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

Alexander Neidhardt [1], Christian Plötz [2], Gerhard Kronschnabl [2], Torben Schüler [2]

Abstract The Geodetic Observatory Wettzell, Germany contributed again very successfully to the IVS observing program during 2015 and 2016. Technical changes, developments, improvements, and upgrades were made to 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 new VGOS receiving system. A main task was to bring this new technique into operation so that the first common, transatlantic VGOS observations became possible.

1 General Information

The Geodetic Observatory Wettzell (GOW) 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) has been an essential component of the IVS since the year 1983. Meanwhile, the 13.2-m Twin radio Telescope Wettzell North (TTW1, Wn) also produces S/X-data as a regular station with about half of the load of RTW. Starting observing with the 13.2-m Twin radio Telescope Wettzell South (TTW2, Ws), which is the first VGOS antenna at Wettzell, the observatory is prepared for future requirements in the IVS.

In addition to the VLBI, an ILRS laser ranging system, several IGS GPS permanent stations, a large laser gyroscope G (ringlaser), and the corresponding local techniques, e.g., time and frequency, meteorology and super conducting gravity meters, are also operated. Meanwhile, Wettzell also operates a DORIS beacon and is now a complete fundamental station with all space geodetic techniques. A new project focuses on atmosphere monitoring and a new timing distribution, using compensated fiber-optic transfers, is under development together with external contractors. The developments also need to meet the requirements for future operation strategies, so that projects to increase automation and remote control are ongoing.

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

2 Staff

The staff of the GOW consists of 34 members in total (plus ten student operators) on permanent and 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.

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

RTW/TWIN Wettzell Network Station

IVS 2015+2016 Biennial Report

Table 1 Staff members of RTW.

Name	Affiliation	Function	Mainly working for
Torben Schüler	BKG	head of the GOW	GOW
Alexander Neidhardt	FESG	head of the microwave group, VLBI chief	RTW, TTW
Erhard Bauernfeind	FESG	mechanical engineer	RTW
Ewald Bielmeier	FESG	technician	RTW, TTW
Martin Brandl	FESG	mechatronic engineer (since Dec. 2016)	RTW, TTW
Gerhard Kronschnabl	BKG	electronic engineer (chief engineer TTW)	TTW, RTW
Christian Plötz	BKG	electronic engineer (chief engineer RTW)	RTW, TTW, O'Higgins
Raimund Schatz	FESG	software engineer	RTW
Walter Schwarz	BKG	electronic engineer	RTW, WVR)
Reinhard Zeitlhöfler	FESG	electronic engineer (until June 2016)	RTW
Armin Böer	BKG	electronic engineer	Infrastruct., RTW
Jan Kodet	FESG	appl. phys. engineer	DFG FOR1503 GNSS, time ref.
Apurva Phogat	BKG	MSc	correlation
Katharina Kirschbauer	FESG	student	Development monitoring
Gordon Klingl	FESG/ BKG	student (till June 2015)	Operator VLBI
Nadine Schörghuber	FESG/ BKG	student (since Oct. 2016)	Operator VLBI
Julia Weber	FESG/ BKG	student (till Sept. 2016)	Operator VLBI

3 20-m Radio Telescope Wettzell (RTW, Wz)

The 20-m RTW has been supporting the geodetic VLBI activities of the IVS and partly other partners, such as the EVN, for over 33 years now. All observed sessions in the reporting period are plotted in Figure 1. The telescope is still in a very good and stable state. The main priority was laid to the participation in all daily one-hour INTENSIVE-sessions (INT/K) in order to determine UT1-UTC. Some INT sessions were additionally planned and observed to characterize the baseline to the new VGOS site Ishioka, Japan. Using the Field System extension for remote control, weekend INTENSIVEs were partly done from remote. The antenna supported all main IVS 24h sessions and is still one of the main components of the IVS.

The complete 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.

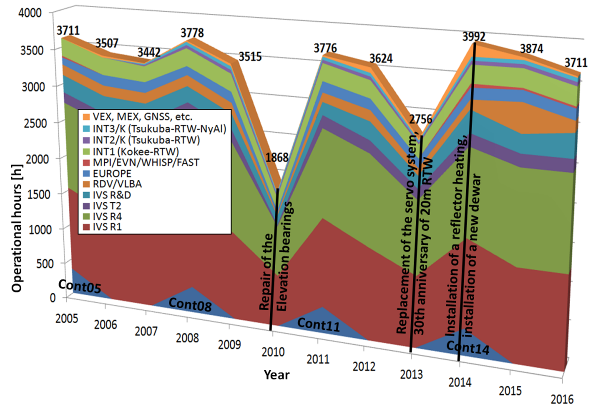

Fig. 1 Operational hours of the 20-m RTW since 2005.

In addition to the standard sessions, RTW was active in other special observations such as the tracking of the Mars Express (MEX) spacecraft and the RadioAstron satellite for the EVN. Progress was also made in tracking of Glonass and GPS satellites using an additional L-band receiver in the S-band path. Observations can be scheduled, observed, correlated, and analyzed directly here on location, using the telescope triple of the Wettzell observatory. On June 19, 2015 at 11:46:56 UT there was a rare event, where the asteroid Erida occulted a quasar, which was visble from Wettzell. The idea to use such occultations to compare and align the VLBI and Gaia based reference frames using asteroid occultations came from Finnish colleagues and was supported by the Wettzell team using the 20-m antenna. Even if the correlation of the data came to no result, it was an interesting research idea.

Another project, initiated by Chinese colleagues, was to observe the Rosetta spacecraft on September 20/21, 2015. Rosetta passed bright calibrator and other ICRF sources. The idea was to adjust the troposphere and ionosphere components of the delay model to get higher accuracy of the tracking. The schedule was prepared by colleagues at JIVE and the Wettzell 20-m antenna observed it together with over ten other telescopes worldwide. The 20-m antenna together with the northern twin telescope Wn also supported Wettzell high-speed VLBI session (WHISP) sessions in February 2015, August 2016, and November 2016, planned by colleagues of the Bonn university. WHISP sessions schedule a large number of observations to validate turbulence models in a local application. During WHISP, common clock tests were made where all telescopes were connected to maser EFOS-39. These tests were quite interesting to find issues in technical solutions for stable frequency transfers over hundreds of meters.

Monthly maintenance days were scheduled to give enough time to maintain the systems. Additionally, more extended service periods were necessary to exchange the lightening protection in July 2016, to repair leakage problems in the gears by the company AKIM in July 2015 and December 2016, and to clean the cover of the antenna tower, the backstructure, and the cabins by an external contractor starting in October 2016.

The dewar system, upgraded by the colleagues of the IVS Centro de Desarrollos Tecnológicos de Yebes, Spain, shows quite stable performance and reduced the maintenance tremendously. A second replacement dewar also was ordered at Yebes and was build and delivered in the reporting period. In April 2016, the latest maser maintenance and upgrade was made, so that all masers at the Wettzell observatory support now 5, 10, and 100 MHz. The NASA Field System is updated to the latest available version 9.11.18 and several DBBCs have been upgraded with new power supplies, up-to-date signal input modules, and software.

Fig. 2 Rescue exercise at the 20-m antenna.

In the early months of 2016, the TUM funded a conformity test of the 20-m antenna to follow the EC Machinery Directive. The conformity declaration was finished in April 2016, so that now all VLBI antennas ensure legal certainty in the sense of European right. Additional safety regulations also required to exercise rescue scenarios together with local fire departments and mountain rescue departments to rescue people from the 20-m antenna using a turnable ladder (see Figure 2).

4 13.2-m Twin Telescope Wettzell North (TTW1, Wn)

The Twin Telescope Wettzell project is Wettzell's realization of a complete VGOS conformity. Nevertheless, the northern antenna Wn is equipped with an S/X/Ka receiving system, which was a suitable solution in the days as no real VGOS feed was available. The northern antenna was the first available antenna supporting fast slewing modes in the IVS. It uses a DBBC2 or an ADS3000+ and a Mark 6B+ in the data acquisition rack. Meanwhile, the antenna is an accepted, full component of the IVS. The main focus is laid on classic S/X-observations. It observes half of the R1 and R4 sessions per year and all INT3 sessions. It was also used to support GNSS and RadioAstron observations. All observed sessions are plotted in Figure 3. Missing partners for Ka sessions reduce the possibilities to demonstrate geodetic Ka session.

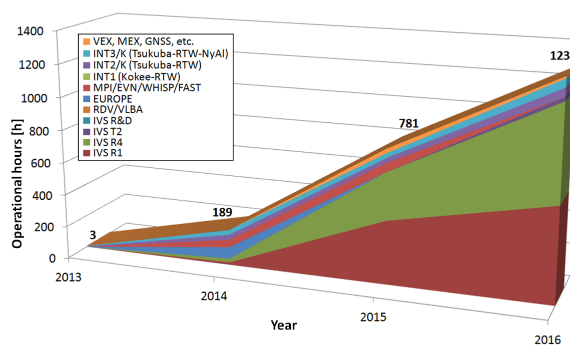

Fig. 3 Operational hours of the 13.2-m TTW1 since 2013.

A special session was scheduled and observed during the IVS General Meeting on March 10, 2016 where Wn was controlled from the lecture room at Hartebeesthoek, South Africa during a lesson to teach and train tasks necessary for a successful observation. To test fast-slewing modes and bring the fast antennas in the IVS network into common observations, Wettzell staff followed the idea to schedule and observe FAST sessions. The idea behind that was to use the fast slewing modes with classic S/X recording systems to get feedback about improvements coming from an increased number of sources per session. Another idea was to find issues and solutions for networks of new antennas with different equipment. Because of missing partners, unavailable systems, and partly insuperable difficulties, Wettzell stopped focusing on FAST sessions and focused on VGOS developments.

The Wn antenna runs quite stable and reliable. Only mechanical problems with the receiver mount in the cabin or electrical issues on the bus system for the encoders at low environmental temperatures had to be solved. A filter in the S-band was installed to improve the IF band quality, so that the DBBC can use its auto-gain control also for the S-band.

5 13.2-m Twin Telescope Wettzell South (TTW2, Ws)

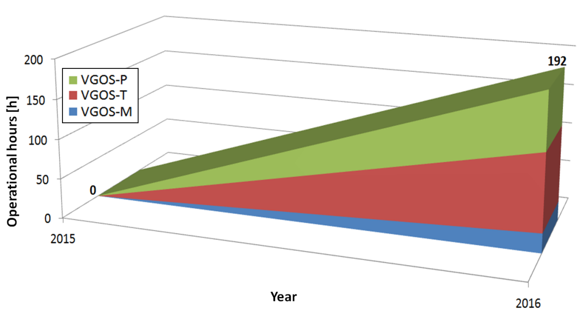

Fig. 4 Operational hours of the 13.2-m TTW2 since 2016.

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 DBBC2, and a Mark 6 to record four bands in both polarizations. In October and November 2015, the feed cone and the feed could be installed after a long-lasting construction phase caused by external contractors. Using the in-house constructed receiver, first light was given in February 2016. Continuous updates, implementations, and constructions finally made it possible to run the first VGOS fringe test and session on April 28, 2016. Finding fringes was the first step towards a transatlantic VGOS baseline. In June 2016, successful fringes between GGAO12m Gs, Westford Wf, and Ws for all four VGOS bands and to Yebes Ys with a reduced band set were detected. The following months showed further issues with the stability of the recording system and the DBBCs. Upgrades of the power supplies in the DBBC brought a general stability. Nevertheless, more investigations are required to find all possible issues and bring the system into routine observations. Ws participated in all possible VGOS sessions (see Figure 4), even if only a few were finally correlated. Currently, all VGOS sessions are correlated at MIT Haystack Observatory, USA. Because of the huge data amount of about 16 or 32 Terabyte per day, the modules must be shipped again using parcel services. This delays any feedback from the correlator after each session.

The staff at Wettzell does continuous upgrades, implementations, and tests of the recording system. One major maintenance was necessary to replace a truss in the backstructure in July 2016, as it was busted due to frost damages in the past winter.

Fig. 5 The Wettzell triple of VLBI antennas: the Twin Telescope in the front and the 20-m telescope in the back (photo: Liu).

6 Other VLBI Relevant Activities

Besides antenna relevant tasks, staff from Wettzell participated in a special correlator training in Bonn. The need for such a special training came up, because BKG received funding for one project position to support correlation of local baselines between the three telescopes of the observatory. In combination with this project, VieVS was installed on different Matlab licenses to schedule own sessions. A DiFX software correlator was prepared and can be successfully used now. The same machine can also be used for analysis (e.g., nuSolve) so that the complete turnaround from planning to analyzing of sessions can now be performed.

Another project is the establishment of a 10 Gbit/sec transfer network, so that the baseband converter of all antennas can send their data to a selectable set of recording systems, consisting of Mark 6 and FlexBuff machines. It meets the requirements of the new VGOS sessions, but can also be used for classic S/X sessions. Each DBBC is connected to a FILA10G board, which is connected to a 10 Gbit/sec switch via fiber. The configuration of the FILA10G decides about the target machine where the data stream is recorded. The network should replace current setups with EVN PCs and connects the data acquisition in a safe way with the e-VLBI possibilities.

Fig. 6 The Wettzell observatory, in the rural area of the Bavarian forest, often offers possibilities to meet special visitors in front of the antennas.

To support co-location projects and the analysis of the connection quality of the systems to the time distribution, a common target was built, which carries a laser reflector and a radio source sending phase calibration pulses. Pointing the antennas to that common point and recording the received, external phase calibration tones, and enables conclusions about the timing. The plan is to observe the common target regularly to produce continuous timelines over longer time intervals.

The permanent survey of the reference point of the twin antennas continued using total stations on different pillars and 20 to 30 reflectors in the backstructure of the antenna. The goal is a continuous monitoring of the reference point over years.

In July and September 2015, tests with the DORIS system were used to find a suitable co-location position for a DORIS beacon, which does not interfere with the IF-bands of the radio antennas. After extended tests, a position was found behind the ring laser hill. The DORIS system was also just switched on for real satellite passages, so that sending times are limited during VLBI observations. DORIS is the fourth technique for a fundamental station and is an essential part for a GGOS core site.

7 Future Plans

Dedicated plans for the next reporting period are:

- Establishing automated observations and a suitable system monitoring;
- Finalizing changes to the DBBC at the 20-m RTW;
- Implementing VGOS compatibility for TTW1;
- Continuing improvements with the VGOS broadband system at TTW2 to participate in all VGOS sessions;
- Installing a DBBC3 and furthering FlexBuff systems; and
- Planning, observing, and analyzing own sessions.