

BKG CVC - The Central VLBI Observation Coordination Office of the Federal Agency for Cartography and Geodesy at the Geodetic Observatory Wettzell

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Abstract The Federal Agency for Cartography and Geodesy (BKG) is operating three radiotelescopes at Wettzell, one telescope at the Argentinean-German-Geodetic Observatory (AGGO) together with Argentinean partners from the research organization CONICET, and one telescope at O'Higgins, Antarctica (BKG holds a share of 20% for geodetic VLBI, with primary operation by the German DLR for satellite communications). Apart from this geodetic base infrastructure, BKG is co-financing the VLBI correlator at the Max-Planck-Institute for Radioastronomy at Bonn, including a separate contract for geodetic correlation services. A local VLBI correlator was installed at the Geodetic Observatory Wettzell in September 2017. Finally, VLBI data analysis and data combination are carried out both at Frankfurt and Leipzig. One important component missing at BKG in the past was a Central VLBI Observation Coordination Facility (CVC). It was implemented at the Geodetic Observatory Wettzell during 2017 in order to better organize domestic VLBI sessions. A total of 28 domestic sessions were coordinated within that year, also featuring dedicated sessions for O'Higgins with up to six telescopes. This contribution portrays the individual VLBI components operated by BKG with a special focus on the VLBI observing and coordination tool. The current realization state is depicted.

Keywords VLBI session coordination, central VLBI coordination, IVS Master Schedule, domestic VLBI sessions, local baselines, integration of VLBI sessions

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1 Background and Motivation

For many years, the Geodetic Observatory Wettzell has been almost exclusively observing sessions for the International VLBI Service for Geodesy and Astrometry (IVS). A few extra sessions per year have been attributed to the European VLBI Network (EVN) requiring a minimum extra coordination effort. This situation has changed with the implementation of the local VLBI correlator *GOWL* at Wettzell [Phogat et al., 2018]. The primary purposes of the local correlator are

1. *Local ties*: The determination of connection vectors between the local radio-telescopes from VLBI data in addition to terrestrial measurements.
2. *Quality assurance*: The regular execution of experiments between all BKG-operated telescopes for quality assurance of the VLBI data.

The increase of in-house sessions triggered a need for better coordination of all VLBI activities. The primary aim is to blend the international sessions (mainly IVS) seamlessly with the domestic ones in order to avoid scheduling conflicts. Further purposes are related to a proper prioritization of both sessions and correlation activities as well as performance monitoring and evaluation.

2 Scope of Effort and Capabilities of Coordination Tool

The following activities are carried out within the scope of the Central VLBI Observation Coordination Office (CVC):

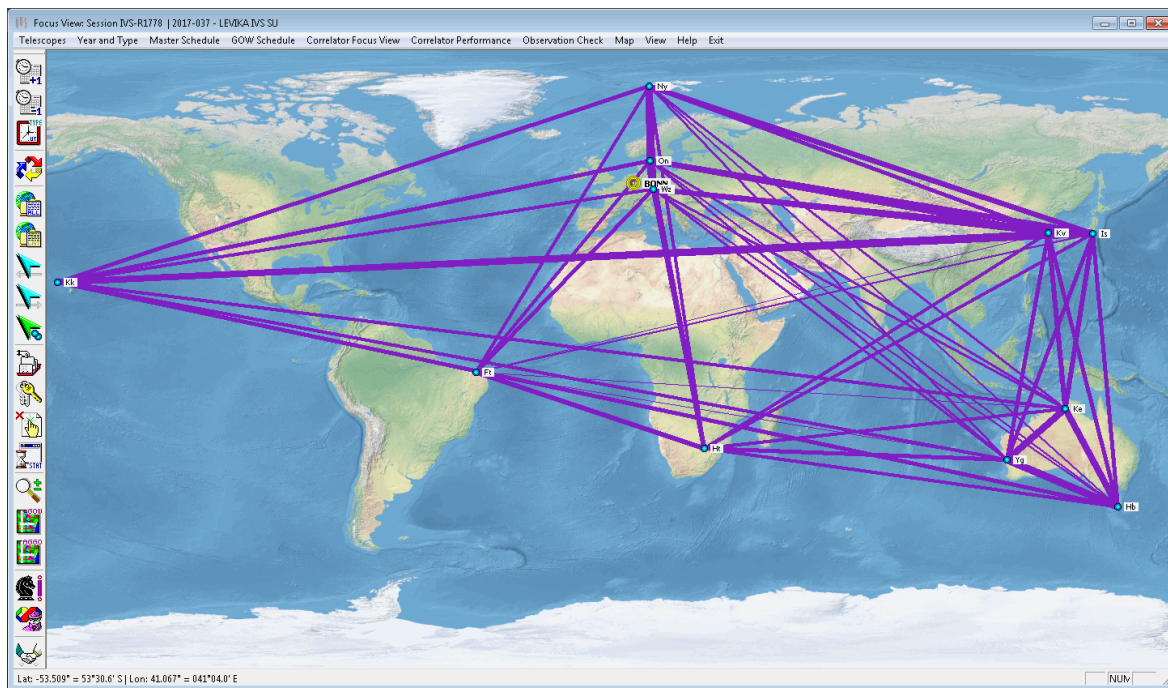


Fig. 1 Screenshot of the VLBI coordination tool. The map overlay is a selected IVS Rapid R1 network. The width of the lines indicates the number of scans commonly observed on the respective baseline.

2.1 Coordination of VLBI Sessions

Firstly, the domestic local sessions for relative radio-telescope positioning (*VLBI ties*) require coordination with the internationally scheduled sessions. Currently, three types of (master) schedules issued by the IVS are taken into consideration:

- *IVS Master Schedule*: This table contains the various sessions coordinated by the IVS with a standard duration of 24 hours, e.g. Rapids, T2 sessions, Research & Development sessions, and others.
- *IVS Intensives*: The short hourly sessions aiming at rapid determination of UT1 coordinated by the IVS.
- *VGOS Pilot Test*: The experimental VGOS test schedule including the evolving network of VGOS telescopes.

All tables are updated daily via FTP by the coordination software and combined with the domestic schedule. The domestic session is plan currently comprised of:

- *Local sessions*: Local Wettzell radio-telescope sessions.

- *Test and quality assurance sessions*: These sessions are not limited to the telescopes at Wettzell but also include AGGO, Argentina and O'Higgins, Antarctica. The purposes are quality assurance and initial testing, i.e. for AGGO. Partner telescopes can be involved in these activities upon need and availability.
- *Special densification programs*: Sessions foreseen to improve performance of remote telescopes such as O'Higgins.
- *Externally handled sessions*: All sessions not directly handled at GO Wettzell, but under participation of BKG-operated telescopes. Although not many of these sessions are foreseen per year, coordination at one central place is essential in order to avoid confusion. Such sessions include EVN and RadioAstron support as well as other special activities, e.g. test sessions for European UT1 estimation, etc.

The coordination tool can blend the domestic sessions seamlessly into the existing IVS schedules. A priority can be assigned to each of these sessions so that a well mapped-out allocation of resources for the execution of the sessions can be assured.



Geodetic Observatory Wettzell

2017 Domestic Sessions

	Date	Day	DoY	Start	Duration	Session Name	DBC	Network	Correlator	Schedule	Issued by
	07.06.2017	Wed	158	18:00	24 h	GOW1715818 (W158AS) Group ID: 251017	X9	Wz Wn Oh <i>Session observed; data not yet available at correlator.</i>	GOWL	GOWL	PLOE
	13.06.2017	Tue	164	18:00	24 h	GOW1716418 (W164AS) Group ID: 251017	X9	Wz Wn Oh Ht Ke Yg <i>Session observed; data not yet available at correlator.</i>	GOWL	GOWL	PLOE
	21.06.2017	Wed	172	18:00	24 h	GOW1717218 (W172AS) Group ID: 251017	X9	Wz Wn Oh Ht Ke Yg <i>Session observed; data not yet available at correlator.</i>	GOWL	GOWL	PLOE
	05.07.2017	Wed	186	20:00	22 h	GOW1718620 (W186AU) Group ID: 289417	X9	Wz Wn <i>Data analyzed - session is closed.</i>	GOWL	BONN	NEID
	10.07.2017	Mon	191	09:00	7 h	GOW1719109 (WA191J) Group ID: 81917	XA	Wz Wn <i>Data analyzed - session is closed.</i>	GOWL	GOWL	APUR
	17.07.2017	Mon	198	09:00	6 h	GOW1719809 (WA198J) Group ID: 81917	XA	Wz Wn <i>Data analyzed - session is closed.</i>	GOWL	GOWL	APUR
	24.07.2017	Mon	205	10:00	6 h	GOW1720510 (WA205K) Group ID: 221917	X9	Wz Wn <i>Data analyzed - session is closed.</i>	GOWL	GOWL	APUR

Fig. 2 Web-based output of domestic sessions. Brief status information is shown. Further details can be browsed on user request, see the following two figures.

Geodetic Observatory Wettzell

WB1160 GOW1811614

Date of session: Thu, 26.04.2018 (2018-116)

Start time: 14:00 UTC

Duration: 1 h

Session name: GOW1811614

Session code: WB1160

Group identifier: 1960

Data base code: X9

Session responsible: [APUR](#) (Phogat, Apurva)

Schedule issued by: GOWL

Correlation facility: VERA

Number of sites: 3

Telescopes: 7224 Wz WETTZE1L
7287 Wz WETT213M
7280 Sa INES23AR

Session notes: Experimental Session
VLBI intensive sessions on a European baseline for the estimation of dUT1

Session approved.

The session was approved and is ready for execution; the telescope schedule must be provided to the VLBI operations team.

Fig. 3 Example of session details (web page view) for an open session that has not been planned in detail (schedule is still to be issued) nor executed yet.

Figure 2 shows a fragment of the intranet web output of the coordination tool showing some 2017 domestic sessions. The plan consists of some local sessions between the two telescopes Wettzell North (Wn, TWIN 1) and Wettzell 20 m (Wz, RTW) and three international sessions coordinated to improve the position accuracy of the O'Higgins telescope at Antarctica including partner telescopes from South Africa (Ht) and Australia (Ke, Yg). Figure 3 portrays the details the user can browse for each domestic session, featuring its status on the right. Figure 4 illustrates a fully completed session with all planning, observing, and analysis steps carried out.

Note that all functions and details are, of course, directly accessible via the graphical user interface of the coordination tool developed (see Figure 5, for instance). The web-based output is generated to provide

Geodetic Observatory Wettzell

WB038J GOW1803809

Date of session: Wed, 07.02.2018 (2018-038)

Start time: 09:00 UTC

Duration: 8 h

Session name: GOW1803809

Session code: WB038J

Group identifier: 2650

Data base code: X9

Session responsible: [APUR](#) (Phogat, Apurva)

Schedule issued by: GOWL

Correlation facility: GOWL

Number of sites: 2

Telescopes: 7224 Wz WETTZE1L
7287 Wz WETT213M

Session notes: GO Wettzell Local Session

These sessions are identified regularly and on special request for one or several of the following purposes:

- To derive the relative positions of the telescopes at GO Wettzell (telescope array alignment).
- To provide feedback in order to trace back potential technical problems with a local telescope.
- To confirm the quality of the radio telescope data at local level.

Session approved.

Scheduling done.

Schedule issued to VLBI operations staff.

Observations completed; data delivered to correlator.

Correlation carried out.

Correlation results provided to analyst.

The session was observed, correlated and analyzed. It is closed.

Fig. 4 Example of session details displayed on the web page upon user request. This example illustrates the complete planning, measurement, and analysis chain for a selected local session at Wettzell.

List of Sessions

DoY	YY-MM-DD	HH:MM	Code	Name	Correlator	Network
101	18-04-11	18:00	XA	AUS-AST041	SWAO	Ht Ke Wn Yg
101	18-04-11	18:00	XB	IVS-R00-3	SWAO	PT Ht Hk Wn Wz Yg
101	18-04-11	18:30	XU	IN18-1801	WASH	Hk Wz
101	18-04-11	18:30	XE	IVS-R4037	WASH	BQ FT Ht Is Ke Kk Ny Sa Wz Yg
102	18-04-12	18:30	XU	IN18-1802	WASH	Hk Wz
102	18-04-12	18:30	XE	IN18-1803	WASH	Hk Wz
104	18-04-14	07:30	XX	IN28-1804	GSI	Is Wz
105	18-04-15	07:30	XX	IN28-1805	GSI	Is Wz
105	18-04-15	07:00	KK	IN28-1806	BONN	Is Ny Sh Wz
105	18-04-16	17:00	XA	IVS-R1238	WASH	PT Is Ke Kk Wn Ny Sh Wz Yg
106	18-04-16	18:30	XU	IN18-1806	WASH	Hk Wz
107	18-04-17	18:30	XU	IN18-1807	WASH	Hk Wz
108	18-04-18	18:00	XA	AUS-AST042	VIEN	Ht Hk Ke Wn Wz Yg
109	18-04-19	18:00	VE	AUS-70189	WASH	Is Wz
109	18-04-19	18:30	XE	IVS-R4038	WASH	BQ FT Is Ke Kk Ny Sa Wz Yg Vs Zc
109	18-04-19	18:30	XU	IN18-1809	WASH	Hk Wz
110	18-04-20	18:45	XU	IN18-1110	WASH	Hk Wz
111	18-04-22	07:30	KK	IN28-1811	GSI	Is Wz
111	18-04-22	07:30	KK	IN28-1812	GSI	Is Wz
113	18-04-23	07:00	XX	IN28-1813	BONN	Is Ny Wz
113	18-04-23	07:00	XA	IVS-R0320	WASH	PT Ht Is Ke Kk Wn Ny On Wz Yg
113	18-04-23	18:30	XU	IN18-1813	WASH	Hk Wz
114	18-04-24	17:30	XB	IVS-72224	BONN	Is Wz
114	18-04-24	18:30	XU	IN18-1814	WASH	Hk Wz
115	18-04-25	18:30	XU	IN18-1815	WASH	Hk Wz
116	18-04-26	14:00	VS	ORAN1101A	UTEM	Wn Wn Ts

Details
Search:
Open File
Pending Sessions
Select and Proceed
 abandon

Fig. 5 List of sessions as displayed in the coordination tool. This screenshot shows the blended view containing all international IVS, as well as domestic, sessions at a glance.

essential pieces of information to operators as well as correlation and analysis staff. It is automatically updated daily and each time a change to the domestic schedule is made.

2.2 High-Level Coordination of Correlation Activities

Similarly to the coordination of observations, sessions can be assigned for VLBI correlation to either the local correlator *GOWL* at Wettzell or the Bonn correlator under contract to BKG. The priority scheme includes four levels.

2.3 Workload and Performance Monitoring

The following functionality is available to monitor the workload of both the radio-telescopes as well as the correlation facilities:

- The load on the correlation facilities can be figured out easily with the coordination tool. Three main workload figures are available:
 1. *Simplified Correlator Load*: This figure is based on the available IVS schedules. Separate figures for the Master and the Intensives Schedule and a combined figure are provided. The session duration is considered.
 2. *Correlation Station Load*: This workload figure takes the size of the network into consideration, because a larger network contains substantially more baselines to be correlated (the number of baselines is a quadratic function of the number of stations in the network).
 3. *Correlator Baseline Load*: This figure requires the analysis of all NGS card files available for the period under investigation. The number of scans on the various baselines successfully correlated is analyzed in order to provide feedback based on real output rather than planning information.
- Performance monitoring of the telescope includes
 1. annual analyses of the number of observations (group delays or scans) successfully collected,

2. corresponding individual baseline statistics and
3. the analysis of group delay standard deviations (precision figures) as obtained at the correlation stage.

2.4 Communication

Communication functions with the planning, operations, correlation, and analysis staff, as well as extra functions for communication with the correlation facilities are implemented into the coordination software.

Bookkeeping is available in the messaging system so that coordination activities are not limited to single individuals, but can be taken over by different persons according to their availability.

2.5 Observation and Correlation Resource Planning and Commitments

The coordination software is also an aid for mutual agreements between BKG and the IVS Coordinating Center. The corresponding support functions provide observation information about the actual and the previous years at a glance in order to easily derive the observation commitment for the following year.

The domestic sessions already planned are automatically communicated, as well as the holidays (at Wettzell, Bavaria, Germany) and the maintenance days, if already fixed.

3 Injection of Domestic Sessions

New domestic observations can be easily added to the list of sessions taking the current plans into consideration. The following steps summarize this procedure:

1. The focus telescopes must be selected. A selection list is supplied for typical sessions. The list is associated to a default set of telescopes. For certain networks, an individual selection can be performed directly afterwards, too. *Example*: The network Wettzell - AGGO - O'Higgins may include several telescopes at Wettzell or just a single one.

In order to remain flexible, the individual selection is supported in that case.

2. The free observation windows for the selected telescopes will be displayed in a dialog as shown in Figure 6.

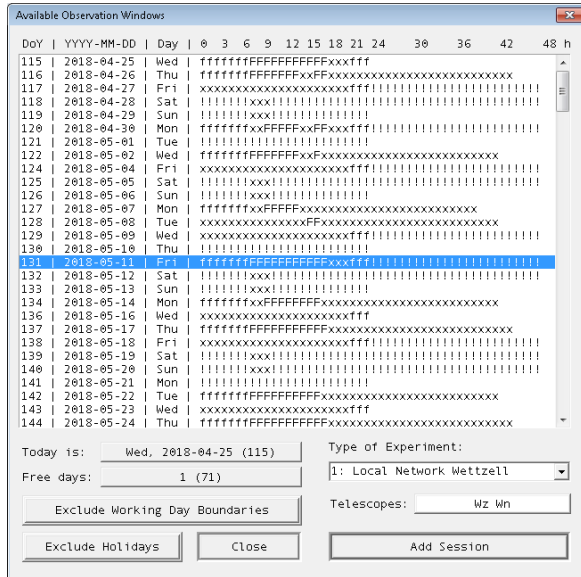


Fig. 6 List of free observation time windows for the selected telescopes Wn (Wetzell North, TWIN 1) and Wz (Wetzell, RTW 20 m) to add a new domestic session. Symbols: F = free observation time during regular working hours (at Wetzell), f = possible observation at less fortunate times, ! = holiday, x = blocked by existing session, X = maintenance day.

3. After selection of the desired day, some details of the session can be defined according to Figure 7. The exact start and end time (integer hours) can be defined, as well as the session responsibility and the scheduling and correlation institutions. Finally, session notes can be inserted to supply further details as needed for successful preparation, observation, and correlation, i.e. sampling and bit rates, sub-channel setup, operation modes like common clock and phase calibration, etc.
4. Once these details are defined, a summary dialog box will be displayed for finalization. After confirmation, the window will be added to the list of sessions to be approved.
5. The request and approval system makes sure that each session or group of sessions is reviewed by the head of operations or the head of the observatory prior to scheduling and execution.

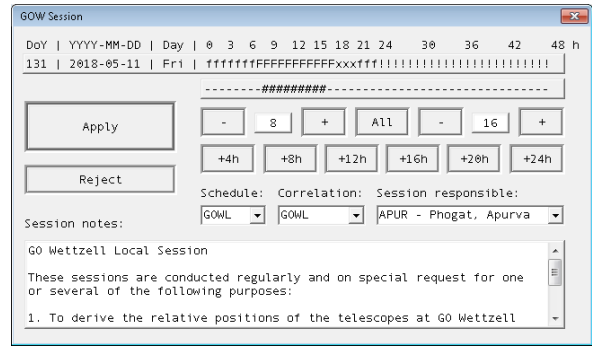


Fig. 7 Setting the details of a new domestic session at the planning stage.

The processing status can be updated any time after approval of the session. The following update states are currently implemented in the coordination tool:

- Schedule submitted to observer
- Observation session finished
- Measured data available at correlation facility
- Data correlated and ready for geodetic analysis
- Analysis completed.

References

[Phogat et al., 2018] 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 Wetzell VLBI Correlator GOWL. In: Proceedings of the IVS 2018 General Meeting, Svalbard, Norway, 3-6 June 2018, this volume.