Twin Telescope and Tide Gauge Plans for the Onsala Space Observatory

Rüdiger Haas, Gunnar Elgered, Johan Löfgren

Abstract We report on the present status of the installation of two new instruments at the Onsala Space Observatory: a twin telescope dedicated to geodetic and astrometric Very Long Baseline Interferometry (VLBI) and a tide-gauge station equipped with several different sensors to complement the experimental set-up of the Global Navigation Satellite Systems (GNSS) tide gauge. The twin telescope project is now at the stage where procurement will start. The tide-gauge station is just starting to be constructed, while the sensors have been bought and will now be calibrated and characterized in the laboratory.

Keywords Onsala Twin Telescope, tide gauge

1 Introduction

The Onsala Space Observatory has been involved in geodetic and astrometric VLBI observations since 1968 [1]. Currently about 40–50 sessions per year are observed in IVS programs. Onsala participated in all CONT campaigns. In April 2012 we received a decision for funding of a twin telescope at Onsala, to be part of the VLBI Global Observing System (VGOS) network. The project has been delayed by approximately one year due to difficulties to get the necessary building permits [2]. In late February 2014, finally all necessary permits were issued and the project is continued. The procurement of the equipment will start in 2014, and we plan that the Onsala Twin Telescope (OTT) will become operational in 2016.

With plans for a significant improvement in accuracy within the VGOS project, the need for complementary instrumentation and observations will increase. Particularly at the Onsala site, being located at the coast, loading effects on the Earth's crust are important. The modeling of the sea level in the Kattegatt strait is complicated and the available tide gauge data today are from Gothenburg and Ringhals at a distance of 33 km and 18 km, respectively. This together with the fact that the Onsala site will be very well determined in the International Terrestrial Reference Frame (ITRF) motivates the installation of an official tide gauge station of the Swedish national network. This network is operated by the Swedish Meteorological and Hydrological Institute (SMHI) and an agreement for a joint responsibility in constructing and operating a tide-gauge station has been signed.

2 The Onsala Twin Telescope Project

The telescope sites identified have received the necessary permissions from the authorities and the procurement phase of the project has started. As is indicated in Figure 1, the twin telescopes will be located at a 500-m distance from the 20-m radome enclosed telescope, which presently is used for all geodetic VLBI observations, approximately in the south direction. The distance between the two telescopes will be approximately 75 m. We foresee a period of several years during which the 20-m telescope will be used in parallel with the twin telescopes.

Chalmers University of Technology (Sweden)

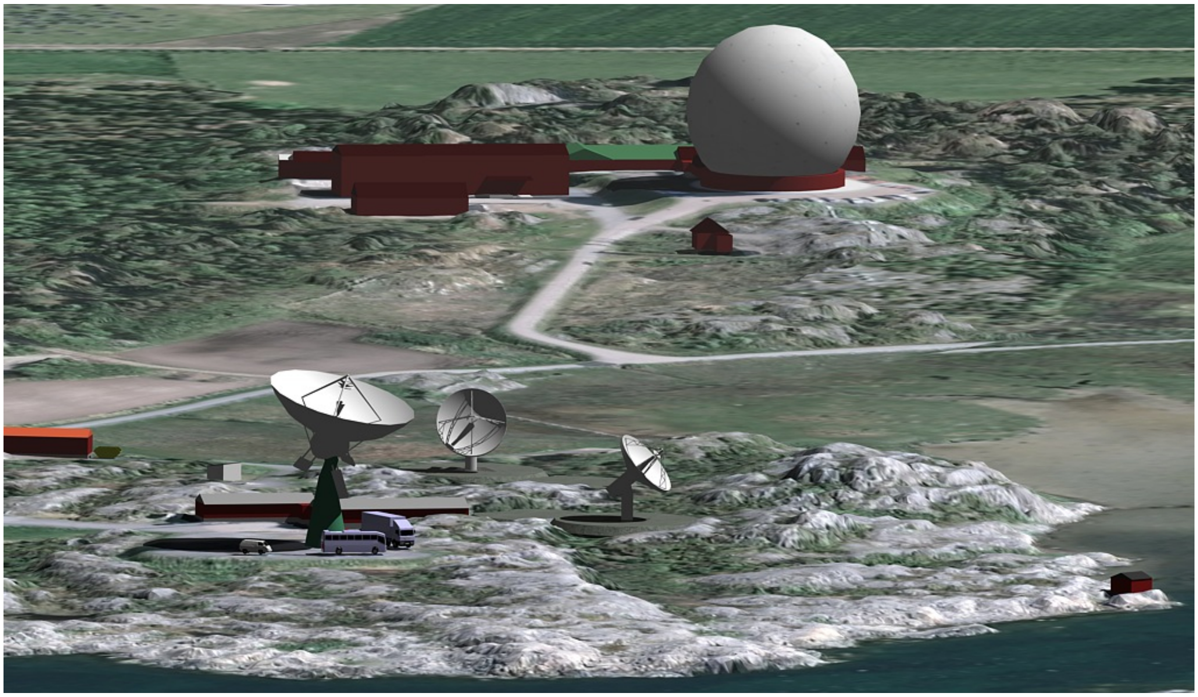

Fig. 1 An artist's impression of the twin telescopes at the Onsala site, roughly looking towards the north-east. The almost zenith looking telescope in the left foreground of the picture is the 25-m telescope from 1964, which is used primarily for astronomical VLBI. The new twin telescopes (OTT1, right, and OTT2, left) will be located in a distance of about 75 m and 125 m, respectively, from the 25-m telescope. The white radome in the upper part of the picture encloses the 20-m radio telescope from 1976 that is currently used for all geodetic VLBI observations. The distance to the twin telescopes will be about 475 m and 540 m, respectively.

The expected horizon masks of the new telescopes are presented in Figure 2. The common horizon of both telescopes together will be obstruction-free above 7.5° and only blocked to 7.5% at elevation 5°.

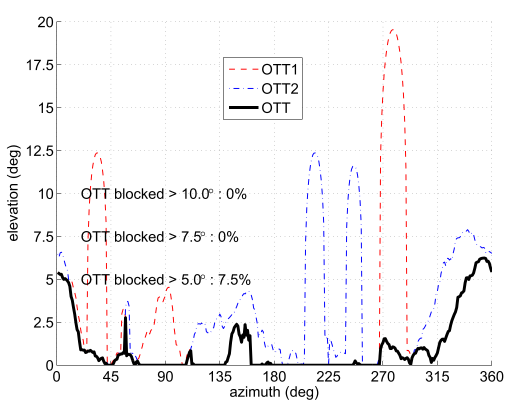

Fig. 2 Expected horizon masks for the individual twin telescopes, OTT1 (dashed line, red) and OTT2 (dashed-dotted line, blue), and combined for both OTT antennas together (solid line, black), as seen from the lower edge of the prime reflectors. The OTT telescopes will see each other (at about 30° and 240° azimuth), and they will see the 25 m telescope at about 210° and 290° azimuth. However, the common horizon is completely free above 7.5° and only blocked by 7.5% at elevation 5°.

We plan to establish a local control network around the twin telescopes. It will include several GNSS-monuments and several ground markers for classical geodetic survey. We aim at installing a fully automated local survey system for the twin telescopes with redundant automized and motorized total stations. A corresponding system has been developed and tested in the past few years [3]. This system will be used in a pilot project during the CONT14 campaign to determine reference point and local-tie information during the whole campaign. The experience gained from this pilot project will be very useful for the system to be implemented for the twin telescopes.

3 The Onsala Tide Gauge Project

Since 2010 we operate a so-called GNSS tide gauge utilizing reflected GNSS signals [4]. The GNSS tide

Fig. 3 A panorama of the GNSS tide gauge at the coastline, looking towards south.

gauge consists of geodetic GNSS equipment in the form of one zenith-looking and one nadir-looking antenna, connected to one receiver each. The installation records both the direct satellite signals and the satellite signals that are reflected off the sea surface. Through analysis of the phase delay of the signals or the signal-to-noise ratio given by the receiver, the sea level can be determined. The GNSS tide gauge is complimented by three pressure-sensor-based tide gauges at the same location, shown in Figure 3.

In the autumn of 2013 a pneumatic tide gauge sensor (called the bubbler sensor) was installed at the small hut, in the lower right corner in Figure 1. The sensor driver unit is shown in Figure 4.

This new location will host the official tide gauge station of the Swedish national network mentioned in the introduction. When finished, a radar sensor and a pneumatic sensor (CS471, Campbell Scientific) will be mounted in a special concrete culvert with heating, in order to ensure operating conditions also when the sea is covered by ice. An artist's impression is shown in Figure 5.

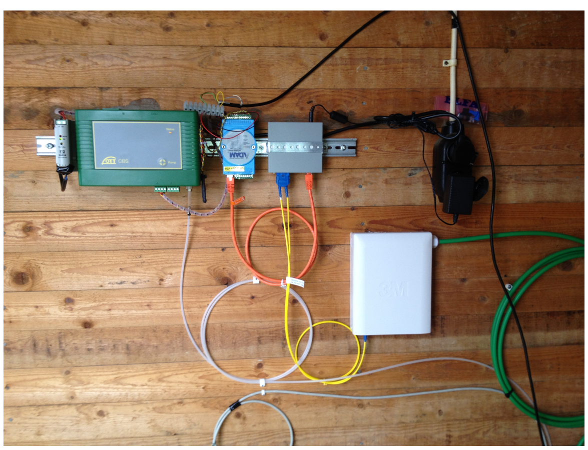

Fig. 4 The bubbler sensor installed in the hut. Compressed air flows from the green unit (to the left) through a plastic tube to a bubble chamber below the sea level. The pressure in the measuring tube is proportional to the height of the water column above the bubble chamber.

The bubbler sensor determines the sea level from differential pressure measurements. One value is the pressure of compressed air necessary in order to release bubbles from a tube at a fixed position, well below the sea level, and the other pressure value is that of the air at the sea level. Examples of one month of sea level observations are shown in Figure 6.

The data presented in the upper graph of Figure 6 are from the bubbler sensor, one pressure sensor, and the GNSS tide gauge. Differences with respect to the bubbler data are presented in the lower graph. As can be seen in the upper graph, the tides on the Swedish west coast are small and the large variations are caused by air pressure, wind, and ocean currents. The storm "Sven" on December 5–6 with wind speeds of up to 34 m/s caused the strong signal in sea level.

The most accurate (i.e., giving the smallest uncertainty) of the current sensors is, as expected, the bubbler: ±3 mm according to the specifications [5]. The two other techniques both result in an agreement with the bubbler on the order of 48 mm (standard deviation after bias removed).

An improved accuracy is expected from the radar sensor (CS476, [6]) to be installed in the autumn of 2014. Until then extensive characterization of the radar and the second pneumatic (bubbler) sensor will be carried out. Calibration measurements with respect to repeatability, linearity and drifts are performed. The experiment setup is shown in Figure 7 and preliminary results of the sensor repeatability are presented in Figure 8.

Fig. 5 An artist's impression of the planned official tide gauge station of the Swedish national network. The red hut exists and will be used to accommodate instrumentation for the tide-gauge station. A first preliminary installation is shown in Figure 4.

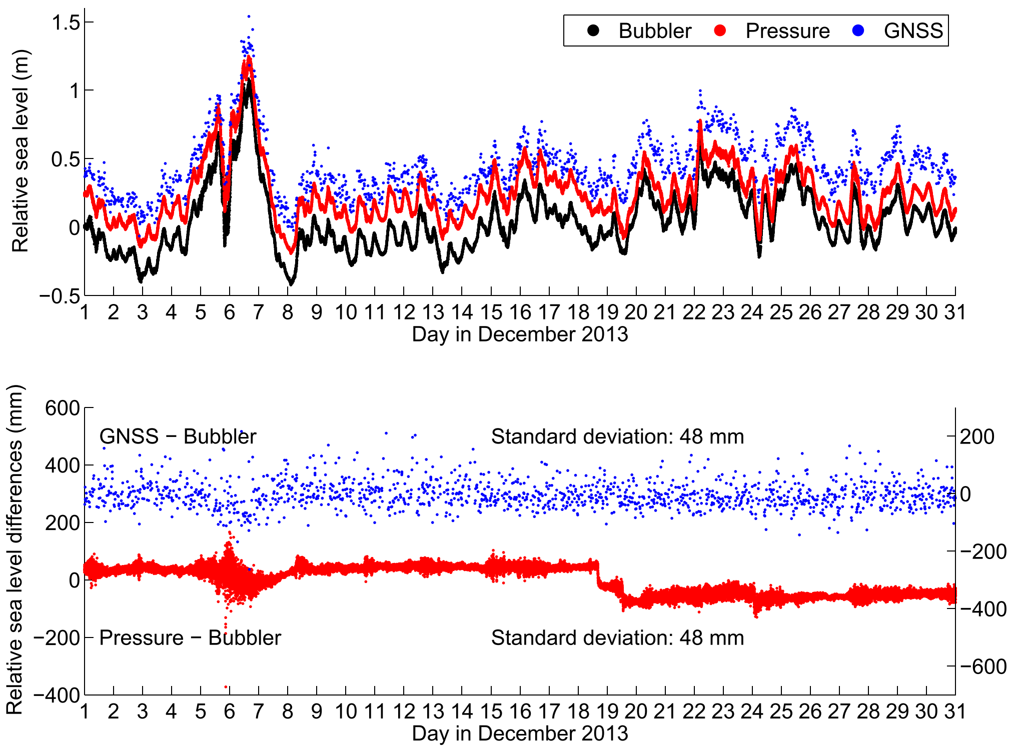

Fig. 6 One month of sea level observations from the Onsala site. Data from the bubbler sensor, one pressure sensor, and the GNSS tide gauge are shown in the upper graph. Differences with respect to the bubbler data are presented in the lower graph. As can be seen in the upper graph, the tides on the Swedish west coast are small and the large variations are caused by air pressure, wind, and ocean currents.

Fig. 7 The plastic tube with the bubble chamber lowered into the water (to the left) and the radar sensor (to the right) being tested in one of the showers at the observatory.

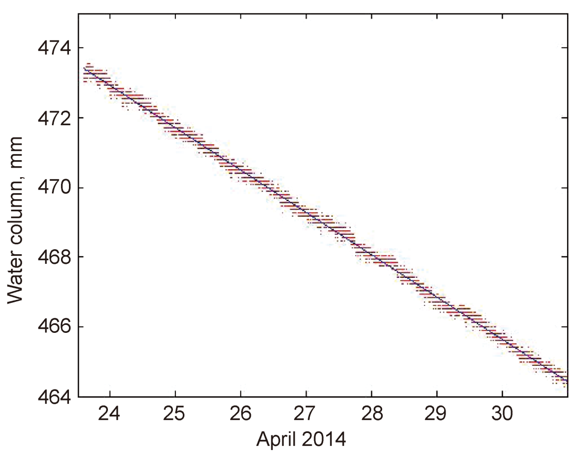

Fig. 8 Measurements of the water column with the bubbler sensor (see Figure 7) give an evaporation rate of 1.2 mm/day and a root-mean-square scatter about this model of 0.1 mm.

4 Outlook

We foresee an intensive period of construction work at the observatory. The plans are that the new tide-gauge station will be inaugurated in the autumn of 2014, whereas the installation of the twin telescopes will continue until 2016.

Acknowledgements

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