GNSS Reflectometry Tide Gauge in North Shields

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1. Aims & Objectives

- Gain knowledge about GNSS
- Develop a prototype GNSS tide gauge
- Install tide gauge at North Shield and analyse correlation with National Oceanography Centre tide gauge

2. Introduction

- Sea, lake, and river level measurements are important in science, as they can help model floods and monitor climate change
- Current spread of such measurements is narrow due to costs and technological limitations
- A possible solution is to use GNSS receivers to monitor sea level by recording signal reflections from the waters surface
- This technique does not involve moving or immersed parts, making it a potentially viable alternative to conventional methods
- To test this theory a prototype device was produced and installed at North Shields
- The captured data was then analysed and an attempt to produce water level time series was under taken. This did not lead to any meaningful results, but experiences for further work were gained

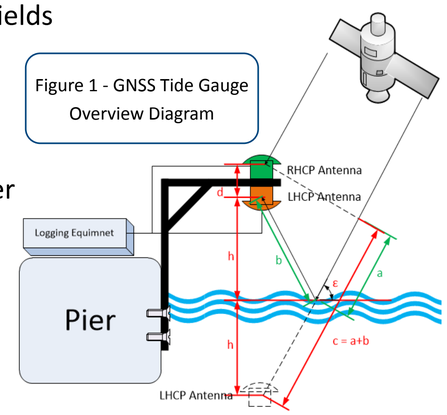

Figure 1 - GNSS Tide Gauge Overview Diagram

Acknowledgments
I would like to thank my two supervisors for all there help and knowledge as well as the many other staff that have help with this project
Funded by Newcastle Universities Research Scholarships & Expeditions

3. Theory

In 2011 it was demonstrated in Sweden that standard geodetic receivers could be used to monitor sea level to a high degree of accuracy. [1] Figure 1 shows how this is achieved.

- The Right Hand Circular Polarized(RHCP) antenna receives the direct satellite signal , and provides a reference position
- The Left Hand Circular Polarized(LHCP) receives the reflected signal off the waters surface
- The reflected signal has to travel further than the direct signal, making the antenna appear to be at a lower height than the RHCP antenna
- This difference in distance travelled is used to calculate sea level in an International Terrestrial Reference Frame
- Any changes in sea level will then alter this difference, and therefore the sea level measurement
- Each satellites signal will reflect at different points on the seas surface giving an average of the current sea level, removing errors such as waves

4. Prototype

- A prototype device was developed using two GNSS dual polarized antenna, two Novatel receivers and a data logger
- It was installed at North shield and left to collect data

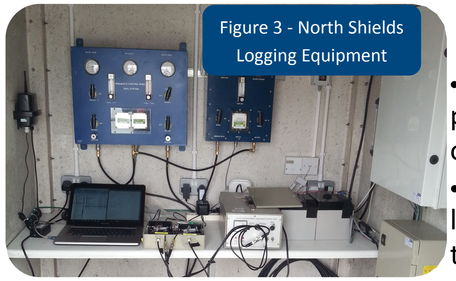
Figure 3 - North Shields Logging Equipment

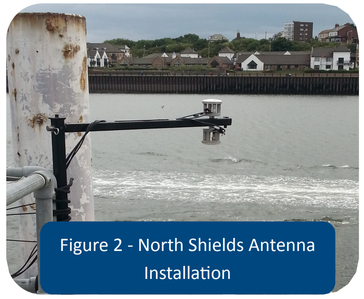
Figure 2 - North Shields Antenna Installation

- Figure 2 shows the positioning of the two antenna over the seas surface
- Figure 3 shows the data logging equipment located on the pier

5. Data Processing

- The data collected was then processed with the school of Civil Engineering an Geosciences on there specialist software
- We aim to improve our computational models and strategies to create an algorithm to derive sea level time series from the collected GNSS data

6. Results

- Two receiver clocks synchronized to a fraction of a nanosecond
- Figure 4 shows the relationship between GNSS predicted sea level and measured with traditional method
- Problems with correlation between results, due to possible uncertainties

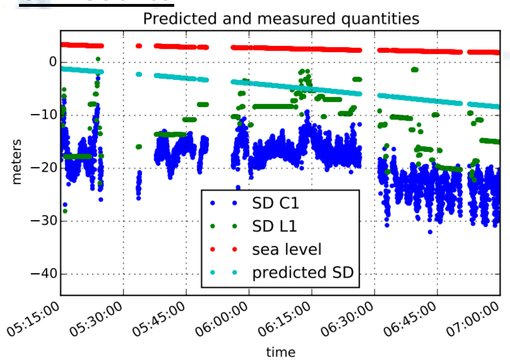

Figure 4 - Preliminary Sea Level Time Series

7. Conclusion

- Further research and development would need to be conducted to produce a standalone system for calculating sea level at an affordable cost
- This product could then be used to extend existing networks of tide gauges by addition of cheap, reliable and versatile GNSS receivers that can also act as water level sensors
- Applications include research for better understandings of water level variability, which would help the increasing populations at low elevations

[1] Löfgren, J. S., R. Haas, and J. M. Johansson (2010). High-rate local sea level monitoring with a GNSS-based tide gauge. In Geoscience and Remote Sensing Symposium (IGARSS), 2010 IEEE International, pp. 3616-3619. IEEE.