Geodetic Observatory Wettzell – 20-m Radio Telescope and Twin Radio Telescopes

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Abstract The Geodetic Observatory Wettzell, located in Germany, very successfully contributed to the IVS observing program and to some observations of the EVN in the years 2021 and 2022. Meanwhile, Wettzell supports different fields of the IVS within program coordination, observation, and correlation. Technical changes, developments, improvements, and upgrades were made to extend and increase the reliability of the entire VLBI observing system. All telescopes were regularly in use.

Fig. 1 Geodetic Observatory Wettzell with the 20-m radio telescope in the front and the twin telescopes in the background (reference: BKG web page).

1 General Information

The Geodetic Observatory Wettzell (GOW; see Figure 1) is jointly operated by the Federal Agency for Cartography and Geodesy (Bundesamt für Kartographie und Geodäsie, BKG) and the Research Facility Satellite Geodesy (Forschungseinrichtung Satellitengeodäsie, FESG) of the Technical University of Munich (TUM). Parts of the observatory are now part of the critical infrastructure of Germany for navigation and geodata. The 20-m Radio Telescope in Wettzell (RTW) has been an essential component of the IVS since 1983 and has produced the longest VLBI-data time series worldwide. The 13.2-m Twin radio Telescope Wettzell North (TTW1, Wn) also produced S/X data as a regular network station and was fitted with a VGOS receiver in late 2022. The 13.2-m Twin radio Telescope Wettzell South (TTW2, Ws) participates in almost all VGOS and EU-VGOS sessions and is part of the VGOS Intensive program. Wettzell observatory also became an official correlation site of the IVS. It is also part of the DACH Operation Center and schedules T2, INT2, INT3, OHIGGINS, and other sessions. Using the Field System extension for remote control and monitoring, all sessions are operated completely unattended. An official on-call service was established in January 2021 to manage appearing issues outside of official business hours. All VLBI data is transferred with e-VLBI techniques to Bonn, Tsukuba, Haystack, Washington, and Socorro, using TSUNAMI or jive5ab on a 5 Gbit/s connection. Bonn and Washington correlators fetch sessions from Flexbuff systems at the Wettzell observatory.

In addition to the VLBI, an ILRS laser ranging system, several IGS GNSS permanent stations, a large laser gyroscope G (ring laser), and the corresponding local techniques (e.g., time and frequency, meteorology, and superconducting gravity meters) are operated. Wettzell also runs a DORIS beacon as a complete geodetic core site. A new radio telescope for solar flux observations is almost fully constructed. Activities

1. Forschungseinrichtung Satellitengeodäsie (FESG), Technische Universität München
2. Bundesamt für Kartographie und Geodäsie (BKG)

RTW/TWIN Wettzell Network Station and Correlator

IVS 2021+2022 Biennial Report

to monitor atmospheric parameters use a continuously growing number of equipment, including a Nubiscope, and weather balloons. A water vapor radiometer permanently scans the zenith position. A project with the company Menlo Systems as external contractor improves the timing system with compensated fiber-optic transfers and a frequency comb which is under test in parallel to the existing timing distribution. The new DFG Research Unit “Clock Metrology: A Novel Approach to TIME in Geodesy” will further investigate and improve time as a geodetic observable. The project is funded for four years.

The GOW is also responsible for the AGGO system in La Plata, Argentina, and the German Antarctic Receiving Station (GARS) O’Higgins on the Antarctic Peninsula (see separate reports).

2 Staff

The staff of the GOW consists of 42 members in total (plus student operators) mainly on permanent but also on fixed-term contracts to do research, operations, maintenance, and repairs, or to improve and develop all systems of the GOW. The staff operating VLBI is summarized in Table 1.

Table 1 Staff members of RTW.

Name	Affiliation	Function	Special tasks
Torben Schüler	BKG	head of the GOW	
Christian Plötz	BKG	BKG head of VLBI ressort, correlator chief	
Alexander Neidhardt	FESG	TUM head of the microwave group, VLBI-operation chief	
Daniel Amberger	BKG	RF eng., solar flux telescope	
Ewald Bielmeier	FESG	technician	
Martin Brandl	FESG	mechatronic engineer	
Elena Dembianny	FESG	physicist (left Feb. 2021)	
Florian Kroner	FESG	RF engineer (started Nov. 2021)	
Gerhard Kronschnabl	BKG	electronic engineer (chief engineer TTW)	
Willi Probst	FESG/ BKG	Correlation, quality control	
Walter Schwarz	BKG	electronic engineer	WVR
Michael Seegerer	BKG	IT, correlation, quality control	O’Higgins
Simon Seidl	FESG	IT/electronic eng. (started Nov. 2021)	
Robert Wildenauer	BKG	IT admin, correlation	

3 Expansion Project for the GOW

The German Federal Ministry of the Interior (BMI) and the BKG have agreed to a four-year project to expand the infrastructure and operations of the GOW in 2018, which is in the final stages. The main objective of this project is to contribute to the 17 sustainable development goals of the United Nations (UN), such as promotion of high-tech-facilities in rural areas in terms of employment and education. Furthermore, Germany intends to deepen its role of supporting Europe’s satellite navigation system “Galileo,” which will also be a major task for the observatory in Wettzell in the future.

To meet these goals, the expansion-project has the following three topics:

- Further development of the existing geodetic infrastructure (VLBI, SLR, GNSS): VLBI is now ISO 9000 certified, a Domestic Coordination Office (DCO) plans and evaluates all observations, an extended quality management is established which offers weekly feedback about performance, and expanded live views show system parameters in real-time.
- Establishment of new systems: The construction phase of the Solar-Flux telescope is finished and the final testing has started. The Wettzell correlator became an IVS component and is regularly operated, the Internet data rate is extended to 2×5 Gbit/s, and magnetometers and other instruments are installed to support space weather monitoring.
- Creation of a center of excellence for space geodesy: Contracts with the district administration were signed to offer official school labs, tours are offered, and public relation and outreach are expanded.

4 Wettzell Correlator

Originally planned for domestic sessions and quality control, the new DiFX correlation facility started operation in January 2021. The correlator increases the efficiency and real-time capabilities for VLBI sessions, but can also be used to support Galileo (e.g., EOPs) for time-critical requests. Meanwhile, the facility is an official component of the IVS doing regular operations, especially for the VGOS network. Technically, it is a

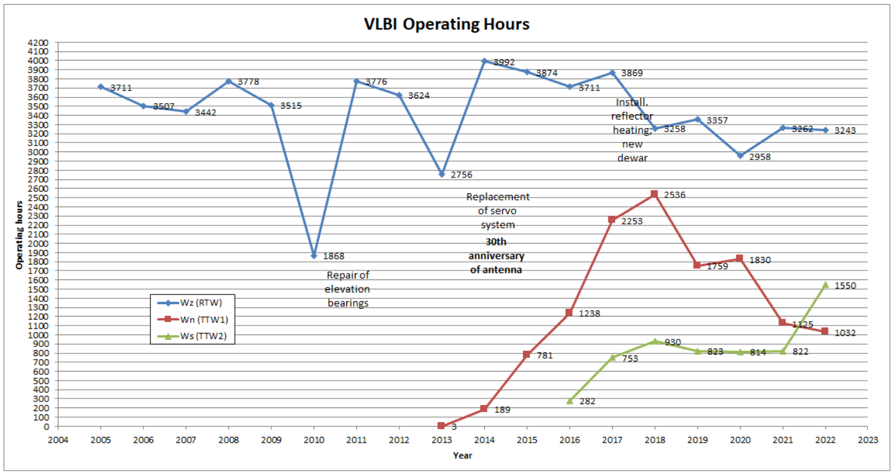

Fig. 2 Annual operation hours of the Wettzell antennas since 2005.

Dell HPC Cluster with 24 compute nodes having 48 Intel® Xeon® CPUs each with 12 cores, so that 576 cores can be used in total. The storage started with a volume of 834 TB. The extension to 2.8 PB is ongoing and will be done beginning of 2023. The software used is DiFX 2.6.1 and 2.5.4 with HOPS (Haystack Observatory Postprocessing System).

5 Legacy System

The 20-m RTW has been supporting geodetic VLBI activities of the IVS and partly other partners, such as the EVN, for over 40 years now. The telescope is still in a very good and stable state supporting legacy S/X observations. The main priority was laid on the participation in all daily one-hour Intensive sessions (INT/K/Q) in order to determine UT1-UTC. The antenna supported all main IVS 24-hour sessions and is still one of the main components of the IVS.

Operation hours in the reporting period compared to the other telescopes are plotted in Figure 2. Sessions operated by RTW in 2021 are in Table 2 and sessions in 2022 are shown in Table 3.

All sessions are recorded on local Flexbuff servers with a volume of 281 TB plus 72 TB. It is connected to the correlator head node, so that the complete volume of the correlator storage can be used. It is also the connection point for e-transfers.

Table 2 Session statistics of the year 2021 (reference: DCO Levika software).

Session	Wz	Wn	Ws	Oh	Ag	**Subtotal**
GOW	43	28	13	1	32	117
VG2			4			4
VGOS			151			151
IN1	240					240
IN2	93					93
IN3	43	23				66
IVS-R1	42	21			27	90
IVS-R4	47	18			2	67
IVS-T2	7	3		7	2	19
IVS-OHG				6	2	8
IVS-CRD				5	4	9
VLBA	6					6
R&D	10					10
Total	531	93	168	19	69	**880**

Monthly maintenance days were scheduled to give enough time to maintain the system. The NASA Field System version is 9.13.2, but new FS-PCs were bought where the FSL10 will be installed on a 64-bit operating system. The DBBC2 at the legacy system uses DDC firmware v105_1 for IVS and v107 for EVN sessions and is connected to a FILA10G to stream data over a 10 Gbit/s transfer network directly to a Flexbuff server in the TWIN operation building.

Table 3 Session statistics of the year 2022 (reference: DCO Levika software).

Session	Wz	Wn	Ws	Oh	Ag	**Subtotal**
GOW	15	8	54		7	84
VG2			70			70
VGOS			240			240
IN1	242	25				267
IN2	102					102
IN3	34	23				57
IVS-R1	47	16			30	93
IVS-R4	45	20				65
IVS-T2	7	4		5	2	18
IVS-OHG				6	4	10
IVS-CRD				4	5	9
VLBA	6					6
R&D	10		1			11
UNKNOWN	66		4			70
Total	574	96	369	15	48	**1102**

A given oil leakage in two elevation gears was fixed. RF-over-fiber signal transfers were tested and are ready for installation, so that the complete backend, clock reference connection, and control system can be moved to the main operation room in the TWIN building. Studies were done to evaluate the use of an L-band antenna in an offset-cassegrain optic. A problem is that the coldhead model 22 of CTI/Brooks is not supported any more. Therefore, a new cryo-system must be planned. Currently, refurbished models are in use. But the quality is poor that longer maintenance time periods or VLBI operations with a warm receiver had to be accepted.

The northern antenna Wn is equipped with an S/X/Ka receiving system to also support the standard S/X sessions of the IVS. It supported the same or replaced sessions of the 20-m antenna. The northern antenna was the first available antenna supporting fast slewing modes in the IVS and uses a DBBC2 (firmware DDC v105_1) in combination with a Mark5B+. Its performance can be found in Figure 2 and Tables 2 and 3. It suffered from broken bands in the DBBC2 end of 2022. It is controlled with the NASA Field System version 9.13.2.

The performance of Wn suffered from a critical failure of the azimuth encoder of the company BEI Inc., which was not able to offer economical repairs after more than ten years of use. Because both twin antennas showed the same failure in a very tight timespan and because only one replacement set was available on location, the decision was made to first repair the VGOS system Ws. This caused a complete shutdown of the Wn antenna from July 2021 to December 2021. A complete replacement with Heidenhain encoders and suitable mechanical fitting was done in May 2022. Besides this critical issue, the failing UPS in the system and in the control room caused more instabilities than usual. Defective touch panels in the controlling system of the antenna had to be replaced in addition.

6 VGOS System

The Twin Telescope Wettzell project is Wettzell's implementation of a complete VGOS conformity. To support a complete VGOS functionality, the Wn antenna gets the QRFH feed, a new receiver front-end, and a DBBC3/Flexbuff backend. The rebuilding started at the end of November 2022 and should be available in the first half of the year 2023.

The southern antenna Ws of the twin telescope is Wettzell's first VGOS compliant antenna using a broadband feed (Elevenfeed). It uses a tunable up-down converter, two DBBC2s, and a Mark 6 to record four bands in both polarizations. Ws uses the VGOS branch of the NASA Field System vers. 9.12.7. Ws is a regular part of the IVS VGOS network, participating in weekly/bi-weekly 24-hour observations. It is also involved in the regular VGOS Intensives. Its performance can be found in Figure 2 and Tables 2 and 3.

Two weak and later defective LNAs in the Elevenfeed reduced the quality of the antenna in May 2022. A first maintenance in June/July 2022 was not successful. Therefore, there was a complete destruction of the two LNAs in November 2022, so that VGOS operations had to be stopped. The cause of the destruction was a melting isolation of the supporting cryogenic cable inside the dewar. A problem is that there is no support anymore by Omnisys and that the construction drawings and line plans are not available. Another issue was the failing BEI encoder, already described for the Wn antenna. A complete replacement with Heidenhain encoders and suitable mechanical fitting was done in May 2022. UPS failures also brought instabilities.

The plan is to bring the antenna back in the early months of 2023.

7 Other VLBI-relevant Activities

Several activities supported VLBI. In April 2021, the backbone network of the observatory was renewed with a 10 Gbit/s fiber infrastructure. This allows data streams between different Flexbuffs and correlator facilities of the observatory. The external connection was upgraded to 2×5 GBit/s, where one line is the main connection point and the other is a equivalent backup.

A photogrammetric survey was done at the 20-m legacy and at the VGOS antennas using overflights with a UAV. The project was lead by the Frankfurt University of Applied Sciences and the Bochum University of Applied Sciences. The goal was to derive a ray-tracing-based delay model for compensating gravitational deformations of VLBI radio telescopes [1].

In November 2021, the Technical University of Munich did laser scanner observations with an automated scanner system mounted in the quadrupod of the 20-m radio telescope. The goal was a 3D deformation analysis [2].

Additionally, local surveys were carried out at the twin telescopes in October 2021.

A big issue was caused by an almost complete outage of the Internet access from January 28 to April 18, 2022. It necessitated manual movements of VLBI modules to dedicated Mark 6 systems with a separate Internet connection. Therefore, it was necessary to establish shifts again doing the data management for that time period.

Another issue is the situation with the hydrogen masers. Contracts ended with T4Science which was additionally sold to Orolia. Essential components of the masers are not available anymore, so that spare parts can not be obtained. Therefore, high efforts were forced to repair EFOS-18 and EFOS-60 in September 2022 to have functional systems again. EFOS-39 was also revised but a failure in the beam stabilizer came up which is not yet repaired, so that it is switched off.

The use of ZABBIX as monitoring and alerting system was extended. Meanwhile, it is an essential part supporting unattended observations. In combination with this local service, the IVS Seamless Auxiliary Data Archive (SADA) was established which collects real-time data of different telescopes. The equivalent EVN monitor is a result of the Jumping JIVE project funded by the Horizon 2020 Framework Programme of the EU. The project ended in the year 2021.

8 Future Plans

Dedicated plans for the next reporting period are:

- Establishing a complete VGOS twin telescope with two VGOS receivers and and an additional possibility for S/X using a hybrid,
- Replacement of the frontend at the 20-m radio telescope because of missing coldhead support,
- Replacing masers by new systems with available components and maintenance,
- Installation of an L-band offset system at the 20-m radio telescope,
- Use of RF-over-Fiber for the 20-m radio telescope and centralizing the backends,
- Upgrade of the gears at the 20-m radio telescope,
- Extending routine correlation and post-processing,
- Upgrade of the Internet connection to 2×10 Gbit/s and connection of the HPC storage with same speed,
- Completely change to DBBC3 at all telescopes,
- Test of time and frequency distribution over compensated fiber,
- Regular cleaning of the radio telesopes.

References

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