Onsala Space Observatory – IVS Technology Development Center Activities

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Abstract This report gives a brief overview on the technical development related to geodetic VLBI done during 2023 and 2024 at the Onsala Space Observatory.

1 General Information

The technical development work for geodetic VLBI at the Onsala Space Observatory (OSO) in 2023 and 2024 was primarily dedicated to installing new equipment and working with the Onsala twin telescopes (OTT), see Figure 1. The main activities are summarized as follows and discussed in detail in the subsequent sections:

- installation of a new ground-based microwave radiometer
- installation of invar measurement systems in the OTT
- testing new frequency setups and recording modes for the OTT.

2 A New Ground-based Microwave Radiometer

In May 2023, a new ground-based microwave radiometer (see Figure 2) was installed at Onsala. The instrument is of type RPG-HATPRO G5 and covers seven

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IVS 2023+2024 Biennial Report

Fig. 1 The three telescopes at Onsala used for IVS observations: Oe (left), On (middle) Ow (right).

Fig. 2 The new mircowave radiometer at OSO, called Greta. The Onsala twin telescopes and the 25-m telescope are visible in the background.

channels each in the frequency range 22.24–31.4 GHz, as well as 51–58 GHz. The data analysis uses a retrieval algorithm based on a neural network that is trained with ECMWF data. The beamwidth for water vapor is 3.0–4.2°, and the instrument delivers brightness temperature measurements with an uncertainty of ±0.15 K. The goal is to use the data provided by the instrument for comparisons to the zenith wet delay results derived from space geodetic measurements and to potentially calibrate VLBI measurements.

3 Invar Measurement Systems for the Onsala Twin Telescopes

One invar measurement system each was installed in the Onsala twin telescopes in December 2023 (Figure 3).

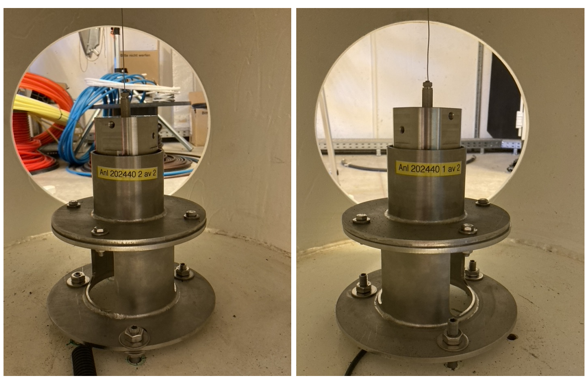

Fig. 3 The magnetic sensors of the invar measurement systems at the bottom of the telescope tower in Ow (left) and Oe (right).

The invar wires are attached at the top of the telescope tower, close to the azimuth encoders, and magnetic sensors in the bottom of the telescope tower measure the distance of the weights at the end of the invar wire with respect to the bottom, thus monitoring height changes of the telescope towers. Measurement data are recorded with 1 Hz sampling and are rather noisy. Averaging with different time lengths reveals the annual variation of the telescope towers more clearly (Figure 4). We plan to make the data available to allow correction of the height variations of the telescope reference points in the data analysis. It seems that Oe is showing larger height variations than Ow. Further investigations are necessary to better understand this behavior.

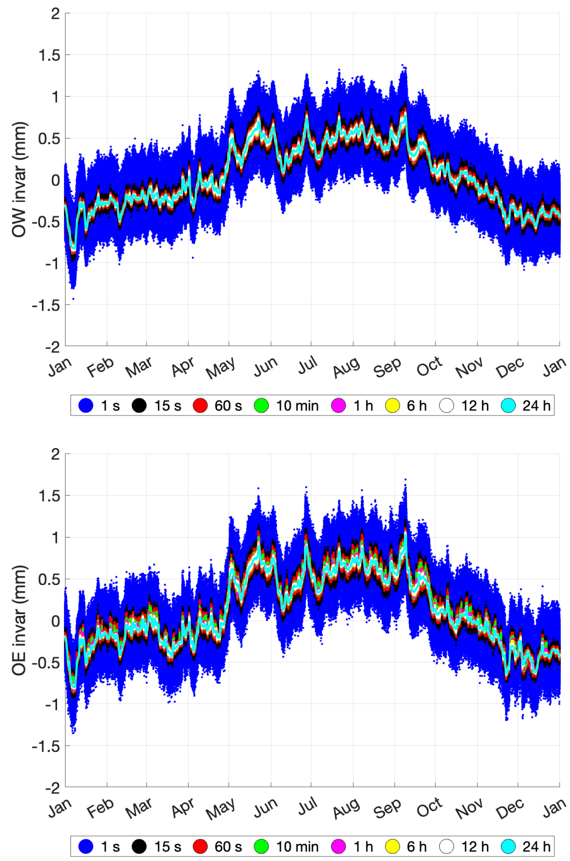

Fig. 4 Invar measurements of Ow (top) and Oe (bottom) for the entire year 2024. The original data are samples with 1 Hz (blue) and rather noisy. Averaging with different time lengths reveals the annual variation of the telescope towers more clearly.

4 Testing New Frequency Setups and Recording Modes for the OTT

Since the start of the VGOS operational series, the VGOS frequencies have been fixed to one setup of eight channels of 32-MHz bandwidth in four bands of 488-MHz bandwidth each, allocated between 3.0 GHz and 10.7 GHz. This means 32 channels per polarization, i.e., recording in total 64 channels. For the test observations to investigate the suitability of alternate frequency setups for VGOS, new frequency allocations were needed. Also the frequency allocation for future observations of the signals sent by the ESA mission Genesis will be different than today's operational frequency setups. This triggered investigations to achieve agility in frequency allocation for the OTT in order to be able to change quickly between different frequency setups. We thus tested OTT observations with the `ddc_v128` firmware of the DBBC3 that allows recording of 64 channels in two polarizations, i.e. recording in total 128 channels. This should allow enough flexibility to allocate frequencies for various VGOS modes as well as a mode to observe Genesis signals. Our tests with 128 channels recording, i.e., 16 Gb/s, were successful on the station level and could also be correlated correctly. However, it turned out that the current version of post-processing software HOPS did not yet allow more than 64 channels to be processed. Thus, fringe-fitting could only be done with subsets of the recorded channels, but not with all 128 channels together. Once an updated HOPS version that can handle 128 channels is available, we will continue with these frequency agility tests.

5 Outlook and Future Plans

Our plan for the upcoming two years is to continue optimizing the OTT systems for VGOS operations.