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

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Abstract The Geodetic Observatory Wettzell, Germany mainly contributed successfully to the IVS observing program and to some observations of the EVN in 2019 and 2020. Technical changes, improvements, upgrades, and developments were made to extend and increase the reliability of the entire VLBI observing system. While the 20-m Radio Teslcope Wettzell (RTW, Wz) and the 13.2-m Twin radio Telescope Wettzell North (TTW1, Wn) are in regular S/X sessions, the 13.2-m Twin radio Telescope Wettzell South (TTW2, Ws) is equipped with a VGOS receiving system and participated in all test and regular international and European VGOS sessions.

Fig. 1 View of the Geodetic Observatory Wettzell: in the foreground one of the two 13.2-m TWIN radio telescope antennas (Wn) and the 20-m Radio Telescope Wettzell (Wz) in the back.

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). The 20-m Radio Telescope in Wettzell (RTW, Wz) has been an essential component of the IVS since 1983 and produced the longest VLBI-data time series worldwide. The 13.2-m Twin radio Telescope Wettzell North (TTW1, Wn) also produces S/X-data as a regular station. The 13.2-m Twin radio Telescope Wettzell South (TTW2, Ws) participates in almost all VGOS and EU-VGOS sessions.

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 also operated. Wettzell also runs a DORIS beacon as a complete geodetic core site.

Activities to monitor atmospheric parameters use a continuously growing number of equipment, including a Nubiscope and weather balloons. A project with external contractor Menlo Systems improves the timing system with compensated fiber-optic transfers and a frequency comb which is under test in parallel to the existing timing distribution.

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Meanwhile, automation and remote control is a central part of operation. One operator monitors and controls all VLBI telescopes and also the laser ranging systems from one central control room located in the Twin operating building.

The GOW is also responsible for the AGGO system in La Plata, Argentina (which is the former station TIGO in Concepción, Chile), and the German Antarctic Research Station (GARS) O'Higgins on the Antarctic Peninsula (see separate reports).

2 Expansion Project for the GOW

The German Federal Ministry of the Interior (BMI) and BKG have agreed to a four-year project to expand the infrastructure and operations of the Geodetic Observatory Wettzell in 2018. 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 European's satelite navigation system "Galileo," which will also be a major task of the observatory in Wettzell in the future.

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

- Further development of the existing geodetic infrastructure (VLBI, SLR, GNSS) to enhance availability and 24/7 real-time capabilities.
- Establishment of new systems, such as a new VLBI correlator, a Solar-Flux telescope to monitor space weather, and a Galileo monitoring station for the Public Regulated Service (PRS).
- Creation of a center of excellence for space geodesy, which will operate in the field of public relations, knowledge transfer, and student education.

A main focus of the program for VLBI is laid on 24/7 observations so that one of the three Wettzell telescopes is active for IVS sessions or domestic sessions. Domestic sessions are planned and scheduled at Wettzell and use one or more of the Wettzell telescopes, AGGO (Argentinia), and O'Higgins (Antarctica). There is also a plan to monitor selected Galileo satellites with one of the VGOS telescopes (due to their broadband feeds which covers L-Band) for quality control. The new solar flux telescope can also be used for these tasks at night, while it monitors space weather during daylight.

Fig. 2 Installation of the new correlation facility at Wettzell observatory.

All domestic sessions can be correlated with the new DiFX correlation facility, where experience is growing. 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. Additionally, the facility may also complement international correlation infrastructure in the future.

Technically, it is a 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 has a volume of 834 TB. Used software is DiFX 2.6.1 with HOPS (Haystack Observatory Postprocessing System). A first test correlation of INT9 sessions between Ag, Wn, and Wz was successful at the end of 2020, using the new correlation hardware.

Table 1 Staff members of RTW.

Name	Affiliation	Function	Special tasks
Torben Schüler	BKG	head of the GOW	
Alexander Neidhardt	FESG	head of the microwave group, VLBI chief	
Ewald Bielmeier	FESG	technician	
Martin Brandl	FESG	mechatronic engineer	
Elena Dembianny	FESG	physicist (starting March 2020)	
Gerhard Kronschnabl	BKG	electronic engineer (chief engineer TTW)	
Christian Plötz	BKG	electronic engineer (chief engineer RTW)	O'Higgins
Willi Probst	FESG/ BKG	physicist (starting January 2020)	Correlation, Quality control
Raimund Schatz	FESG	software engineer (till March 2020)	
Walter Schwarz	BKG	electronic engineer	WVR
Michael Seegerer	BKG	IT	Admin, Correlation
Robert Wildenauer	BKG	physicist	SW, Correlation
Armin Böer	BKG	electronic engineer	Infrastruct., RTW
Martin Hohlneicher	BKG	physicist	PRS, expansion project

To solve all new tasks, a new scientific staff was permanently employed in 2020, while further positions might follow, so that at least up to 24 new positions might be possible. This is the largest increase since the beginning of the observatory.

3 Staff

The staff of the GOW consists of over 40 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. Christian Plötz will become the BKG head of VLBI resort at Wettzell in 2021.

4 20-m Radio Telescope Wettzell

The 20-m RTW (Wz) has been supporting geodetic VLBI activities of the IVS and partly other partners, such as the EVN, for over 37 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. Using the Field System extension for remote control and unattended observations, mostly all sessions were operated unattendedly starting mid-2020. 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 3. The operational hours of RTW are listed in Table 2.

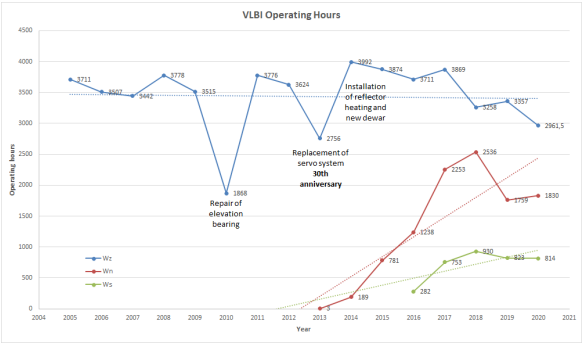

Fig. 3 Annual hours of operation of the Wettzell antennas since 2005.

Table 2 Annual participation of RTW in services.

Network	Number of observations	Hours of operation	Percent of operation
2019			
IVS	558	3157	94 %
Local (X9)	31	200	6 %
Others	0	0	0 %
2020			
IVS	470	2916	98.5 %
Local (X9)	171	42	1.4 %
Others (EVN)	2	3.5	0.1 %

All VLBI data from the 20-m RTW is transferred with e-VLBI techniques to Bonn, Tsukuba, Haystack, Washington, and Socorro, using TSUNAMI or Jive5ab on the 1 Gbit/sec connection of the Wettzell observatory. Bonn and Washington correlators fetch sessions from Flexbuff systems at the Wettzell observatory. Most of the sessions are recorded on Mark 5B+ systems and later on transferred to the local Flexbuff servers in the reporting period. In mid-2020, the complete recording was changed to a direct recording on Flexbuff after an upgrade of volume (currently 281 TB plus 72 TB).

Monthly maintenance days were scheduled to give enough time to maintain the systems. Additionally, service periods were necessary to finalize the cleaning and coating of the antenna tower, the back structure, and the cabins by an external contractor. The NASA Field System is now on version 9.13.2. All DBBC2s use now firmware DDC v105_1 and are connected to a FILA10G to stream data over 10 Gbit/s networks.

Open issues of an oil leakage in two elevation gears were solved. Test with RF-over-fiber were performed and will become the future technique. A safe and automated wind stow mechanism was established and all automated processes were checked with risk analysis and risk matrixes.

5 13.2-m Twin Telescope Wettzell North (TTW1, Wn)

The Twin Telescope Wettzell project is Wettzell's implementation of a complete VGOS conformity. Currently, the northern antenna Wn is still equipped with an S/X/Ka receiving system to support the standard S/X sessions of the IVS. It was used for tests with the new QRFH feed to get performance values of the whole system. The feed was dismounted again after the tests. 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 Mark 5B+. It is used in sessions like the 20-m antenna. Its performance in operating hours can be found in Figure 3 (also see Table 3). All recorded data is transferred with e-VLBI techniques.

Table 3 Annual participation of TTW1 in services.

Network	Number of observations	Hours of operation	Percent of operation
2019			
IVS	177	1557	88.5 %
Local (X9)	26	196	11.1 %
Others (EVN)	3	6	0.4 %
2020			
IVS	130	1702	93 %
Local (X9)	37	116	6.3 %
Others (EVN)	1	12	0.7 %

The Wn antenna runs stable and reliable. It is controlled with the NASA Field System version 9.13.2.

6 13.2m Twin Telescope Wettzell South (TTW2, Ws)

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-downconverter, two DBBC2s, and a Mark 6 to record four bands in both polarizations. Meanwhile, Ws is a regular part of the IVS VGOS network doing bi-weekly observations. Its performance in operating hours can be found in Figure 3 (also see Table 4). Data of the VGOS sessions is shipped on modules to Haystack for correlation because of the huge data amount of about 16 or 32 Terabyte per day. VGOS Intensives started with tests and became a regular task.

The staff at Wettzell does continuous upgrades, implementations, and tests of the backend system. A DBBC3 was installed and is under testing. Ws uses the VGOS branch of the NASA Field System version 9.12.7.

Table 4 Annual participation of TTW2 in services.

Network	Number of observations	Hours of operation	Percent of operation
2019			
IVS	54	708	86 %
Local	11	115	14 %
2020			
IVS	61	757	93 %
Local	6	57	7 %

7 Other VLBI Relevant Activities

To improve the e-VLBI capacities, Flexbuff systems with a total volume of 353 TB are used. The main systems behind are extendable DELL PowerVault MD3460 Storage Arrays connected to a DELL PowerEdge R730 server. All systems are accessible with Jive5ab.

For a better overview of antenna parameters and for emergency detections, a monitoring system was installed as central data archive using the ZABBIX software, sending alert levels to the guard of the observatory. Trained operators monitor and control laser ranging systems and VLBI systems from one control room. An on-call service was established to interact with the system in cases of alerts.

The TUM at Wettzell still works in the project "Joining up Users for Maximizing the Profile, the Innovation and Necessary Globalization of JIVE" (Jumping JIVE) to implement a monitoring infrastructure for the whole EVN network coordinated by Joint Institute for VLBI ERIC, Dwingeloo, The Netherlands. Jumping JIVE is funded by the Horizon 2020 program of the European Union. Part of the local Wettzell development and installation is a web-based monitoring system for the NASA Field System, which can be used to retrieve about 110 parameters. Additionally, data collectors and web screens were implemented for other hardware.

The permanent survey of the reference point of the twin antennas was continued using total stations on different pillars and 20 to 30 reflectors in the back structure of the antenna. With about four sessions per year, a continuous monitoring of the reference point over the year is possible.

Wettzell also became a scheduling center, so that INT3 and T2 sessions are produced at Wettzell. The scheduling process is meanwhile completely automated, which was realized as cooperation with TU Vienna, Austria, and ETH Zürich, Switzerland.

The year 2020 was marked by the pandemic situation with Covid-19, so that most of the work and operations were made remote using teleworking capabilities. Nevertheless, all sessions could be observed, so that no data losses or reductions were seen.

8 Future Plans

Dedicated plans for the next reporting period are:

- Improving and extending automated observations,
- Establishing of routine workflows of correlation and post-processing,
- Routine correlation of ongoing INT9 programs,
- Upgrade of the Internet connection to 2×3 Gbit per second,
- Continuous improvements with the VGOS broadband system at TTW2,
- Use of DBBC3s for both Twin telescopes,
- Use of QRFH feed to establish two VGOS antennas with hybrid to directly convert to circular polarization,
- Test of time and frequency distribution over compensated fiber.