Monitoring Coastal Sea Level With Reflected GNSS Signals

Rüdiger Haas, Johan Löfgren
Chalmers University of Technology
Department of Earth and Space Sciences
Onsala Space Observatory, SE-439 92 Onsala (Sweden)

Motivation and Introduction

- Climate change is expected to change global sea-level
- Global sea-level change will impact human population living in coastal regions and on islands
- ==> Coastal sea level needs to be monitored

- Traditionally, sea level is monitored with coastal tide-gauges, i.e. relative to the land where they are established
- Coastal tide-gauges are affected by land surface motion
- ==> Measurement of absolute sea-level change requires the knowledge of land surface motion

- Land surface motion can be monitored by Global Navigation Satellite Systems (GNSS)
- ==> We developed a new concept to measure both land surface motion and coastal sea level variations
- GNSS-based tide gauge

- Support by the Adlerbertska Research Foundation in 2007
- Test installation at the Onsala Space Observatory

Principle and Installation

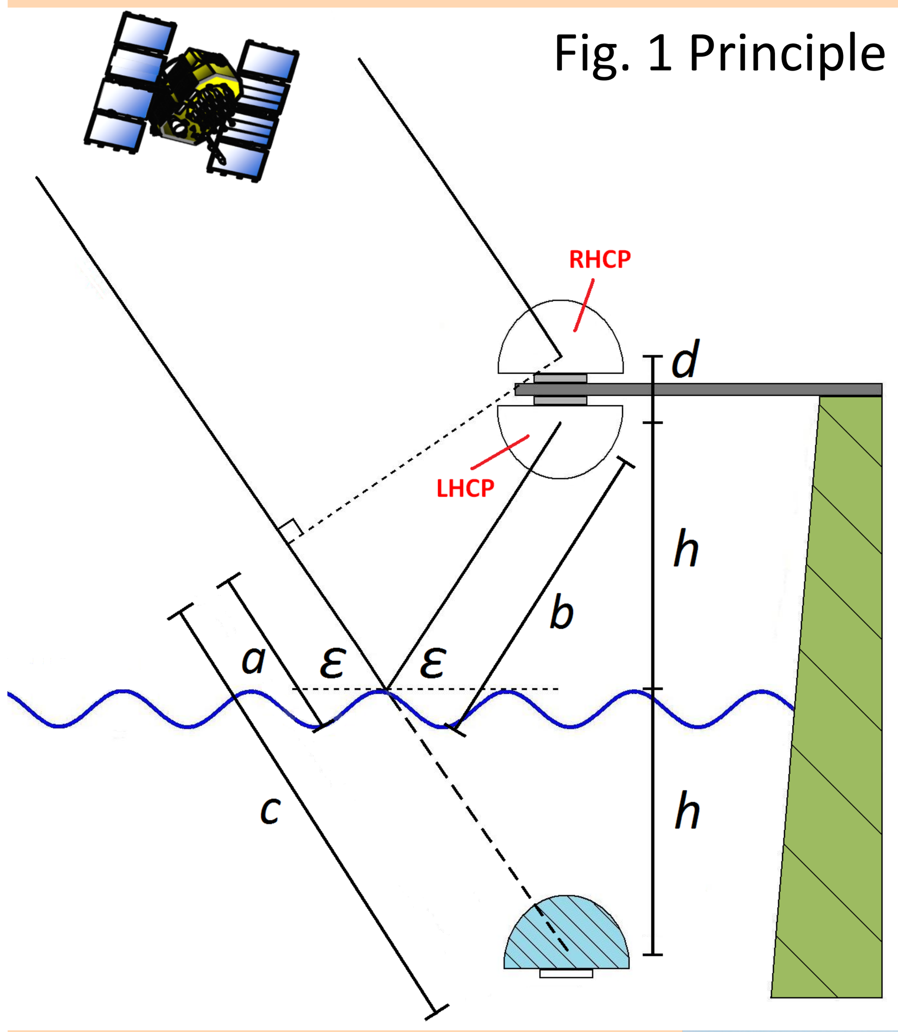

Figure 1 GNSS-signals are received directly and reflected off the sea surface with an upward-looking right-hand circular polarized (RHCP) and a downward-looking left-hand circular (LHCP) polarized antenna. The reflected signals experience an additional path delay ***c***. The LHCP antenna appears as a virtual antenna below the sea surface at the same distance ***h*** as the actual LHCP antenna is located above the sea surface.

Figure 2 Test installation at the coast at the Onsala Space Observatory: a) down-ward–looking LHCP antenna, b) upward-looking RHCP antenna, and c) the house with the GNSS-receivers. The installation is directed towards the south . The antennas are covered by protective radomes.

Data Analysis and Results

- Data recorded since September 2010 every second
- Kinematic GNSS data analysis and estimation of vertical baseline between the two antennas
- Vertical baseline is linearly related to sea surface height *h*
- Comparison of sea surface time series to independent data from traditional tide gauges at Gothenburg and Ringhals
- Root-mean square (RMS) agreement better than 6 cm
- Tidal signals visible and tidal parameters can be derived

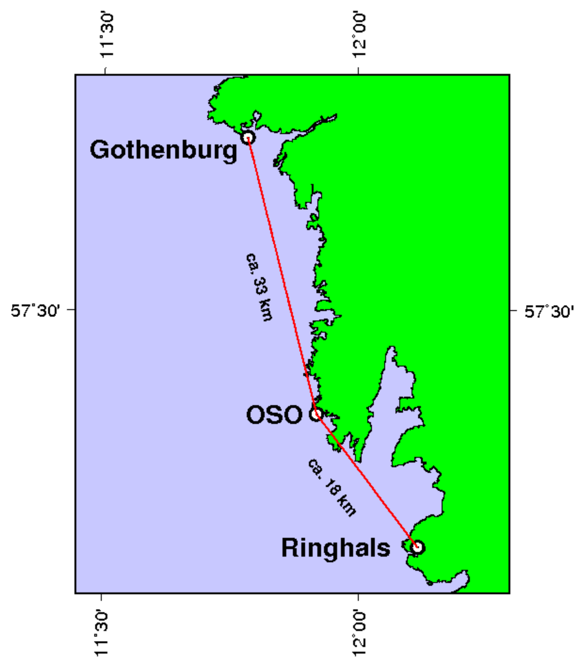

Fig. 3 Traditional tide gauges at Gothenburg, Ringhals and GNSS-based tide-gauge at Onsala.

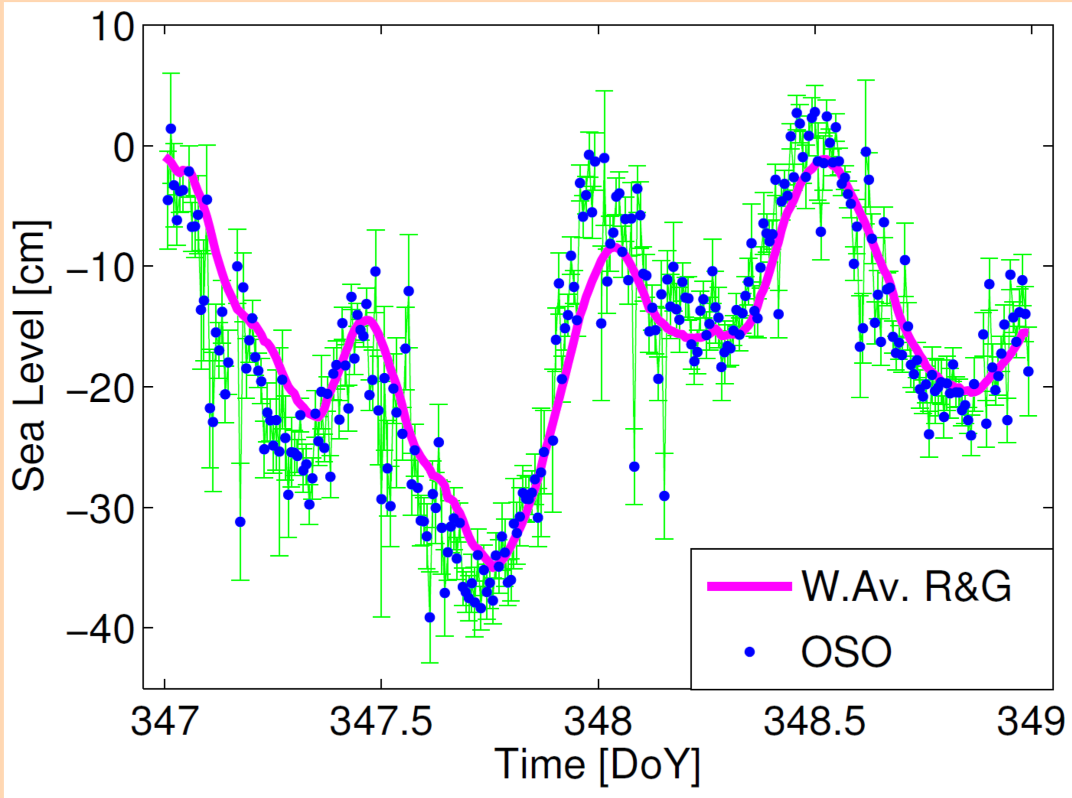

Fig. 4 Weighted average (W.Av.) of Ringhals and Gothenburg sea level compared to Onsala.

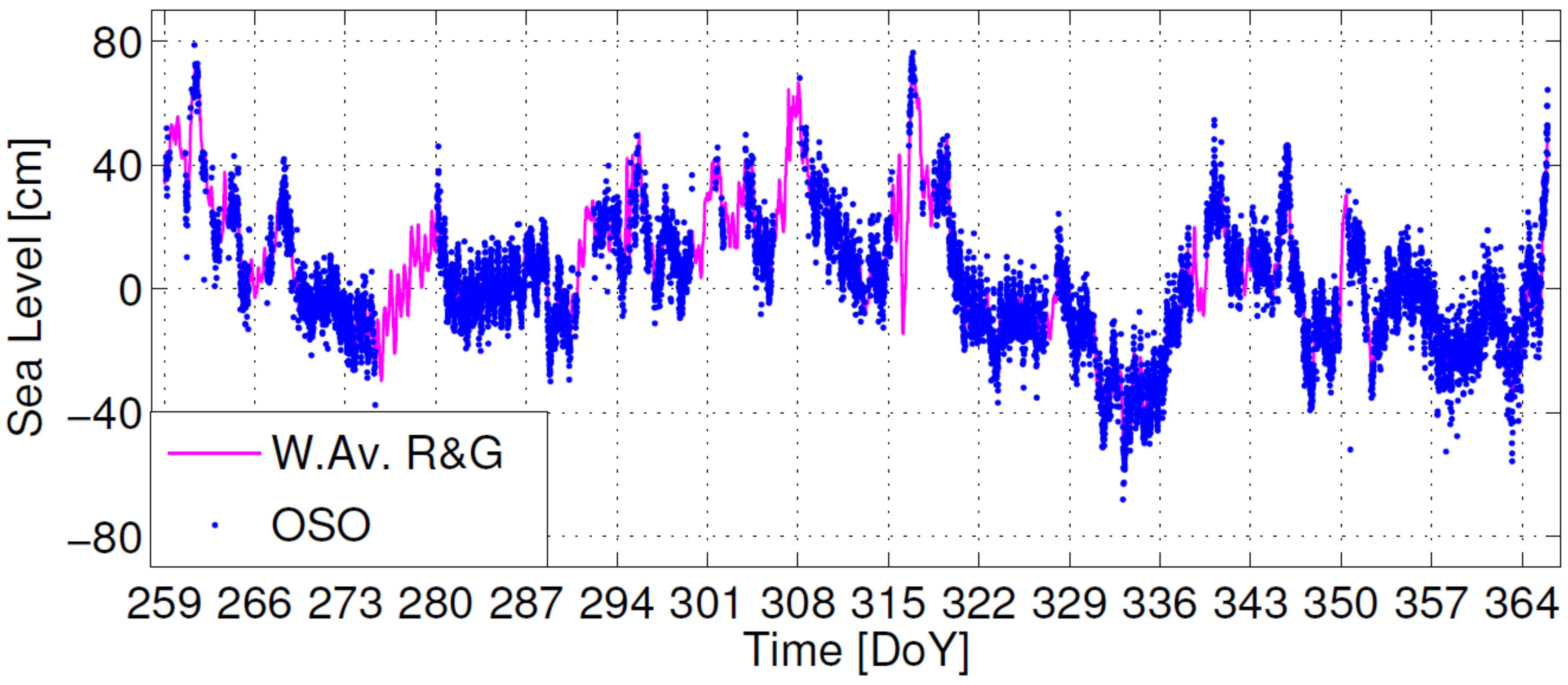

Fig. 5 Weighted average (W.Av.) of Ringhals and Gothenburg sea level compared to Onsala. Tidal signatures are clearly visible.

Conclusions and Outlook

- GNSS-based tide gauge gives valuable sea level results
- Both relative and absolute sea level can be derived
- Agreement to traditional tide gauges at cm level
- Tidal constituents can be investigated
- Next step: Semi-permanent installation at Onsala plus additional pressure sensors on site

Reference

Löfgren J, Haas R, Scherneck H-G, Bos M (2011) Three months of local sea level derived from reflected GNSS signals. *Radio Science*, 46 (RS0C05) , 12 pp., doi: 10.1029/2011RS004693