Vienna Analysis Center Biennial Report 2019/2020

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Abstract The IVS Analysis Center VIE is jointly run by the Technische Universität Wien (TU Wien) and the Bundesamt für Eich- und Vermessungswesen (Federal Office of Metrology and Surveying, BEV). Besides the operational analysis of VLBI sessions, a focus in 2019 and 2020 was on the development of the new scheduling tool VieSched++, which is now widely used for the planning of VLBI sessions, and on the development of the raw data simulator VieRDS. Additionally, we continued the series of VieVS Days to educate interested groups in using the Vienna VLBI and Satellite Software (VieVS) and VLBI.

1 General Information

The Special Analysis Center in Vienna (VIE) is made up by members from the Technische Universität Wien (TU Wien) and the Bundesamt für Eich- und Vermessungswesen (Federal Office of Metrology and Surveying, BEV). The Department of Geodesy and Geoinformation (GEO) in the Faculty of Mathematics and Geoinformation of TU Wien is divided into seven research units. One of those entities, the research unit Higher Geodesy (HG) with about twenty members, is focusing on satellite navigation systems and VLBI for geodesy and astrometry. In September 2019, five out of the seven research units of GEO moved from Gußhaus-

1. Technische Universität Wien
2. Bundesamt für Eich- und Vermessungswesen
3. Czech Academy of Sciences
4. ETH Zürich

VIE Analysis Center

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traße 27 to the so-called "Freihaus" at TU Wien, located at the Wiedner Hauptstraße 8 (see Figure 1). HG has its offices in the yellow area on the second floor.

BEV is the institution responsible for official surveying, geo-information and weights and measures (metrology) in Austria. Currently, it belongs to the Federal Ministry on Digital and Economic Affairs. The Department of Control Survey at BEV is divided into several sections, such as the sections on reference systems as well as on geophysics and precise leveling. VLBI staff at BEV is attached to those two sections.

Personnel at TU Wien and BEV associated with the IVS Special Analysis Center in Vienna (see Figure 2) in the years 2019 and 2020 together with their main research fields and activities are summarized in Table 1. The staff members at TU Wien are partly paid by the regular budget from TU Wien, and partly they are funded by the Austrian Science Fund (FWF) within several projects listed in the acknowledgments.

2 Activities during the Past Years

2.1 Vienna VLBI and Satellite Software

The Vienna VLBI and Satellite Software (VieVS, [2]) is the umbrella for all software developments at HG. In the past two years, not only the VLBI module has been developed further (e.g., the possibility of baseline-dependent clock offset estimation), but also a new scheduling tool VieSched++ ([5]) and a VLBI raw data simulator VieRDS ([8]) have been developed. VieVS is distributed openly at https://github.com/TUW-VieVS, and a wiki is provided at https://vievswiki.geo.tuwien.ac.at. Addi-

Fig. 1 The "Freihaus" of TU Wien (second floor, yellow area) is the new home of the research unit Higher Geodesy of the Department of Geodesy and Geoinformation since September 2019.

Table 1 VIE members ordered alphabetically with their main tasks related to VLBI.

Johannes Böhm	Reference frames, Chair of HG
Sigrid Böhm	VieVS administrator, Earth orientation
Jakob Gruber	Correlation and fringe-fitting, raw data simulation
Andreas Hellerschmied	Operational VLBI processing, Web site
Frederic Jaron (since Sep. 2020)	EU-VGOS, correlation and fringe-fitting
Lisa Kern (since Oct. 2019)	Intensive sessions, Earth orientation
Hana Krásná	Reference frames, VLBI global solutions
David Mayer	Operational VLBI processing, ITRF2020 submission
Markus Mikschi	Analysis of VGOS sessions, local sessions
Axel Nothnagel (since Oct. 2019)	Consultant, Chair of IVS
Matthias Schartner (until Sep. 2020)	Development of VieSched++, scheduling VLBI sessions
Helene Wolf	Scheduling VLBI observations to satellites
Anna Zessner-Spitzenberg (from Oct. 2019 to Aug. 2020)	Terrestrial reference frames

tionally, we have set up a VieVS channel on Youtube where we provide useful tutorials on scheduling and the analysis of VLBI sessions with VieVS.

2.2 Scheduling

As part of his PhD thesis, Matthias Schartner developed a new scheduling software VieSched++ ([5]) in C++, which has been used in simulation studies ([6]) and is already operationally applied for many IVS ses-

Fig. 2 Picture of members of the Vienna Analysis Center taken in December 2019 (clockwise): Anna Zessner-Spitzenberg, Helene Wolf, Markus Mikschi, David Mayer, Lisa Kern, John Gipson (guest), Axel Nothnagel, Jakob Gruber, Matthias Schartner, Sigrid Böhm, Andreas Hellerschmied.

sions. Schedules generated with VieSched++ are optimized based on Artificial Intelligence, in particular by using evolutionary strategies ([7]). Large scale Monte-Carlo simulations with thousands of simulation runs of thousands of different scheduling approaches ensure a high-quality result.

Together with the Geodetic Observatory in Wettzell and ETH Zürich, the joint Operation Center DACH is run with fully automated tools for the generation of schedules. Based on these tools, almost all IVS sessions are automatically scheduled. After generating a schedule, the corresponding files, as well as meaningful statistics and charts, are distributed to responsible persons per mail for quality control. The schedule files are automatically uploaded to the IVS servers in the case that no human intervention is necessary and the observing program of the schedule is assigned to the DACH Operation Center. Based on this concept, the human workload was reduced to a minimum while ensuring a high-quality result.

A full list of all scheduled sessions, as well as graphics and statistics, can be found on the DACH Web page[1].

2.3 Web Site https://www.vlbi.at/

In order to reflect the cooperation between BEV and TU Wien, a joint Web site https://www.vlbi.at/ was set up to promote our activities and to distribute results and findings. The Web site not only covers our analysis results but contains information about our activities in scheduling, correlation, and fringe-fitting.

2.4 VieVS Days 2019 and 2020

In 2019 and 2020, VieVS Days were held at TU Wien. While the participation in 2019 was in person, the

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[1]   https://www.bkg.bund.de/DE/Observatorium-Wettzell/IVS-VLBI-Operations_Center/IVS-VLBI-Operations_Center.html

VieVS Days 2020 had to be organized as a virtual meeting. We daresay that this format worked reasonably well for the purpose of teaching the various modules of VieVS. However, the chats in between and the common dinner at a restaurant were missed.

2.5 Reference Frames and Earth Orientation

At TU Wien, we are routinely analyzing all VLBI sessions and submit the SINEX files of the 24h sessions to the IVS Combination Center via CDDIS. Additionally, all Intensive sessions are analyzed automatically, and the results are displayed at https://www.vlbi.at/. Together with colleagues at HartRAO, University of Tasmania, and ETH Zürich, we have started the observation and analysis of Southern Intensive sessions.

With VieVS, we analyze not only observations in the traditional S/X bands but also process K-band data (24 GHz, 1.2 cm), which we use for the estimation of reference frames and Earth orientation parameters ([3]). Furthermore, we analyze BL229 series from the astronomy VLBA campaign MOJAVE observed at Ku-band (15 GHz, 2 cm) where we focus on the estimation of geodetic parameters.

As a member of the IVS WG8, Hana Krásná studied the effect of Galactic aberration in VLBI analysis ([4]), and in 2020, much effort was put into the preparations for the submission of SINEX files for ITRF2020.

2.6 Analysis of VLBI Global Observing System Sessions

In 2019 and 2020, the number of available VGOS sessions was steadily increasing. One complication in the analysis of those sessions was the lack of accurate station coordinates of the new telescopes, making it impossible to use three or more sites to define the datum. Consequently, we determined coordinates of the new VGOS stations by fixing the coordinates of WEST-FORD and the Earth orientation parameters in an unconstrained adjustment ([9]).

2.7 EU-VGOS

The EU-VGOS collaboration aims at verifying and further developing the VGOS processing chain from scheduling to final parameter estimation [1]. Of our group at TU Wien, several persons are members of the EU-VGOS collaboration. Matthias Schartner (now at ETH Zürich) develops new methods for scheduling, as part of VieSched++, and uses these methods to schedule test sessions with European VGOS stations, also in the role of PI for some experiments. Jakob Gruber and Frédéric Jaron are responsible for correlation and fringe-fitting. Jakob Gruber focuses on the processing of VGOS sessions. Frédéric Jaron takes care of the processing of EU-VGOS sessions. In order to advance the development of the VGOS processing chain, Frédéric Jaron organizes and chairs regular meetings within the EU-VGOS collaboration. Hana Krásná and Axel Nothnagel explore aspects of the analysis of EU-VGOS sessions with VieVS. Johannes Böhm supervises the EU-VGOS activities in the Working Group and is actively involved in the analysis aspects.

3 Current Status and Future Plans

In the next years, we will focus on the scheduling and analysis of VLBI observations to Galileo satellites. While optimization tools for satellite observations will be added to VieSched++, the VLBI module of VieVS will be equipped with sophisticated estimation procedures for the determination of Galileo and other orbits. Another focus will be on the best application of source structure corrections during the fringe-fitting process. We expect to improve the group delays significantly with advanced procedures. Jakob Gruber has developed the raw data simulator VieRDS as part of his PhD thesis. This module allows plenty of new investigations on the improvement of VLBI observables or the optimization of the observation setup.

Acknowledgements

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