Mobile GNSS reflectometry

How to measure sea level with your mobile phone

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Introduction

With the ever increasing capacity of mobile phones and tablet computers comes more and more inovative usages. While GNSS positioning has been a staple for a long time, some modern devices are even able to record raw GNSS observations, allowing for post processing data using methods such as ground based GNSS reflectometry (GNSS-R).

By analysing SNR data from GNSS signals, GNSS-R can be used to measure on the environment of a GNSS antenna. Using a mobile device supplies both antenna and receiver in the same unit, for a relatively low price, while simultaneously providing the processing power needed to analyse the measurements.

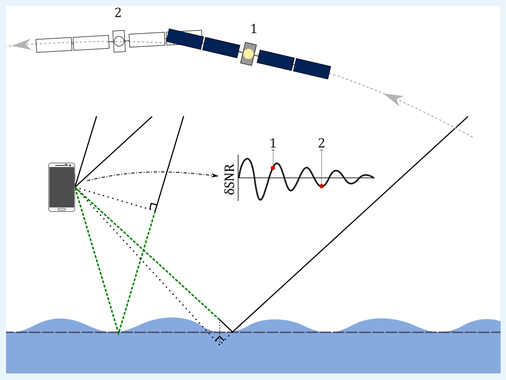


Fig 1: In GNSS-R the basic observation is the oscillating SNR from a satellite passage. The oscillation frequency depends on the reflector height.

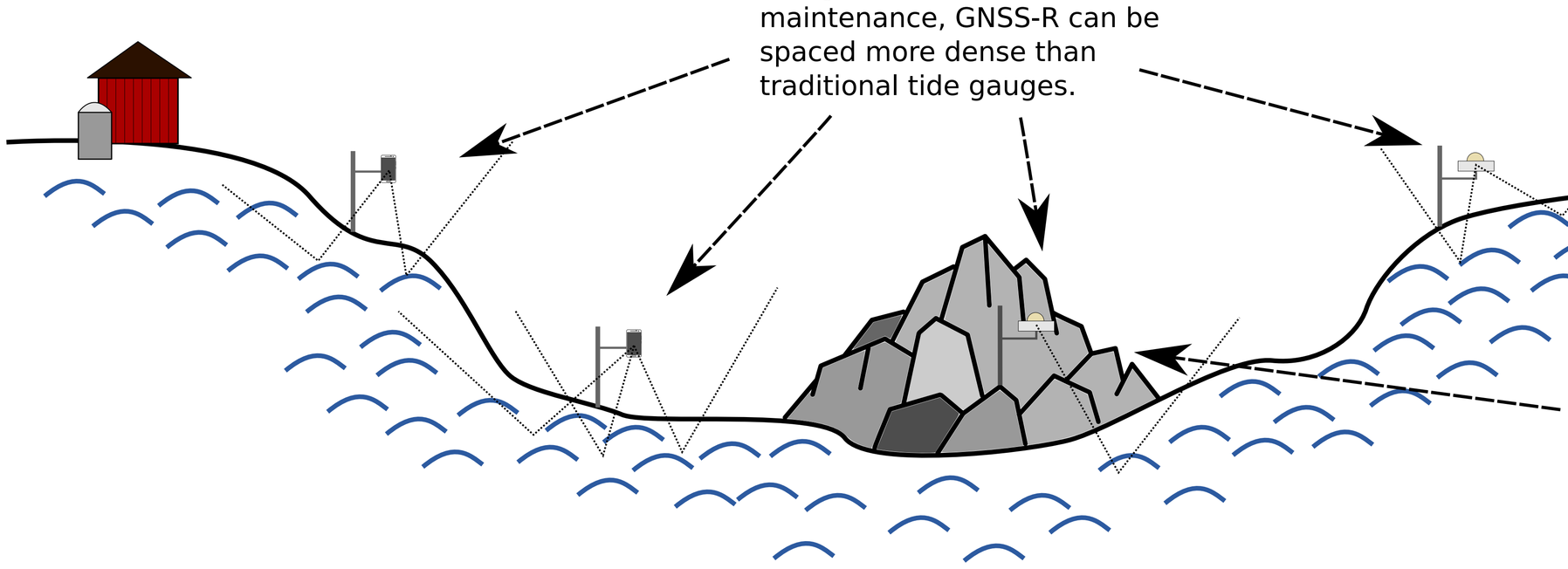
Test campaign

To test how GNSS-R with mobile devices performs compared to using geodetic instruments we set up a test installation next to the permanent GNSS-R installation GTGU at Onsala Space Observatory, Sweden. The temporary installation consisted of a Samsung Galaxy Tab A (2019) 10.1 4G, capable of recording GNSS L1 data, mounted on a tripod just a few meter away from the geodetic installation. The test campaign consisted of two 36 h recordings between September 19 and 25, 2019.

Fig 2: The test setup at Onsala Space Observatory with the tablet mounted on the tripod to the left, close to the GTGU installation on the right.

The GNSS data was recorded in RINEX format using the Geo++ RINEX Logger app, and was post processed on a separate device. However, the processing power on the device itself would be enough, making a full implementation on a mobile device feasible.

Being both inexpensive and low in maintenance, GNSS-R can be spaced more dense than traditional tide gauges.



As a close-range remote sensing technique, GNSS-R can be used where other tide gauges can not, for example where the direct coastline is inaccessible.

Comparison to geodetic station

For this proof of concept we retrieved sea level from the SNR data recorded by the two installations, using Lomb-Scargle retrievals in which the frequencies of the oscillations of the SNR arcs are transformed into reflector heights. More advanced retrieval methods with higher precision exist, but this approach is simple to implement, requiring relatively short measurement periods.

Comparing the retrieved results to a nearby tide gauge showed that the RMS errors of the tablet and the GTGU installation are both 6.2 cm for the test campaing, showing that a mobile device can perform on the same level of precision as a geodetic installation. There is however a difference in the number of measurements, with 220 for GTGU, and only 90 for the tablet.

Another difference is that the geodetic instrument can record newer high quality signals such as L2 and L5, and using these the rms error decreases slightly to 5.8 cm. However, if these had been available to the tablet, it would likely have the same effect on its measurements.

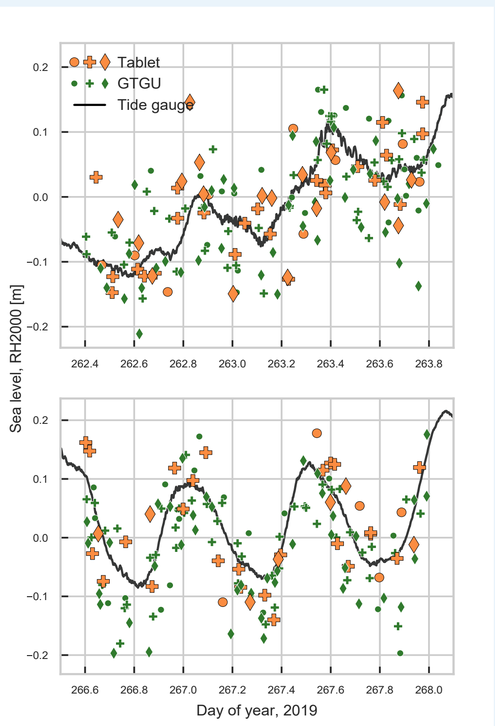


Fig 3: Sea level retrieved from GNSS-R, using L1 data from both the tablet and the GTGU installation. GPS (diamonds), Glonass (plus signs), and Galileo (round markers).

Outlook

In addition to sea level, GNSS-R has been shown to be able to measure for example soil moisture, vegetation and snow depth. Mobile GNSS-R makes these measurements accessible to even more users as the equipment is cheap and readily available, and possible usage cases include densifying the tide gauge network and farmers using their mobile devices to monitor their fields.

For references, scan the QR-code to the right, or visit:

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