VLBI Correlator Wettzell – A New IVS Component

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Abstract The Geodetic Observatory Wettzell (GOW) in Germany was enhanced with a VLBI correlation facility. An initial DiFX-based correlator was operated between 2016 and 2020 for the evaluation of local VLBI baseline measurements between the three VLBI radio telescopes of the GOW (Wz, Wn, and Ws). In December 2021, a high performance cluster (HPC) based DiFX VLBI correlator replaced obsolete small hardware, which also enabled the necessary performance for handling VGOS observations. Additional correlation duties came along with serving the local VLBI observation program in Wettzell and a small VLBI network with BKG radio telescopes located in Argentina (AGGO) and O'Higgins (Antarctica). Since late 2021, the VLBI correlator at Wettzell has been acknowledged as an official IVS correlation component in order to contribute to the IVS correlation resources. A special focus is on serving a timely ΔUT1 estimation with dedicated legacy S/X Intensive sessions between Wettzell and AGGO and with a newly established IVS VGOS Intensive observation program between Wettzell and MacDonald Observatory (MGO). Automation is an important aspect from provisioning the IT infrastructure towards an automatized correlation workflow, in particular the Intensive sessions. The new VLBI correlation facility has a close integration into the Geodetic Observatory Wettzell and its infrastructure as a geodetic fundamental station, as well as the other IVS components at Wettzell, namely the Operation Center (OC DACH) and the three VLBI network stations. These components are a valuable addition to the worldwide geodetic VLBI infrastructure.

Keywords VLBI correlator, DiFX, VGOS Intensive

1 Introduction

The Geodetic Observatory Wettzell contributes since 1983 with the 20-m radio telescope as network station to the international VLBI community. Over the years, several other components were added. The German Antarctic Receiving Station (GARS) O'Higgins in Antarctica was established in 1991. Since 2002, the 6-m radio telescope TIGO (Transportable Integrated Geodetic Observatory) in Chile was in operation before moving to Argentina in 2016. It was since named Argentinian German Geodetic Observatory (AGGO). In 2013, the VGOS twin radio telescopes, Wettzell-South and Wettzell-North, extended the geodetic infrastructure at the GOW. All of these network stations take part in a broad range of VLBI observation programs (e.g., R1, R4, T2, VGOS, and various Intensive programs). The IVS VLBI Operation Center DACH (Deutschland: BKG, Austria: TU Wien, Confoederatio Helvetica: ETH Zürich) began operations in November 2019. In September 2020, the IVS Seamless Auxiliary Data Archive (SADA) was initiated at Wettzell. The latest addition is the establishment of the IVS VLBI correlator Wettzell (WETZ) in September 2021.

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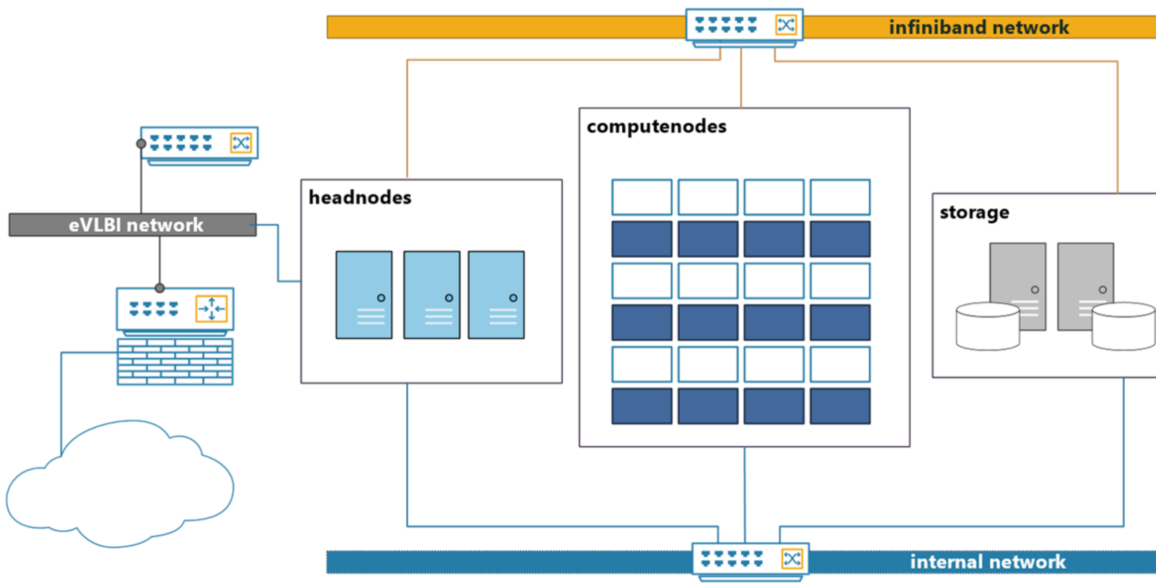

Fig. 1 Wettzell VLBI correlator: Hardware block diagram.

2 VLBI Correlator Wettzell – Hardware and Software Overview

The hardware topology was specified as a High-Performance Cluster (HPC) configuration. There are three head nodes (one of them acts for data transfers) and 24 compute nodes available. The data is transported with an Infiniband bus and a corresponding switch interconnects all related hardware units. The HPC-cluster storage capacity is currently at 834 TB. A dual-UPS protects against power failures. The nominal usable internet data rate is 4 Gbps for up- and download of VLBI raw data.

The software installation consists of Linux CentOS 7 as operating system for the HPC cluster. Ansible is the software tool for provisioning, configuration management, and application deployment. DiFX is used as a software correlator application [Deller et al., 2011] and the Haystack Observatory Postprocessing System (HOPS) is installed for the subsequent fringe-fitting process. In order to manage different users and configurations for all correlation duties, a SLURM (Simple Linux Utility for Resource Management) workload manager for batch processing was introduced at the HPC cluster. Two basic configuration sets are currently in use. One for VGOS (DiFX version 2.5.4, hops 3.23) and another for legacy S/X (DiFX 2.6.3, hops 3.23).

3 Current IVS Correlation Program

A milestone towards an official IVS VLBI correlator component was the start of VLBI short baseline observations at the GOW in 2016 [Phogat et al., 2019]. Since 2018, a domestic Intensive VLBI session program with AGGO and Wettzell was established [Plötz et al., 2019]. Furthermore, in this context, a few dedicated VLBI sessions between Wettzell, AGGO, and O'Higgins were conducted. In 2019, the small initial correlator hardware needed to be replaced and a new correlator hardware was installed at the end of December 2020.

Currently, a VGOS Intensive observation program is assigned to the Wettzell correlator. The IVS VGOS Intensive series S22 between McDonald (Mg), located in Texas/US, and Wettzell (Ws) in Wettzell/Germany is observed on Tuesdays at 19:45 UT and the duration is one hour. After the S22 had finished a short calibration session (S2A), which takes normally ten minutes, is appended. The purpose is to collect further insight in correlation, source characterization, and slewing characteristics of the involved radio telescopes.

The VGOS Intensive series started on December 7, 2021 with the first session. As of the time of writing, there were 12 sessions correlated and their analysis showed that the S22 VGOS Intensive series performed well. For example, let's consider the VGOS In-

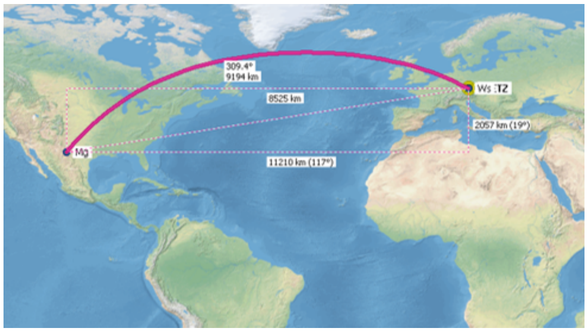

Fig. 2 VGOS Intensive baseline: McDonald (Mg) to Wettzell (Ws).

tensive session S22053. The formal error value of 4 µs for ΔUT1 is within the expectation. In one hour, 91 scans were observed and no losses occurred during correlation. The analysis showed few outliers (3.2 %). The standard deviation of the group delays is at a level of 12 mm and comparable to other VGOS Intensive sessions.

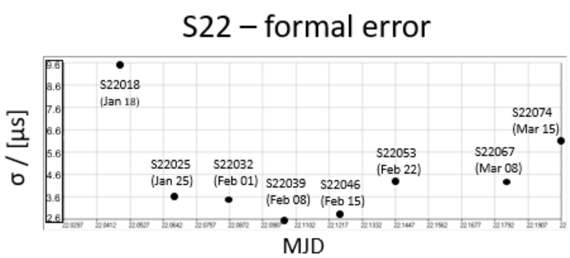

Fig. 3 Formal errors of the first S22 VGOS Intensive sessions.

The current in-house observation program with the legacy S/X Intensive program was conducted with the radio telescopes of Wettzell and AGGO. Typical session durations were two hours to correlate. At Wettzell, the short baseline VLBI observations between the 20-m radio telescope Wettzell and both twin radio telescopes were also VLBI sessions handled at the VLBI correlator Wettzell.

4 Conclusions

The VLBI correlator Wettzell started regular operations in December 2021 as an official IVS component. Currently, the S22 and S2a IVS sessions are assigned to the Wettzell VLBI correlator. A focus is on the development of an automatic VGOS Intensive correlation workflow as the next step. The configuration and setup management of the HPC-based VLBI correlator is based on the common and well-established software tool-chains of Ansible and SLURM. The general design of the VLBI correlator hardware enables scalability as it will be needed in the future. An advantage of the close integration into the infrastructure of the Geodetic Observatory Wettzell is that the recorded raw data of the Wettzell network station are instantaneously obtainable and do not use internet network resources, when the session is correlated at Wettzell. This gives an advantage towards a closer real-time workflow. Quality monitoring procedures were established and the supervising of them is an ongoing task that will lead to improving the VLBI processing chain. This means, for example, that continuous station monitoring checks many system parameters and reports if any value is out of an expected range. The VLBI correlation resources are available for more sessions to correlate. It is intended to upgrade the internet bandwidth up to 10 Gbps and the correlator storage capacity might be enhanced up to 2 PT.

References

[Deller et al., 2011] A. T. Deller, W. F. Brisken, C. J. Phillips, J. Morgan,W. Alef, R. Cappallo, E. Middelberg, J. D. Romney, H. Rottmann, S. J. Tingay & R. Wayth. "DiFX-2: A More Flexible, Efficient, Robust, and Powerful Software Correlator." PASP, 123, 275–287, 2011.

[Plötz et al., 2019] C. Plötz, T. Schüler, H. Hase, L. La Porta, M. Schartner, J. Böhm, S. Bernhart, C. Brunini, F. Salguero, J. Vera, A. Müskens, G. Kronschnabl, W. Schwarz, A. Phogat, A. Neidhardt, M. Brandl, "INT9 – ΔUT1 Determination Between the Geodetic Observatories AGGO and Wettzell." In: R. Haas, S. Garcia-Espada, and J. A. López Fernández (eds.), Proceedings of the 24th European VLBI Group for Geodesy and Astrometry Working Meeting, pp. 124–128, 2019. doi: 10.7419/162.08.2019.

[Phogat et al., 2019] A. Phogat, C. Plötz, T. Schüler, H. Hase, G. Kronschnabl, A. Neidhardt, J. Kodet, U. Schreiber, W. Alef, H. Rottmann, L. La Porta, S. Bernhart, "Implementation and First Results of the Local Wettzell VLBI Correlator GOWL." In: K. L. Armstrong, K. D. Baver, and D. Behrend (eds.), IVS 2018 General Meeting Proceedings "Global Geodesy and the Role of VGOS – Fundamental to Sustainable Development", pp. 102–106, NASA/CP-2019-219039, 2019.