GPS L1 Reflections from Seawater Observed with the GNSS-Based Tide Gauge

Johan S. Löfgren, Rüdiger Haas, Jan M. Johansson

Chalmers University of Technology, Department of Radio and Space Science,
Onsala Space Observatory SE-439 42 Onsala, Sweden

The GNSS-Based Tide Gauge

○ Two antennas: one zenith-looking Right Hand Circular Polarized (RHCP) and one nadir-looking Left Hand Circular Polarized (LHCP) mounted back-to-back, see Fig. 1.

○ The RHCP antenna receives the GNSS-signals directly, whereas the LHCP antenna receives the signals reflected from the sea surface.

○ The distribution of the reflected signal energy is governed by the sea surface roughness, the signal wavelength, and the elevation angle.

○ The reflected signals experience an additional path delay (see specular reflection in Fig. 2), implying that the LHCP antenna can be regarded as a virtual antenna located below the sea surface.

○ When the sea level changes, the path delay of the reflected signal changes, thus the LHCP antenna will appear to change position.

○ Since the height of the LHCP antenna over the sea surface is directly proportional to the sea surface height and the RHCP antenna is directly proportional to the land surface height, the installation monitors changes in local sea level.

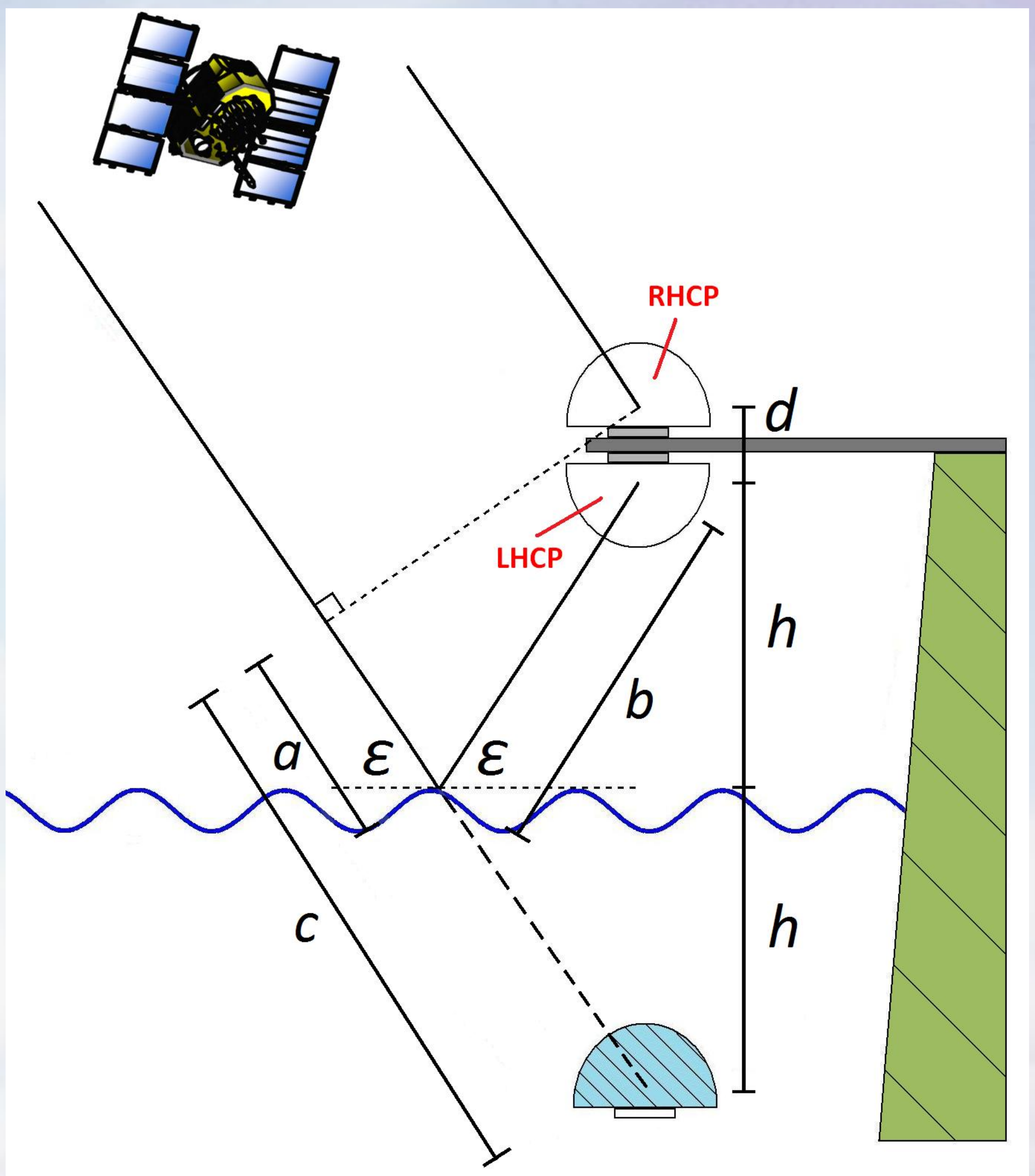

Figure 2. Schematic drawing of the GNSS-based tide gauge.

Figure 1. The installation of the GNSS-based tide gauge at OSO.

Data Analysis and Results

○ Relative positioning using single differenced GPS L1 phase data.

○ Solutions were made with 20 minutes of data around every full hour.

○ Least-squares estimation of differences in: local vertical components (every interval), receiver clock differences (every epoch), and phase ambiguity differences (every interval).

○ Comparison with local sea level from 2 stilling well gauges at Ringhals (18 km south) and Göteborg (33 km north) show an RMS agreement of better than 4 cm (see Fig. 3).

○ Maximum difference < 9.3 cm (7.5 cm for the stilling well gauges), which mostly depends on different locations and averaging techniques.

○ Possible to measure local sea level in mild sea state conditions.

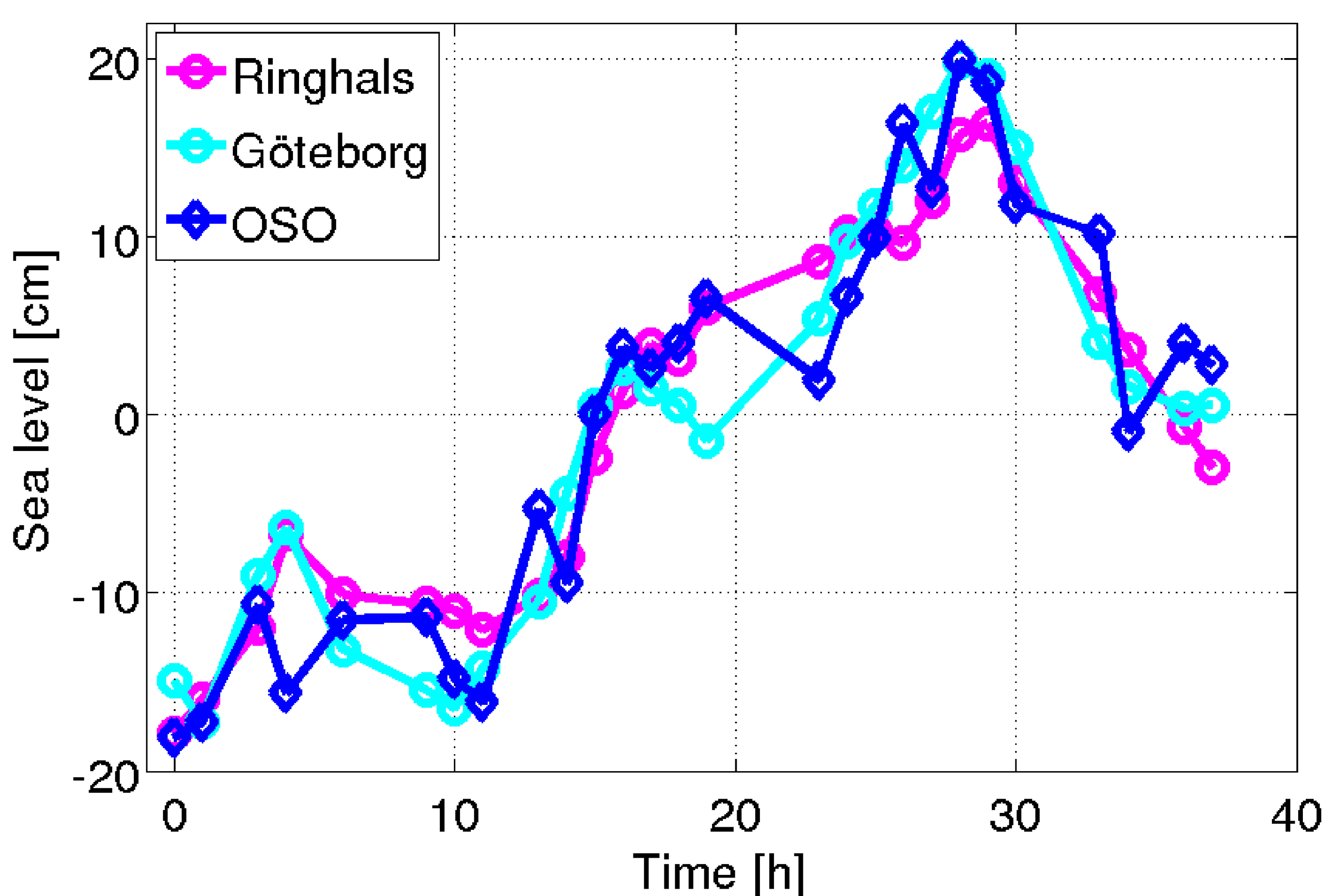

Figure 3. Local sea level from the GNSS-based tide gauge and from 2 stilling well gauges.

Future work

○ Install the GNSS-based tide gauge permanently at the Onsala Space Observatory (OSO).

○ Install a pressure sensor based tide gauge at the same site at OSO in order to further evaluate the GNSS-based tide gauge.

○ Develop strategies for real-time local sea level monitoring.

○ Derive tidal constituents (amplitude and phase) and compare them to theoretical models.

○ Increase the temporal resolution of the processing either by using existing GNSS software or by developing own algorithms.

○ Analyze the high-rate (20 Hz) observations in post-processing.

IGS Workshop, 28 June - 2 July 2010, Newcastle upon Tyne, England