# Onsala Space Observatory – IVS Analysis Center

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**Abstract**

This report briefly summarizes the activities of the IVS Analysis Center at the Onsala Space Observatory during 2012 and gives examples of results of ongoing work.

## 1. Introduction

We concentrate on research topics that are relevant for space geodesy and geosciences. These research topics are related to data observed with geodetic VLBI and complementary techniques.

## 2. VLBI and GPS Frequency Link Stabilities

We analyzed the two continuous campaigns CONT08 and CONT11 to study the frequency link stabilities that can be achieved today with VLBI and GPS [1], [2]. Our analysis shows that VLBI and GPS perform today equally well for frequency comparisons. We achieved overlapping Allan Deviations for 1 day on the order of $1.2 \cdot 10^{-15}$ and better, and the VLBI and GPS derived frequency estimates agree in most cases with common clocks at a level of $5 \cdot 10^{-16}$. As an example, Figure 1 depicts the overlapping Allan Deviations for CONT11. The residual phase differences in a root-mean-square sense were on the order of 100 ps. The result is that VLBI is an interesting alternative for frequency transfer since it is completely independent of the usual techniques applied. The upcoming VLBI2010 system could thus be of interest for continuous time and frequency transfer.

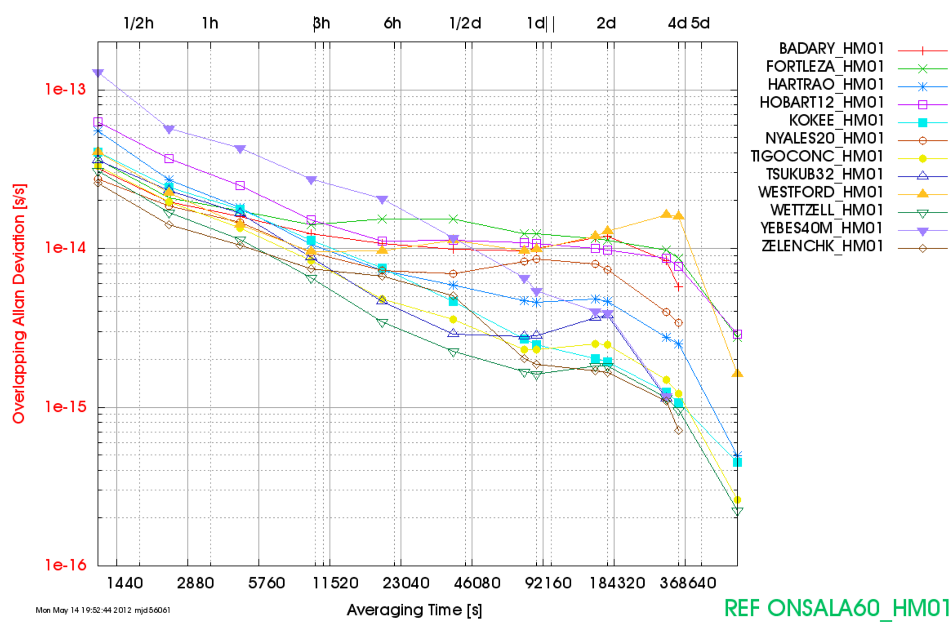


Figure 1. Frequency link instability for CONT11. The reference clock is the H-maser at Onsala.

## 3. Atmospheric Water Vapor from CONT Campaigns

We analyzed the four continuous campaigns CONT02, CONT05, CONT08, and CONT11 and compared the atmospheric water vapor results derived from the co-located equipment available at the participating stations [3]. All VLBI stations contributing to the CONT campaigns are co-located with GPS stations, and several of the stations also operated water vapor radiometers (WVR) during the CONT campaigns, see Table 1.

Table 1. Co-located instrumentation (V - VLBI, G - GPS, W - water vapor radiometer), operated at the stations contributing to the four continuous campaigns CONT02, CONT05, CONT08, and CONT11.

| Station | continuous campaign | | | |
|---|---|---|---|---|
| | CONT02 | CONT05 | CONT08 | CONT11 |
| Hartebeesthoek (South Africa) | V G | V G W | V G | V G |
| Kokee Park (Hawaii, USA) | V G W | V G W | V G | V G |
| Ny-Ålesund (Svalbard, Norway) | V G | V G | V G | V G |
| Onsala (Sweden) | V G W | V G W | V G W | V G W |
| Westford (Massachusetts, USA) | V G | V G | V G | V G |
| Wettzell (Germany) | V G W | V G W | V G | V G |
| Algonquin Park (Canada) | V G | V G W | | |
| Gilcreek (Alaska, USA) | V G | V G | | |
| Svetloe (Russia) | | V G | V G | |
| Tigo Concepción (Chile) | | V G | V G | V G |
| Tsukuba (Japan) | | V G W | V G W | V G W |
| Medicina (Italy) | | | V G | |
| Zelenchukskaya (Russia) | | | V G | V G |
| Fortaleza (Brazil) | | | | V G |
| Hobart (Tasmania, Australia) | | | | V G |
| Yebes (Spain) | | | | V G |

In general, we found good agreement between the zenith wet delay (ZWD) results derived from VLBI and GPS for all stations in all four CONT campaigns. The biases are on the order of $\pm 5$ mm, and the standard deviations are on the order of $5-10$ mm. The biases are however not constant for a given station, but vary from campaign to campaign. The comparison between VLBI and WVR is heavily dependent on the WVR instrument operated. The Onsala Space Observatory is the only station that had three co-located techniques for all four CONT sessions. The comparison between VLBI and WVR at Onsala showed biases on the order of $1-5$ mm and standard deviations on the order of $5-15$ mm. As an example, Figure 2 shows times series of zenith wet delay (ZWD) values derived from the co-located techniques at Onsala for all four CONT campaigns.

## 4. Ocean Tide Loading

The Automatic Ocean Tide Loading service has been moved to a new machine and can now be found at `http://holt.oso.chalmers.se/loading`. There have only been slight improvements during 2012, such as to the graphics display.

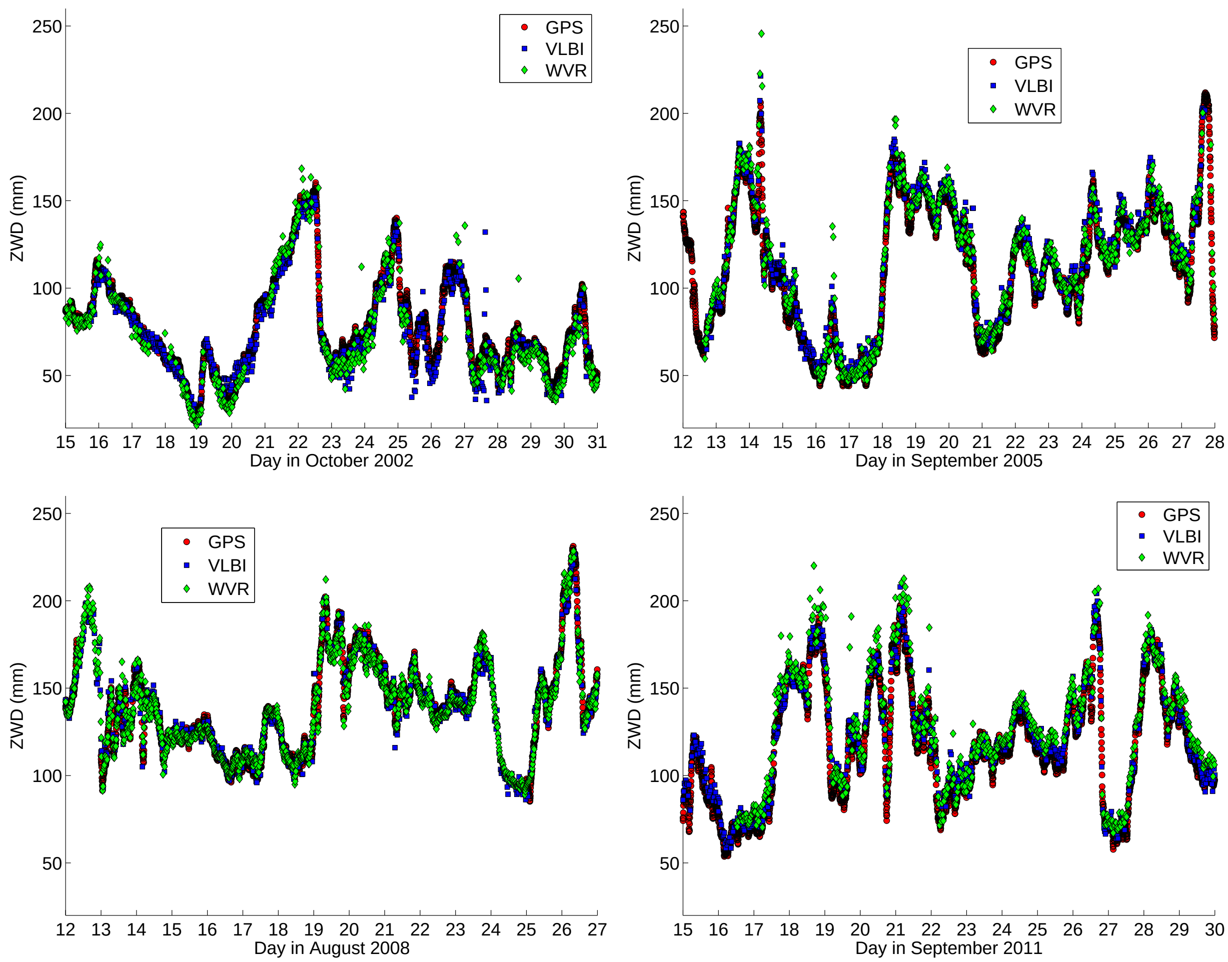


Figure 2. Zenith Wet Delay (ZWD) values derived from the co-located techniques GPS (red dots), VLBI (blue squares), and WVR (green diamonds) at Onsala for the continuous campaigns CONT02, CONT05, CONT08, and CONT11.

## 5. Gravimetric Laboratory

The Superconducting Gravimeter GWR 054 has been running without interruption during 2012. Since December 2012, one-second data has been available through a monitoring Web interface with a maximum latency of two minutes. The address is `http://holt.oso.chalmers.se/hgs/SCG/monitor-plot.html`, see Figure 3.

From June 6 to September 11 a calibration project with Leibniz University Hannover, Germany, was carried out. A portable ZLS Burris gravimeter was operated continuously in parallel with the GWR 054. The portable meter was calibrated before and after the project on the calibration line in Hannover. The result was somewhat disappointing because the GWR 054 calibration factor was achieved at a similar precision level as previous calibration attempts by short, parallel recordings with an absolute FG5 gravimeter.

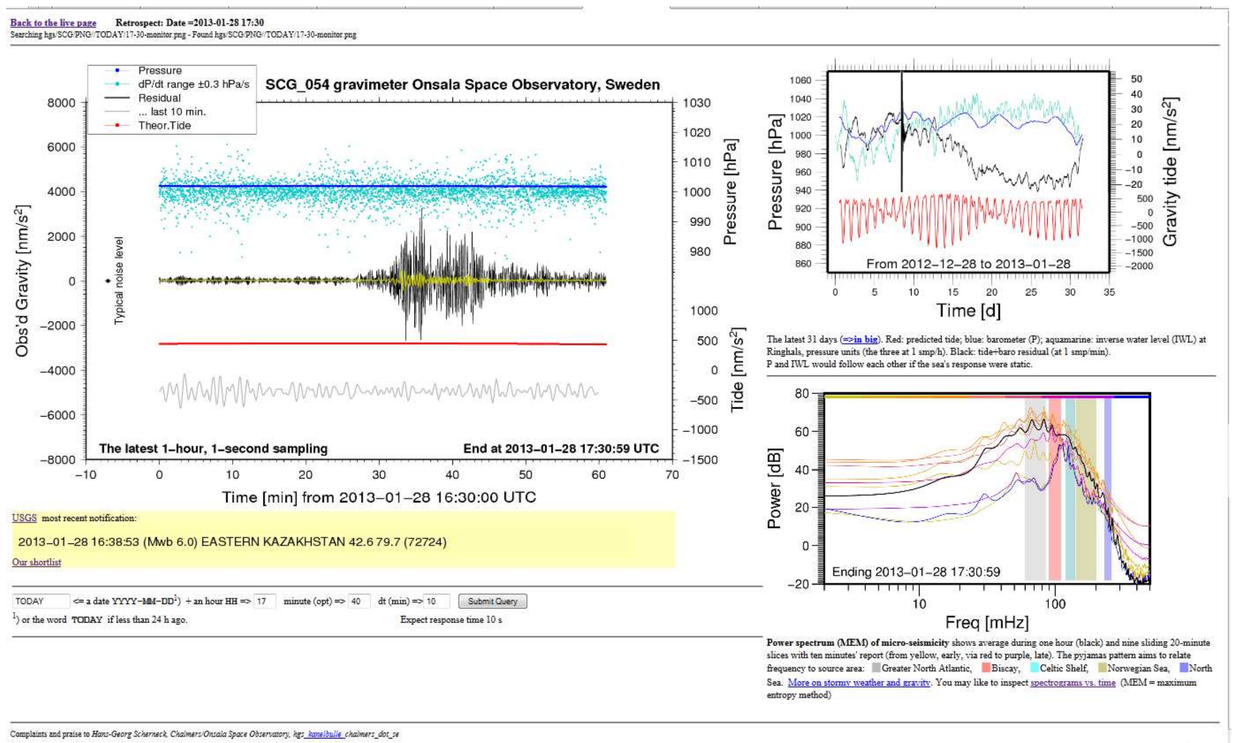


Figure 3. http://holt.oso.chalmers.se/hgs/SCG/monitor-plot.html, the monitoring site for the Superconducting Gravimeter at Onsala with links to power spectrograms, earthquake information, and numerical data. Earlier segments of the data can be visualized interactively.

## 6. Outlook

The IVS Analysis Center at the Onsala Space Observatory will continue its efforts to work on specific topics relevant to space geodesy and geosciences. For the future we plan to intensify our activities, in particular concerning horizontal gradients in the atmosphere using VLBI, GNSS, and radiometers.

## References

[1] Haas R, Rieck C, Jarlemark P (2012) VLBI and GNSS Frequency Link Instabilities during CONT Campaigns. In: D. Behrend and K. Baver (eds.): *International VLBI Service for Geodesy and Astrometry 2012 General Meeting Proceedings "Launching the Next-Generation IVS Network"*, NASA/CP-2012-217504, 425–429.

[2] Rieck C, Haas R, Jarlemark POJ, Jaldehag RTK (2012) VLBI Frequency Transfer using CONT11. In: *Proc. of the 26th European Frequency and Time Forum, Gothenburg, Sweden, 24-26 April, 2012*, 163–165.

[3] Haas R (2012) Atmospheric water vapour from CONT-campaigns. EGU General Assembly 2012, EGU2012-11432.