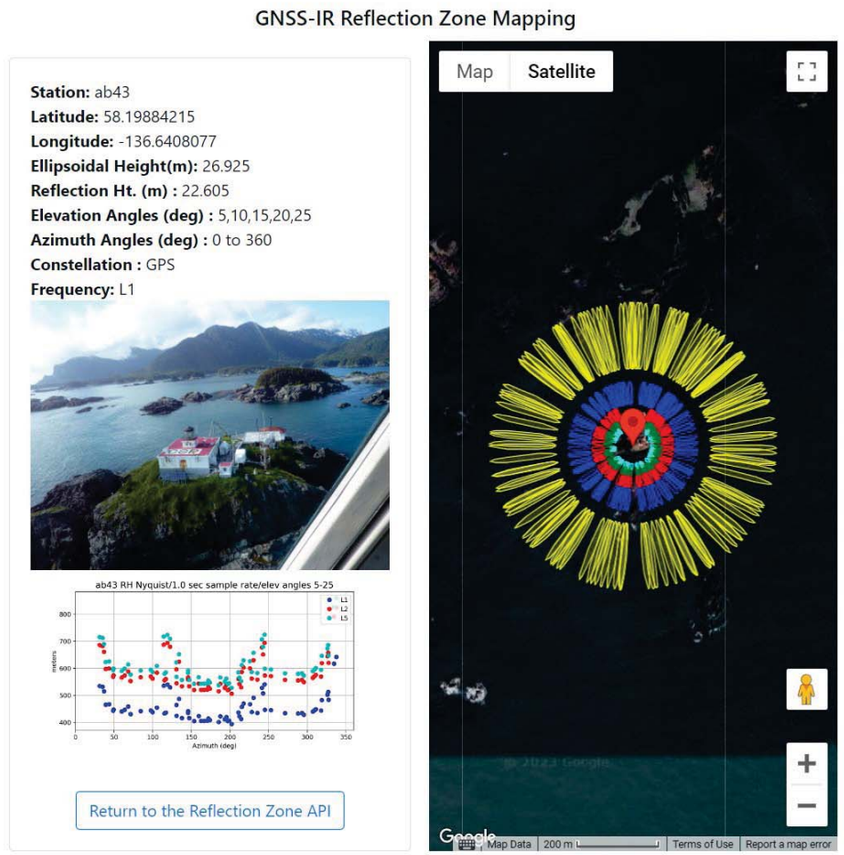
Site Analysis for Processing Parameters





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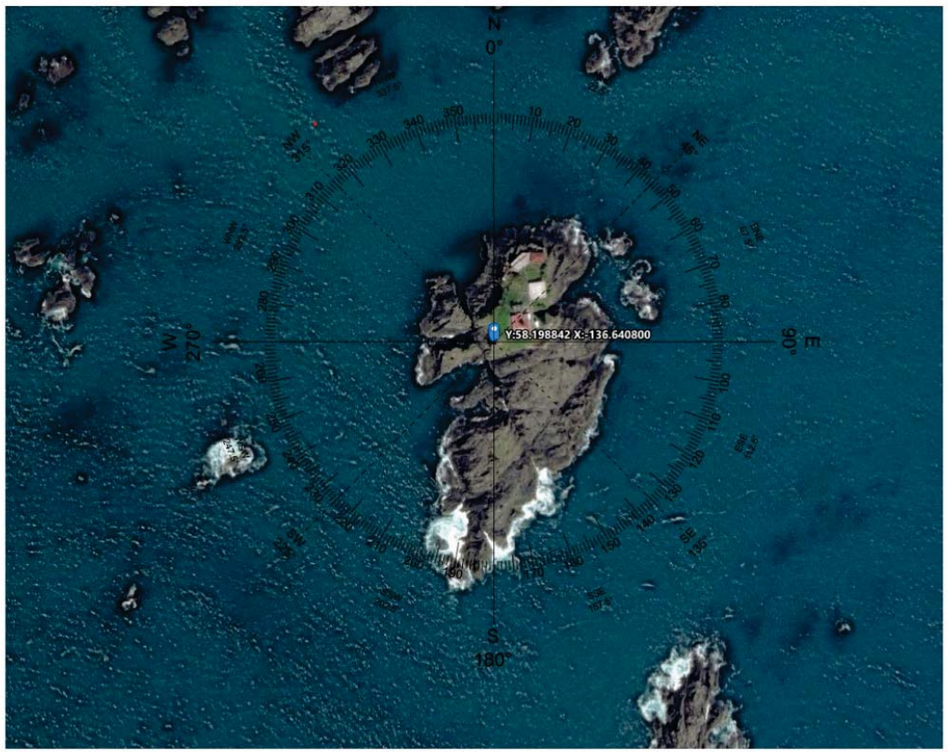
Site Analysis for Processing Parameters

ab43



CORS station AB43 is located on a island near the Gulf of Alaska. The antenna is ~23m above the water.

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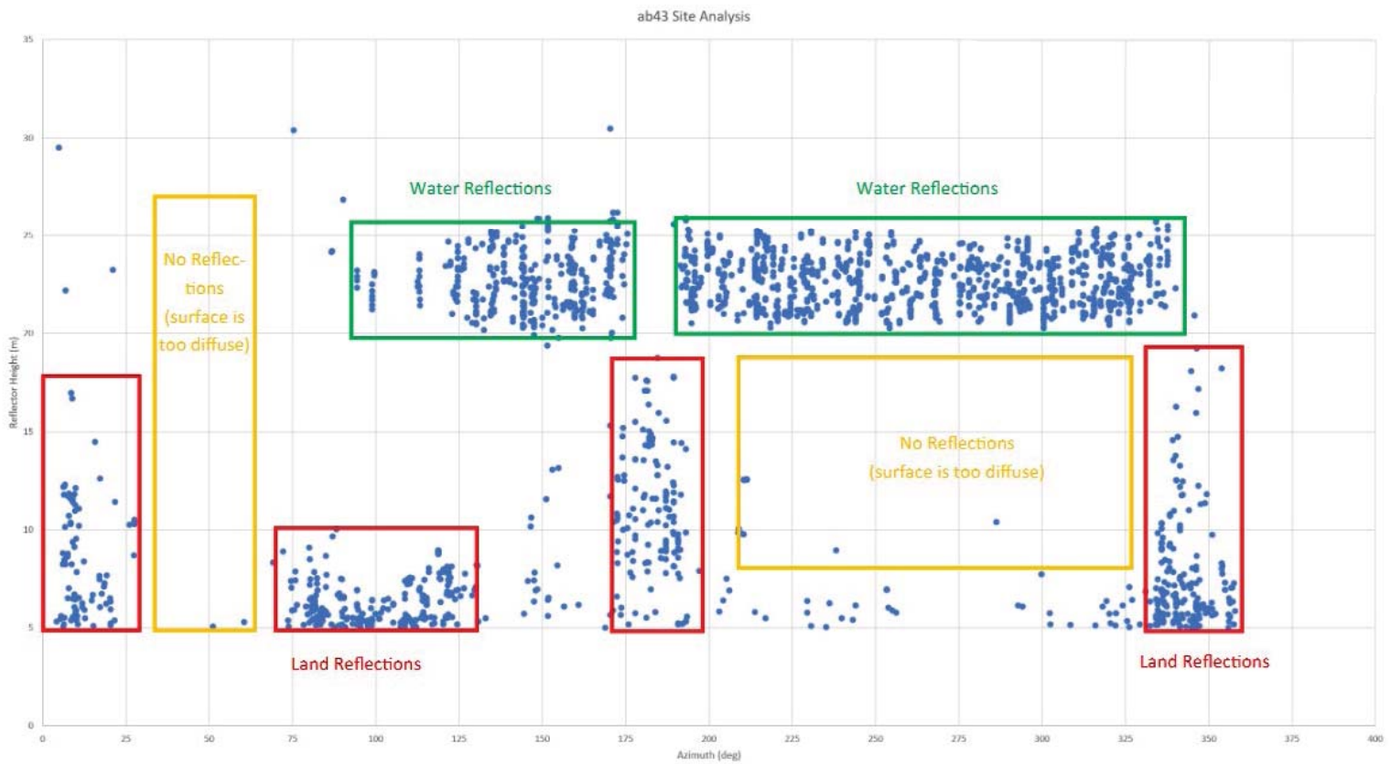
Site Analysis for Processing Parameters



GNSS-R analysis of data from CORS AB43 using full 360 degree azimuth span.

Azimuths for isolating water returns as outlined in green.

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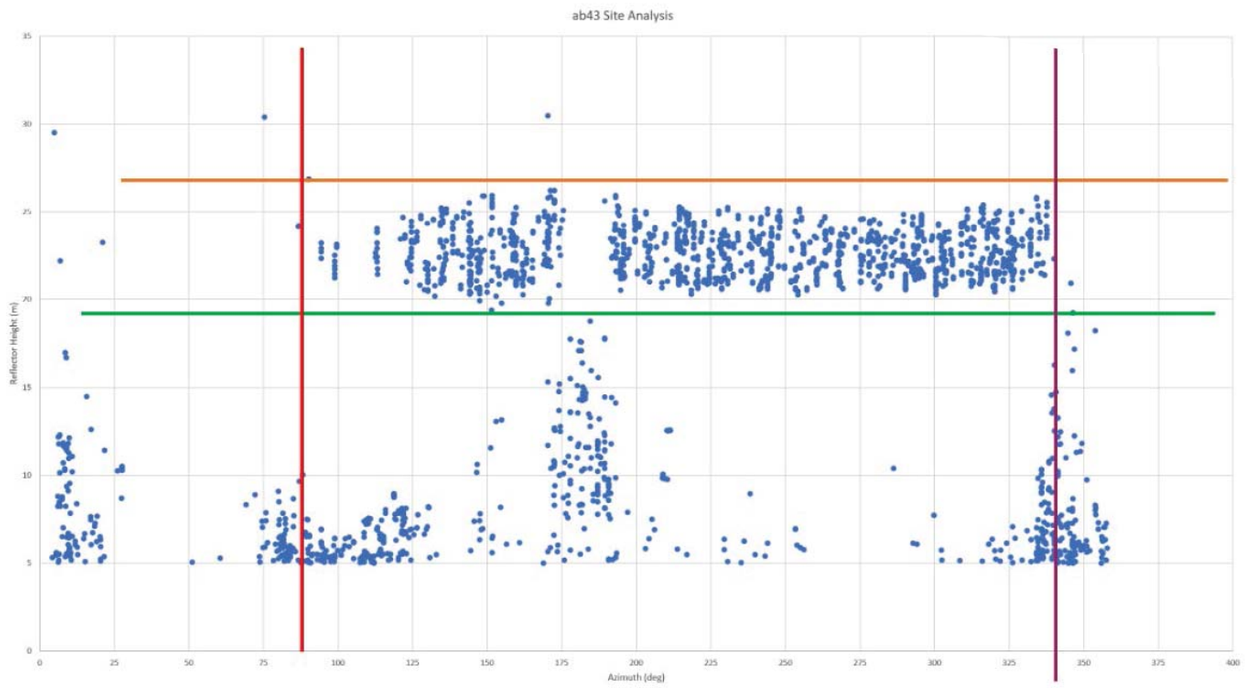
Site Analysis for Processing Parameters



Setting for this station:

reflector height min = 19 m

reflector height max = 27 m

azimuth min = 85°

aximuth max = 340°

Processing parameters for AB43

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AB43 Processing

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Ideal Receiver Setup

* GPS GLONASS Galileo BeiDou …. (LEO)
* 1 Hz
* SNR (Hi res)
* 0 degree mask
* Raw Binary or RINEX 3

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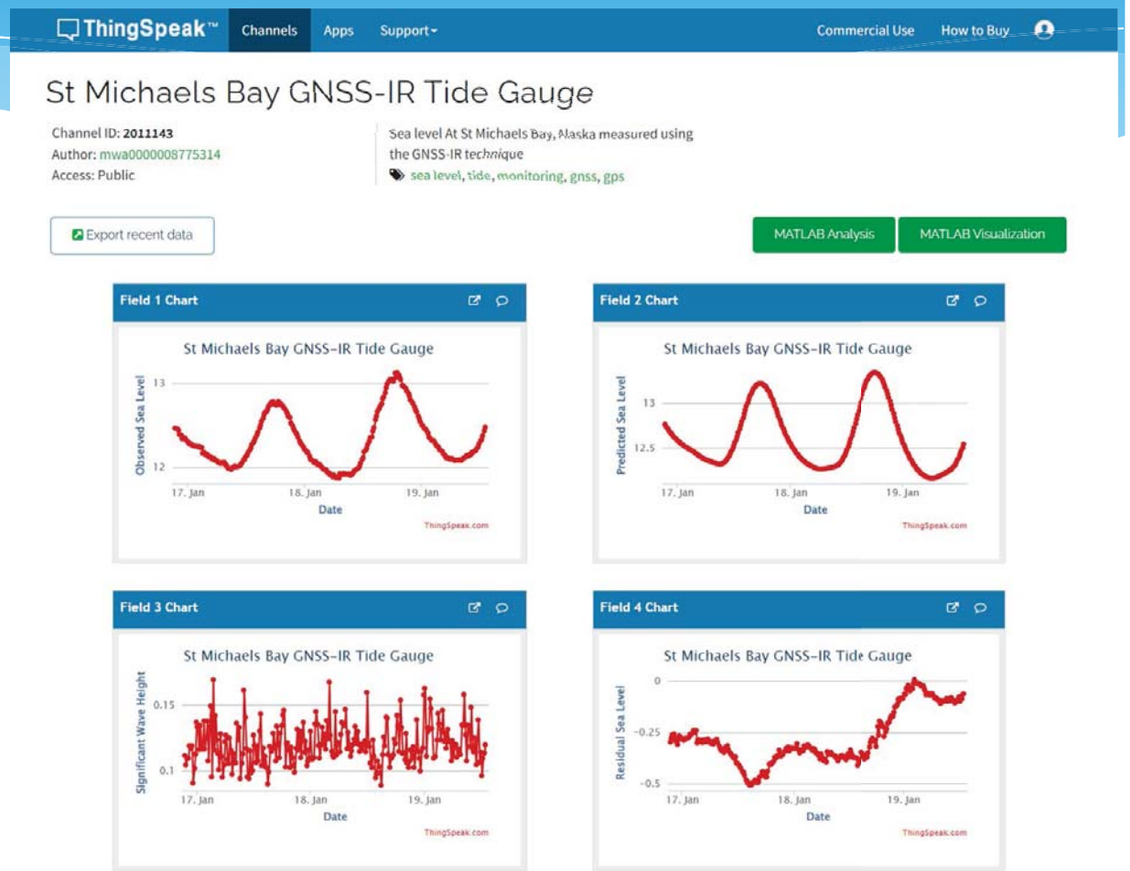
Near Real Time: AT01

* AT01 Near Real Time (15 minute)
  Simon Williams
  https://thingspeak.com/channels/2011143



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STP1 Prudhoe Bay

* Early season ice growth
  * STP1 - Data provided by Hilcorp, with thanks to Karl Kyzer

STP1

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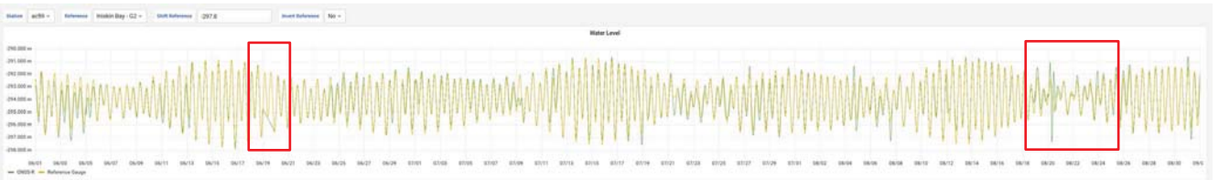
Accidental VDATUM Tide Gauge AC59

Events:

6/01-9/01 945 6525 Iniskin Bay VDATUM Gauge

6/19 Receiver Swap

8/20 – 8/22 High Winds



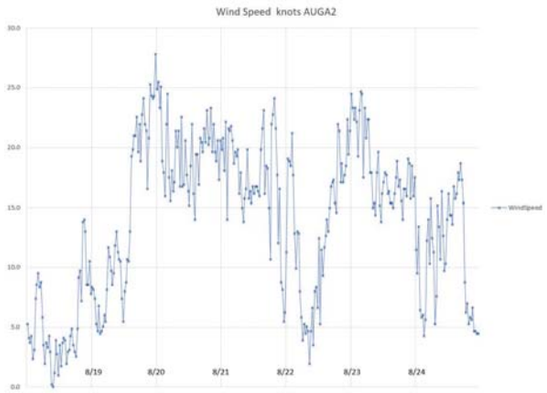
<u>AC59</u> UNAVCO PBO GNSS Data

~ 290 m. above Cook Inlet

~ 7.5 sq. mi. refl. zone

~ 500 m. inshore

1 Hz data rate required



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Results

* GLBX – Full GNSS Large Window 500 arcs/day
* ATO1 – 946 8333 missing low tides

GLBX – Data provided by National Parks Service, with thanks to Joel Cusick
STP1 - Data provided by Hilcorp, with thanks to Karl Kyzer
ATO1 & AC59 – Data provided by UNAVCO

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Going Forward

* Algorithm Development – (Strandberg) 1.0 ready latency 12 hours
  * 2.0 Kalman Filter latency 15 min.
  * Quality Control / Quality Assurance (or is it stormy)
* Low Power setup with real-time communication
* Automated near real-time processing with data access (AOOS?)
* Address NWLON Gaps

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Questions

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