# Onsala Space Observatory – IVS Network Station Activities During 2013

Rüdiger Haas, Gunnar Elgered, Johan Löfgren, Tong Ning, Hans-Georg Scherneck

**Abstract** We participated in 40 IVS sessions. As in the previous five years, we used several of the sessions that involved both Onsala and Tsukuba to perform ultra-rapid UT1-UTC observations together with our colleagues in Tsukuba. Additionally, we observed two dedicated ultra-rapid sessions. The first was together with Tsukuba, Hobart, and HartRAO and aimed at determining ultra-rapid EOP. The second was together with Tsukuba and aimed at a northern hemisphere ultra-rapid UT1-UTC determination in parallel with the AUST-13-06 session. We also performed a short session in which we observed a GLONASS satellite using the Onsala 25-m telescope and the Wettzell 20-m telescope. The progress of the Onsala Twin Telescope (OTT) project was unfortunately delayed due to issues concerning wildlife protection. Extensive OTT simulation studies were performed, trying to optimize the sky visibility from a number of possible antenna locations. An updated application for the installation was submitted to the authorities at the end of 2013.

## 1 General Information

The Onsala Space Observatory is the national facility for radio astronomy in Sweden with the mission to support high-quality research in radio astronomy and geosciences. The observatory was established in 1949 and is located at Råö on the Onsala Peninsula on the Swedish west coast, about 40 km south of Gothenburg. Onsala belongs to the municipality of Kungsbacka. Figure 1 shows an aerial photo of Råö.

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Onsala IVS Network Station

IVS 2013 Annual Report

**Fig. 1** An aerial photo of Råö with the Onsala Space Observatory. The white spot approximately in the center of the photo is the 30-m diameter radome that encloses the 20-m radio telescope which is used for geodetic VLBI observations. (Credit: Onsala Space Observtory/Västkustflyg, 2011)

The geoscience instrumentation at Onsala includes equipment for geodetic VLBI, GNSS, a superconducting gravimeter with a platform for visiting absolute gravimeters, several microwave radiometers for atmospheric measurements, both GNSS based and pressure based tide gauges, and a seismometer. The Onsala Space Observatory can thus be regarded as a fundamental geodetic station.

In the coming years, the Onsala Twin Telescope (OTT) will be installed at the observatory and will consist of a pair of two new antennas following the VLBI2010 recommendations.

The staff members associated with the IVS Network Station at Onsala are listed in Table 1.

**Table 1** Staff members associated with the IVS Network Station at Onsala. All e-mail addresses have the ending @chalmers.se, and the complete telephone numbers start with the prefix +46-31-772.

| Function | Name | e-mail | telephone |
|---|---|---|---|
| Responsible P.I. for geodetic VLBI | Rüdiger Haas | rudiger.haas | 5530 |
| Observatory director | Hans Olofsson (– 2013.11.30) | hans.olofsson | 5520 |
| | John Conway (2013.12.01 –) | john.conway | 5520 |
| Head of department | Gunnar Elgered | gunnar.elgered | 5565 |
| Ph.D. students and postdocs involved in geodetic VLBI | Johan Löfgren | johan.lofgren | 5566 |
| | Niko Kareinen (2013.08.19 –) | niko.kareinen | 5566 |
| | Tong Ning | tong.ning | 5578 |
| Responsible for the VLBI Field System | Michael Lindqvist | michael.lindqvist | 5508 |
| | Rüdiger Haas | rudiger.haas | 5530 |
| Responsible for the VLBI equipment | Karl-Åke Johansson | karl-ake.johansson | 5571 |
| | Leif Helldner | leif.helldner | 5576 |
| VLBI operator | Roger Hammargren | roger.hammargren | 5551 |
| Telescope scientist | Henrik Olofsson | henrik.olofsson | 5564 |
| Software engineer | Mikael Lerner | mikael.lerner | 5581 |
| Responsible for gravimetry | Hans-Georg Scherneck | hans-georg.scherneck | 5556 |

## 2 Geodetic VLBI Observations

We participated in all of the 40 planned IVS sessions. In order to gain experience with the modern digital backends, for about 2/3 of these sessions we used both VLBI backends at Onsala, i.e. the Mark IV and the DBBC, and recorded in parallel on the Mark 5A and the Mark 5B+ data acquisition systems, respectively. We asked the staff at the Bonn correlator to do fringe-tests for these parallelly recorded sessions, or we did zero-baseline correlation tests ourselves with the software correlator DiFX at Onsala. There were some difficulties in the handling of the DBBC in the beginning, but we gained experience and learned how to use the DBBC/Mark 5B+ system successfully. Fringes were found with the DBBC/Mark 5B+, and the Bonn correlator could not detect any systematic changes w.r.t. the Mark IV/Mark 5A observations. Several databases were produced by the Bonn correlator that include Onsala both as a Mark IV/Mark 5A and a DBBC/Mark 5B+ station. We analyzed these databases and could not find any significant effects on the geodetic results due to the type of backend and recording system. As a consequence we decided on a smooth transition to the DBBC/Mark 5B+ VLBI system for regular IVS production in the fall of 2013.

In addition to the 40 regular IVS sessions, we also observed two dedicated ultra-rapid sessions, a four-station session UR-13-01 together with Tsukuba, Hobart, and HartRAO, and a one-baseline session UR-13-03 together with Tsukuba.

Furthermore, we did a test experiment together with Wettzell to observe signals from the GLONASS satellites.

## 3 Monitoring Activities

We continued with the monitoring activities as described in previous annual reports:

**Vertical height changes of the telescope tower.**

We continued to monitor the vertical height changes of the telescope tower using the invar rod system at the 20-m telescope. The measurements are available at `http://wx.oso.chalmers.se/pisa/`.

**Calibration of pressure sensor.**

We continued to calibrate the Onsala pressure sensor using a Vaisala barometer borrowed from the Swedish Meteorological and Hydrological Institute (SMHI). This instrument was installed at Onsala in late 2002 and has been calibrated at the SMHI main facility in Norrköping every one to two years since then. The latest calibration was on October 11, 2011. Since the installation of a new VLBI pressure sensor in 2008 the agreement between the Onsala VLBI pressure and the pressure read by the calibrated sensor is on the level of $\pm$0.1 hPa.

**Table 2** Geodetic VLBI observations at Onsala during 2013. Information is given on which VLBI backend was used, whether data were e-transferred in real-time (RT) and/or off-line (OL) and to which correlator, whether modules were shipped to a correlator, and whether Ultra-rapid UT1-UTC results were produced. The last column gives some general remarks and information on the percentage of the scheduled Onsala observations that were used in the analysis (as reported in the Web pages for the IVS session analyses), compared to the station average percentage per experiment.

| Exper. | Date | VLBI-backend | | E-transfer | | Module | Ultra-rapid | General remarks and % of scheduled observations used in the |
|---|---|---|---|---|---|---|---|---|
| | | Mark IV | DBBC | RT | OL | shipment | UT1-UTC | analysis as reported in the IVS Web pages' analysis reports. |
| R1-566 | 01.02 | yes | yes | – | Bonn | – | – | Mark IV in production, Onsala: 93.2 % (station avg. 88.8 %) |
| R1-567 | 01.07 | yes | yes | – | Bonn | – | – | Mark IV in production, Onsala: 96.5 % (station avg. 93.2 %) |
| EUR-121 | 01.21 | yes | yes | – | Bonn | – | – | Mark IV in production, Onsala: 85.4 % (station avg. 70.3 %) |
| R1-569 | 01.22 | yes | yes | Tsuk | Bonn | – | yes | Mark IV in production, Onsala: 80.2 % (station avg. 65.6 %) |
| G-0128 | 01.28 | yes | – | – | JIVE | – | – | GLONASS observations together with Wettzell, 1 h, OK |
| R1-570 | 01.28 | yes | yes | Tsuk | Bonn | – | – | Mark IV in production, Onsala: 91.4 % (station avg. 89.6 %) |
| RD-13-01 | 01.29 | yes | yes | Tsuk | Hays | – | – | not correlated yet in Haystack |
| UR-13-01 | 01.30 | yes | – | Tsuk | – | – | yes | scheduled for ultra-rapid UT1-UTC determination |
| R1-572 | 02.12 | yes | yes | – | Bonn | – | – | Mark IV in production, Onsala: 90.5 % (station avg. 85.6 %) |
| R1-573 | 02.18 | yes | yes | Tsuk | Bonn | – | yes | Mark IV in production, Onsala: 96.5 % (station avg. 94.4 %) |
| T2-088 | 02.19 | yes | – | Tsuk | Bonn | – | yes | Mark IV in production, Onsala: 78.8 % (station avg. 63.2 %) |
| R1-578 | 03.25 | yes | – | – | Bonn | – | – | Mark IV in production, Onsala: 94.7 % (station avg. 90.0 %) |
| R1-579 | 04.02 | yes | – | Tsuk | Bonn | – | – | Mark IV in production, Onsala: 90.5 % (station avg. 85.6 %) |
| R1-580 | 04.08 | yes | – | Tsuk | Bonn | – | – | Mark IV in production, Onsala: 94.4 % (station avg. 90.3 %) |
| RD-13-02 | 04.09 | yes | – | – | Hays | – | – | Mark IV in production, Onsala: 95.2 % (station avg. 92.8 %) |
| R1-582 | 04.22 | yes | – | Tsuk | Bonn | – | – | Mark IV in production, Onsala: 96.5 % (station avg. 94.7 %) |
| EUR-123 | 05.06 | yes | yes | – | Bonn | – | – | Mark IV in production, Onsala: 82.8 % (station avg. 72.6 %) |
| R1-585 | 05.13 | yes | yes | – | Bonn | – | – | Mark IV in production, Onsala: 94.1 % (station avg. 90.1 %) |
| RD-13-03 | 05.14 | yes | yes | – | Hays | – | – | Mark IV in production, Onsala: 92.5 % (station avg. 87.3 %) |
| R1-591 | 06.24 | yes | yes | – | Bonn | – | yes | Mark IV in production, Onsala: 97.3 % (station avg. 94.3 %) |
| T2-090 | 06.25 | yes | yes | Tsuk | Bonn | – | yes | Mark IV in production, Onsala: 72.9 % (station avg. 52.4 %) |
| R1-592 | 07.01 | yes | yes | Tsuk | Bonn | – | yes | Mark IV in production, Onsala: 94.3 % (station avg. 93.0 %) |
| EUR-124 | 07.04 | yes | yes | – | Bonn | – | – | Mark IV in production, Onsala: 83.4 % (station avg. 71.1 %) |
| R1-598 | 08.12 | yes | yes | Tsuk | Bonn | – | – | Mark IV in production, Onsala: 92.7 % (station avg. 79.0 %) |
| R1-599 | 08.19 | yes | yes | – | Bonn | – | – | Mark IV in production, Onsala: 71.7 % (station avg. 58.9 %) |
| RD-13-06 | 08.21 | yes | yes | Tsuk | Hays | – | – | Mark IV in production, Onsala: 79.2 % (station avg. 70.7 %) |
| R1-600 | 08.26 | yes | yes | – | Bonn | – | – | Mark IV in production, Onsala: 58.8 % (station avg. 48.0 %) |
| EUR-125 | 09.02 | yes | yes | – | Bonn | – | – | Mark IV in production, Onsala: 64.6 % (station avg. 46.3 %) |
| R1-601 | 09.03 | yes | yes | – | Bonn | – | yes | Mark IV in production, Onsala: 95.5 % (station avg. 92.8 %) |
| R1-602 | 09.09 | yes | yes | – | Bonn | – | yes | Mark IV in production, Onsala: 86.0 % (station avg. 79.3 %) |
| RDV-101 | 09.11 | yes | – | – | – | Socc | – | Mark IV in production, Onsala: 86.2 % (station avg. 69.2 %) |
| R1-604 | 09.24 | yes | yes | – | Bonn | – | yes | Mark IV in production, Onsala: 67.0 % (station avg. 52.2 %) |
| T2-092 | 10.01 | yes | – | – | Bonn | – | yes | Mark IV in production, Onsala: 66.6 % (station avg. 55.8 %) |
| RD-13-08 | 10.02 | yes | – | – | Hays | – | yes | Mark IV in production, Onsala: 81.1 % (station avg. 82.9 %) |
| R1-606 | 10.07 | yes | – | – | Bonn | – | yes | Mark IV in production, Onsala: 69.5 % (station avg. 57.2 %) |
| R1-612 | 11.18 | yes | yes | – | Bonn | – | yes | Mark IV in production, Onsala: 81.8 % (station avg. 68.7 %) |
| T2-093 | 11.19 | yes | yes | – | Bonn | – | yes | DBBC in production, Onsala: 38.8 % (station avg. 26.9 %) |
| UR-13-06 | 12.05 | yes | – | Tsuk | – | – | yes | scheduled for ultra-rapid UT1-UTC determination |
| R1-615 | 12.09 | yes | yes | Tsuk | Bonn | – | yes | Mark IV in production, Onsala: 92.5 % (station avg. 88.2 %) |
| RDV-102 | 12.11 | yes | – | – | – | Socc | – | Mark IV in production, Onsala: 85.9 % (station avg. 55.4 %) |
| R1-616 | 12.16 | yes | yes | Tsuk | Bonn | – | yes | DBBC in production, Onsala: 92.5 % (station avg. 88.2 %) |
| T2-094 | 12.17 | yes | yes | – | Bonn | – | yes | not correlated yet in Bonn |
| RD-13-10 | 12.18 | yes | – | – | Hays | – | yes | Mark IV in production, Onsala: 87.1 % (station avg. 77.6 %) |

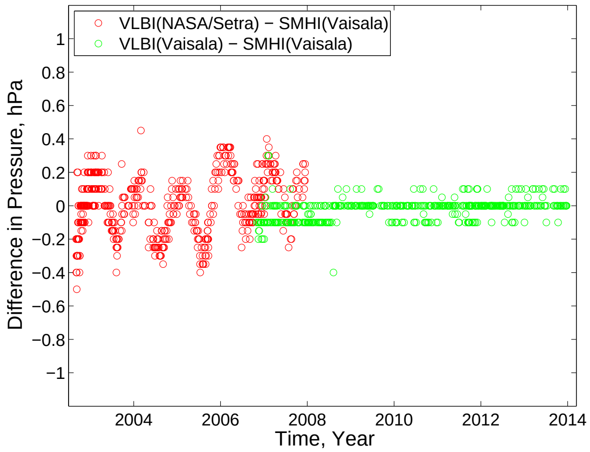


**Fig. 2** Time series of pressure differences between the VLBI pressure sensors and the calibrated pressure sensor from SMHI.

**Microwave radiometry.**

The water vapor radiometer Konrad was in operation continuously observing in a so-called sky-mapping mode. The second water vapor radiometer, Astrid, was operated in the winter, but its 31 GHz channel malfunctioned since the spring. Thus, during cloudy conditions (liquid water drops in the atmosphere) less useful data were acquired with Astrid after that.

**Sea-level monitoring.**

The GNSS-based tide gauge was operated continuously. A tide gauge based on pressure sensors was operated next to it throughout the year. In August an additional new bubbler sensor was installed at a new tide-gauge site under development at a distance of approximately 300 m from the GNSS/pressure-sensor site.

**Superconducting gravimetry.**

The superconducting gravimeter operated continuously and produced a highly precise record of gravity variations. Near real-time analysis results of the superconducting gravimeter are continuously updated at `http://holt.oso.chalmers.se/hgs/SCG/monitor-plot.html`.

**Absolute gravimetry.**

We supported a visiting absolute gravity measurement campaign by Lantmäteriet, the Swedish mapping, cadastral, and land registration authority.

**Seismological observations.**

The seismometer owned by Uppsala University and the Swedish National Seismic Network (SNSN) was operated throughout the year.

## 4 A New Onsala Tide Gauge Station

We signed a contract with SMHI to install an official SMHI tide gauge station at the observatory. This new tide gauge will have several sensors, e.g. one radar and two bubbler sensors for the sea-level observations. In addition these data will be complemented by several temperature and salinity sensors. Figure 3 depicts an artist's impression of this planned tide gauge site.

**Fig. 3** An artist's impression of the future SMHI tide gauge station at the Onsala Space Observatory.

## 5 Future Plans

- For 2014 we plan to observe a total of 50 IVS sessions, including the CONT14 campaign. Most likely there will, however, be an interruption in the observations after the summer. The original radome enclosing the 20-m telescope, installed in 1975, has aged and will be replaced by a new one.
- We strive to operate most of the IVS sessions as ultra-rapid UT1-UTC sessions, together with our colleagues at Tsukuba, Hobart, and HartRAO. This includes the CONT14 campaign.
- We will use the digital VLBI system, i.e. the DBBC and the Mark 5B+, for all the sessions for which this is possible. The old Mark IV VLBI system will be decommissioned in the spring of 2014.
- We will continue the usual monitoring activities at the observatory, and we plan to perform a new local tie measurement.
- As mentioned above a new tide gauge station will be installed, and the Onsala Twin Telescope project will be officially started when all necessary permissions have been received from the authorities.