Vienna Special Analysis Center Annual Report 2017/2018

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Abstract Since July 2018, following the signing of a Memorandum of Understanding with the President of BEV, the Federal Agency of Metrology and Surveying in Austria, VIE is run as a joint Analysis Center by Technische Universität Wien (TU Wien) and BEV aiming at increased participation in the operational generation of geodetic products, such as the routine determination of Earth orientation parameters. The main activities by VIE in 2017 and 2018 are related to the further development of the Vienna VLBI and Satellite Software (VieVS), for example, with respect to the implementation of the vgosDB format. Furthermore, we have developed a new scheduling software VieSched++ as part of VieVS and we have submitted solutions for the ICRF-3, the most recent realization of the International Celestial Reference Frame.

1 General Information

The Department of Geodesy and Geoinformation in the Faculty of Mathematics and Geoinformation of TU Wien is divided into seven Research Divisions. One of those, the Research Division Higher Geodesy (HG) with about twenty members, is focusing on satellite geodesy and geodetic VLBI.

The Federal Office of Metrology and Surveying (Bundesamt für Eich- und Vermessungswesen, BEV) is the body responsible for official surveying, geoinformation 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 on reference systems or geophysics and precise levelling. VLBI staff at BEV is attached to those two sections.

1. Technische Universität Wien
2. Bundesamt für Eich- und Vermessungswesen

2 Staff

Personnel at TU Wien and BEV associated with the IVS Special Analysis Center in Vienna and their main research fields and activities are summarized in Table 1. The staff members at TU Wien are partly paid by TU Wien and partly funded by the Austrian Science Fund (FWF) within several projects listed in the acknowledgements.

Figure 1 shows some of the current members of VIE together with former members at the excursion to Ny-Ålesund held as part of the IVS General Meeting 2018.

3 Current Status and Activities

3.1 Global Reference Frames and Earth Orientation

Although not yet an operational Analysis Center of the IVS, we routinely analyze all IVS 24-hour sessions and submit SINEX files for the R1 and R4 sessions to the IVS Combination Center at BKG. Based on the cooperation with BEV, we are planning to become an operational Analysis Center in the near future.

Fig. 1 Current and former members of the IVS Analysis Center VIE at the excursion to Ny-Ålesund in June 2018 held during the IVS General Meeting 2018. From left to right: Johannes Böhm, David Mayer, Jakob Gruber, Matthias Schartner, Andreas Hellerschmied, Maria Karbon (now at Observatoire de Paris), and Benedikt Soja (now at NASA JPL).

Table 1 Staff members ordered alphabetically with the main tasks related to VLBI.

Johannes Böhm	Reference frames, Chair of HG
Sigrid Böhm	VieVS admin, Earth orientation
Jakob Gruber	Correlation, vgosDB in VieVS
Andreas Hellerschmied	Operational VLBI processing, VLBI to satellites
Hana Krásná	Reference frames, VLBI global solutions
Daniel Landskron	Troposphere delay models
David Mayer	Operational VLBI processing, celestial reference frames
Markus Mikschi	Support for correlation activities
Matthias Schartner	Development of VieSched++, scheduling VLBI sessions, ringlaser
Helene Wolf	Scheduling VLBI observations to satellites

In 2017 and 2018, we have contributed to the ICRF-3 Working Group of the International Astronomical Union (IAU) by regularly submitting CRF solutions determined with VieVS (Mayer, 2019 [6]) (compare Figure 2). Special emphasis was put on the determination of galactic aberration from the history of VLBI observations and on the impact of different analysis strategies, such as different tropospheric delay models or the application of different datum stations. Mayer (2019 [6]) has also carried out detailed comparisons against celestial reference frames from the ESA Gaia mission.

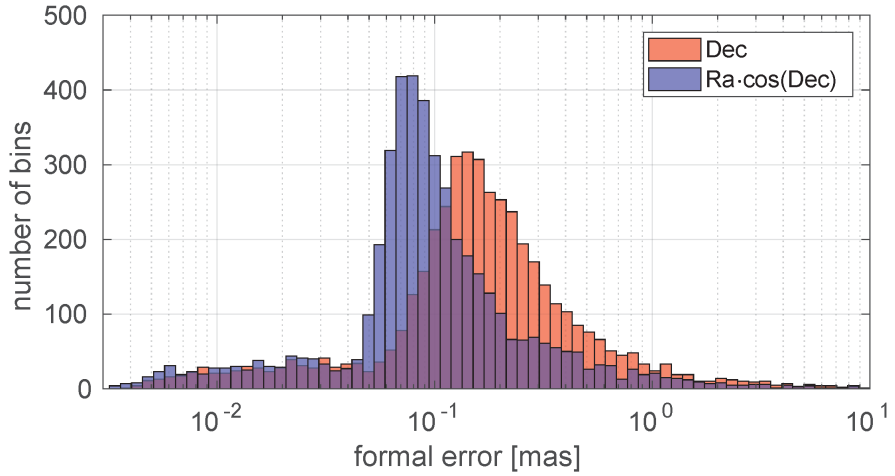

Fig. 2 Distribution of the formal uncertainties in the Vienna solution to the ICRF-3 ([6]). Please note that the errors are not scaled.

3.2 Tropospheric Delays

We are providing the parameters of the Vienna Mapping Functions (VMF) to the scientific community, both from analysis data as well as from forecast data of the European Centre for Medium-range Weather Forecasts. It should be mentioned that we moved the provision of the coefficients from the server *http://ggosatm.hg.tuwien.ac.at/* to the new server *http://vmf.geo.tuwien.ac.at/*. There, we are not only providing parameters of VMF1, but also of the recently developed VMF3 (Landskron and Böhm, 2017 [4]) and the corresponding horizontal gradients model GRAD (Landskron and Böhm, 2018 [5]). Besides the troposphere delay models we also provide a complete database of ray-traced delays for each geodetic VLBI observation since 1980. The software VieVS can apply these ray-traced delays directly in VLBI analysis. An individual ray-tracing tool enables creating ray-traced delays also for GNSS and DORIS stations. Additionally, the code of our ray-tracing software RADIATE (Hofmeister and Böhm, 2017 [3]) has been made freely available via GitHub at *https://github.com/TUW-VieVS/RADIATE*, providing users with even more flexibility in creating their own ray-traced delays. For the future, we plan to compute all models for optical wavelengths as well, so that they can be used for the analysis of SLR observations, too.

3.3 Development of VieVS

VieVS stands now for Vienna VLBI and Satellite Software (Böhm et al., 2018 [1]) and is the umbrella brand for our software activities at the Research Division HG. It does not only comprise the VLBI modules but also the ray-tracing module, upcoming SLR and GNSS-PPP modules, or the new scheduling tool VieSched++ written in C++ (Schartner and Böhm, 2019 [8]). The VLBI module is capable of using and analyzing files in the vgosDB format. VieSched++ has already been successfully tested for various session types, e.g., INT3 or T2 sessions. It is based on a multi-scheduling approach, i.e., a large number of schedules is generated and the best one is selected based on Monte-Carlo simulations.

We want to highlight here that we are now providing VieVS via Github: https://github.com/TUW-VieVS. As in previous years, we are going to organize VieVS Days at TU Wien from 15 to 17 October 2019 where participants have the chance to get to know VLBI analysis with VieVS as well as the scheduling of geodetic and astrometric VLBI sessions.

3.4 VLBI Observations to Satellites

In 2017 and 2018, we have completed and summarized our work on VLBI observations to satellites. The observations to GNSS satellites are documented by Plank et

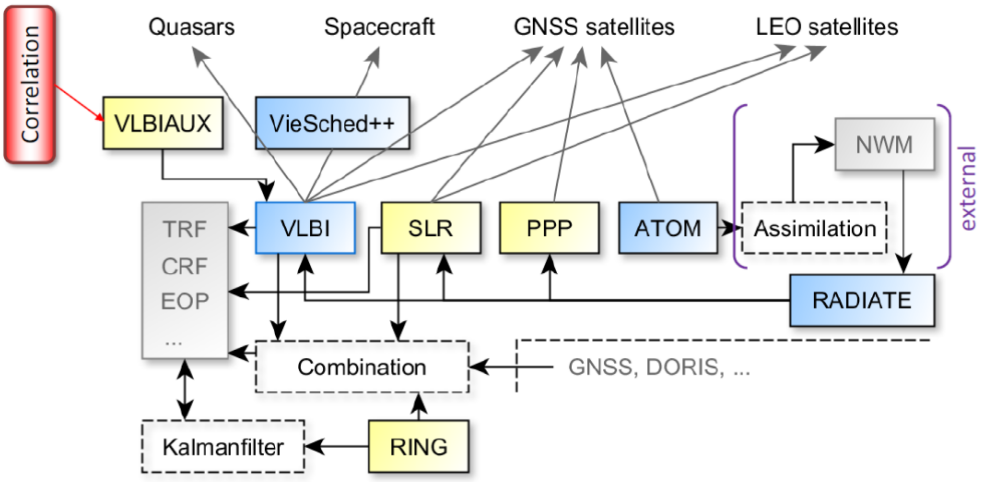

Fig. 3 Planned future developments of the Vienna VLBI and Satellite Software (VieVS). The boxes in blue are already quite mature and distributed via Github, whereas the boxes in yellow are under development.

al. (2017 [7]) and the observations to APOD by Hellerschmied et al. (2018 [2]). With both experiments, we reach an accuracy of a few nanoseconds for the observed delays. At the moment, we are working on the implementation of satellite observations in the new VieSched++ scheduling tool.

4 Future Plans

We plan to become an operational IVS Analysis Center in the near future. Since we also host an IVS Correlation Center, we plan to close the gap between the correlation output and the analysis of VLBI observations with the VLBI module of VieVS. In other words, we will add the ambiguity resolution and the ionosphere calibration to the VieVS package.

Acknowledgements

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