DGFI-TUM Analysis Center

Matthias Glomsda, Manuela Seitz, Detlef Angermann, Michael Gerstl

Abstract This report describes the activities of the DGFI-TUM Analysis Center (AC) in 2021 and 2022. We investigated our own and the combined IVS contribution to the ITRS 2020 realizations and computed several secular terrestrial reference frame (TRF) solutions. One focus of attention was the analysis and integration of the new VLBI Global Observing System (VGOS) broadband measurements. Another one was the reduction of non-tidal loading (NTL) in VLBI (and TRF) analysis.

1 General Information

DGFI-TUM has been serving as an IVS AC since the establishment of the IVS in 1999. Since November 2008, we are an operational AC regularly submitting datum-free normal equations for the rapid turnaround sessions in SINEX format. Since 2008, we are also involved in the BKG/DGFI-TUM Combination Center at the Bundesamt für Kartographie und Geodäsie (BKG) by maintaining the combination software DOGS-CS (DGFI Orbit and Geodetic parameter estimation Software – Combination & Solution).

DGFI-TUM is an institute of the Technische Universität München (TUM) since January 2015 and is located in the city center of Munich, Germany. The research performed at DGFI-TUM covers many different fields of geodesy (e.g., reference systems, satellite altimetry, Earth system modeling) and includes contributions to national and international scientific services and research projects, as well as various functions in scientific organizations (see http://www.dgfi.tum.de).

Deutsches Geodätisches Forschungsinstitut der Technischen Universität München (DGFI-TUM)

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IVS 2021+2022 Biennial Report

2 Staff

For the last two years, Matthias Glomsda was responsible for the operational IVS analysis and the development of the VLBI analysis software DOGS-RI (Radio Interferometry). He was supported and deputized by Manuela Seitz. Detlef Angermann was the head of the *Reference Systems* research area at DGFI-TUM, to which the IVS AC belongs. Michael Gerstl, the originator of DOGS-RI, retired in 2018 but is still occasionally providing advice. Table 1 lists all VLBI related staff members.

Table 1 Staff members and their main areas of activity.

Name	Tasks
Detlef Angermann	Head of research area *Reference Systems*
Matthias Glomsda	Operational data analysis; software development
Manuela Seitz	CRF/TRF combination; combination of different space geodetic techniques
Michael Gerstl	Software development; advice

3 Current Status and Activities

Since 2020, the activities of our research area have been dominated by DGFI-TUM's ITRS 2020 re-

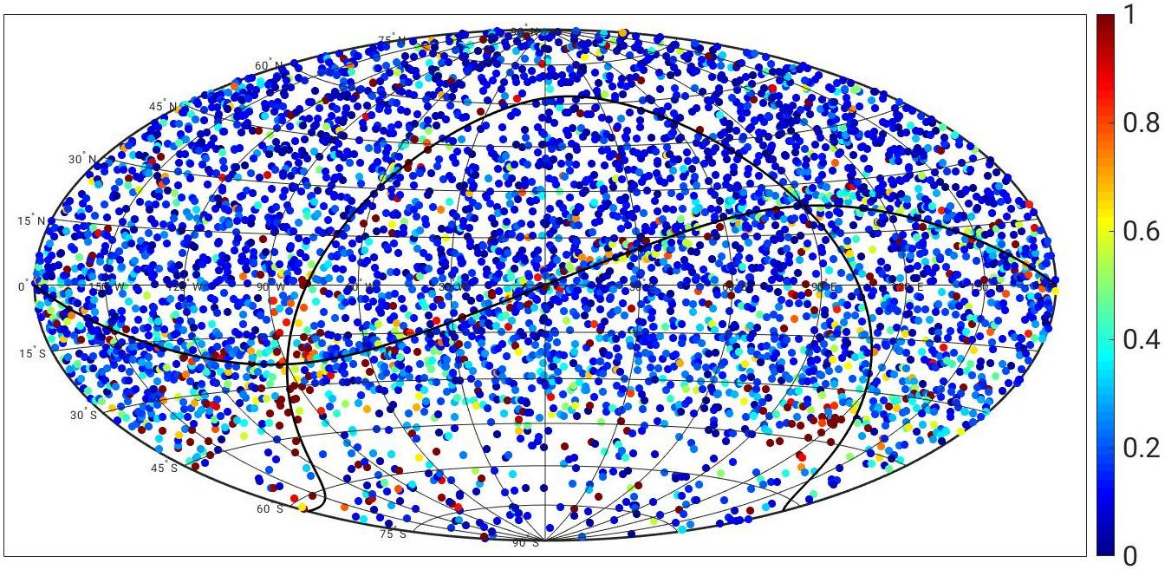

Fig. 1 Geocentric positions and formal errors (in [mas]) of the estimated source coordinates in the basic TRF/CRF solution in [1], i.e., without VGOS data.

alization work. The resulting DTRF2020 [4] will be released in 2023. Regarding VLBI, we analyzed the IVS input data, which was created by the IVS Combination Center. It represents a combination of the distinct AC solutions (including the solution by DGFI-TUM) at the normal equation level, which was performed with DOGS-CS. The explicitly estimated and combined parameters are session-wise station positions and Earth orientation parameters (EOP), and both parameter types are used for the computation of the DTRF2020.

However, the original contributions by the IVS ACs to the ITRS 2020 realizations also contained free source positions for the celestial reference frame (CRF). Hence, we used our solution *dgf2020a* to compute several consistently combined TRF/CRF solutions [1]. For the latter, the EOP were reduced and not explicitly estimated. Furthermore, the source velocities were fixed to the values derived from Galactic aberration, and only the source coordinates at 2015.0 have been estimated (see Figure 1).

The biggest challenge, though, was the inclusion of the new VGOS data. In contrast to the legacy S/X system, VGOS provides delay observations from broadband measurements with a joint ionospheric delay calibration. As a consequence, the legacy and the VGOS antenna networks are separated on principle, and the source positions might deviate due to the different observation frequencies. To overcome the first issue, *mixed-mode* sessions are introduced, in which VGOS antennas observe in legacy S/X mode together with the legacy antennas. As it turned out, more connecting information is needed. Thus, the DTRF2020 (while fixing the CRF) also makes use of local ties between legacy and VGOS antennas, combines the velocities of such co-located antennas, and incorporates dedicated short baseline measurements between the legacy and VGOS antennas (e.g., at Onsala, Sweden [5]).

We further investigated the new VGOS data by comparing the results of three years of simultaneous legacy and VGOS sessions from 2019 to 2021 [2]. In general, there are fewer antennas per VGOS session, but since these antennas are mostly smaller and faster than their legacy counterparts, they collect more observations per unit time. In addition, the formal errors of the VGOS broadband measurements are usually smaller (compare Figure 2). However, the global distribution of VGOS antennas is poor, since none of them was operating in the Southern hemisphere as of December 2021. Probably as a consequence, we observe mean offsets of about 0.1–0.2 mas in the estimated polar motion parameters w.r.t. the IERS 14 C04 reference series for the VGOS sessions. DUT1, on the

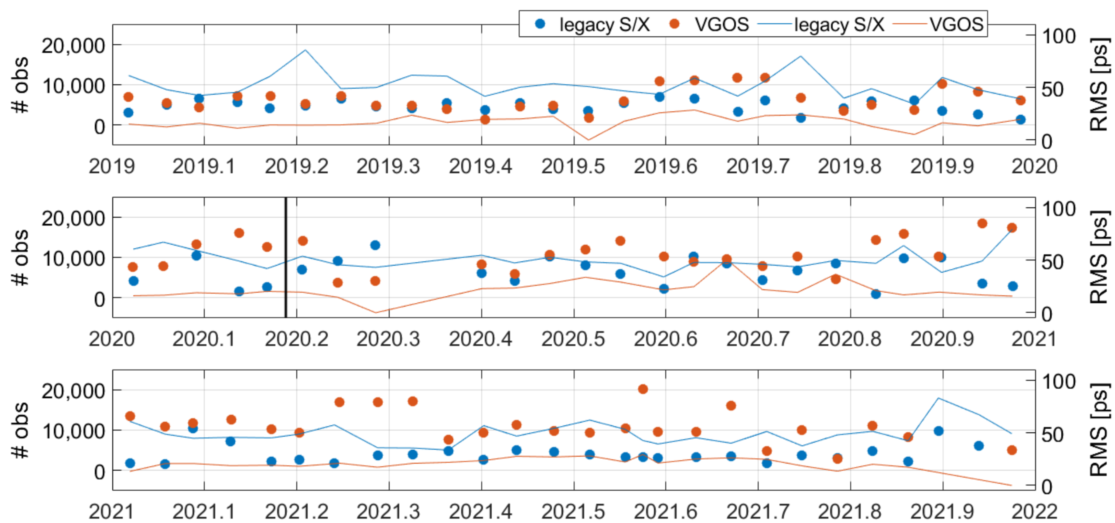

Fig. 2 Number of observations (dots) and RMS of the observation residuals (lines) per simultaneous—yet separately solved—legacy (blue) and VGOS (red) sessions.

other hand, is not noticeably different compared to the legacy results and the C04 series. In our session-wise solutions, we could also not determine a significant difference between the estimated source coordinates with legacy and VGOS observations. The estimation of VGOS antenna velocities still suffers from the short (and sometimes sparse) observation time spans, though.

Finally, we continued our studies on the reduction of NTL in VLBI analysis [3]. We applied NTL at both the observation and the normal equation levels in a secular VLBI-only TRF. The results might provide insights into the application of NTL at the normal equation level in the DTRF2020, albeit the latter represents a combination of all four geodetic space techniques. We found that the impact of NTL is largest for antenna velocities based on short observation time spans and that the results for the antenna motions are very similar for both application levels. The jointly estimated EOP, on the other hand, depend more strongly on the application level and also on the solution type, i.e., single-session vs. secular TRF.

4 Future Plans

A prominent issue w.r.t. the ITRS 2020 realizations is a contingent scale drift in the combined IVS contribution and/or the single AC solutions. We are participating in the corresponding IVS Working Group to investigate this matter.

These ITRS 2020 realizations will give rise to a new operational DGFI-TUM solution *dgf2023a*. Additional empirical gravitational deformation models and a new session naming convention require (albeit small) further software developments.

We finally began to analyze *Intensive* sessions, so that these can be run routinely soon. The same is planned for the increased number of VGOS sessions. The estimated parameters of both session types shall be further compared to and/or combined with the legacy R1/R4 parameters. This includes continuing studies of the connection (combination) of VGOS and legacy networks (observations) for consistent TRF/CRF/EOP solutions.

References

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