3.6 ITRS Combination Centres

3.6.1 Deutsches Geodätisches Forschungsinstitut (DGFI)

In 2013, the focus of the work of the ITRS Combination Centre at DGFI was on the computation of a new common realization of the ITRS and ICRS and on the computation of epoch reference frames.

Simultaneous computation of CRF and TRF

In the annual reports of the years 2011 and 2012 the motivation for a common realization of ITRS and ICRS was given. The first solution set up, performed in the last years, included only 18 of the 24 VCS sessions. Now, a new solution was computed, including observation data of VLBI, GNSS and SLR from the individual beginning of the techniques until the end of 2010. In case of VLBI, most of the X/S sessions (4341) observed in this time span and all 24 VCS sessions are included now so that the CRF solution is more complete and comparable to ICRF-2. The computation is based on the combination of time series of constraint free normal equation systems provided by three Analysis Centres of the international technique services. Table 1 gives an overview about the input data.

Table 1: Input data for a simultaneous and consistent realization of ITRS and ICRS.

	Institution	Time span	Sessions	Number of obs.
VLBI	IGG Bonn	1980-2010	4341 (all 24 VCS) only sessions with at least 3 stations are used	7,900,328
GNSS	TUM	1994-2010	6208 (daily SINEX)	3,530,603,612
SLR	DGFI	1983-2010	1272 (weekly SINEX)	3,080,959

The combination of constraint free normal equation systems means that the original technique observations are adjusted and the input normal equations do not contain any constraint related to the geodetic datum. The orientation of the combined solution is determined by no-net-rotation conditions applied for the station network and the source positions w.r.t. respective a priori frames. The parameters determined explicitly are given in Tab. 2. Altogether, 57,032 parameters are estimated.

Parameters common to all techniques are the station coordinates and the EOP. Even, if the satellite techniques cannot provide UT1–UTC and nutation parameters in an absolute sense, these parameters are set up in the satellite normal equations in a piecewise linear representation. This means, that the satellite-only normal equations can only be solved by fixing at least one UT1–UTC

Table2: Explicit parameters of the common realization of ITRS and ICRS.

	station coord.	source coord.	pole	nuta-tion	UT1-UTC	Indirect parameters: origin	Indirect parameters: scale
VLBI	x	x	x	x	x		x
GPS	x		x	rate	LOD		
SLR	x		x		LOD	x	x

offset or one offset per nutation component to the a priori value or zero, respectively. However, in the combination the absolute information is provided by VLBI and constraints are not necessary.

A first solution was computed by combining VLBI and GNSS as some problems did arise with the early SLR EOP. The combination has an impact in particular on the EOP and thus indirectly also on the CRF. The combined EOP series are continuous during the satellite era and benefit w.r.t. their standard deviations and scatter. Figure 1 shows the decrease of the standard deviation of the x-component of the terrestrial pole compared to the VLBI-only solution. In particular during the early years, the standard deviations decrease even if the first GNSS data are available in 1994. This means that the whole solution benefits w.r.t. stability. A detailed analysis of the change of correlations has still to be done. The marked standard deviations related to VCS sessions do not show a special characteristic.

Figure 2 shows the results for UT1–UTC. As GNSS provides daily information on LOD only the combined series is continuous but shows a higher scatter than the VLBI-only series. Zooming into the time series of standard deviations (Fig. 3) shows that they increase for the GNSS only epochs and reach maximum values

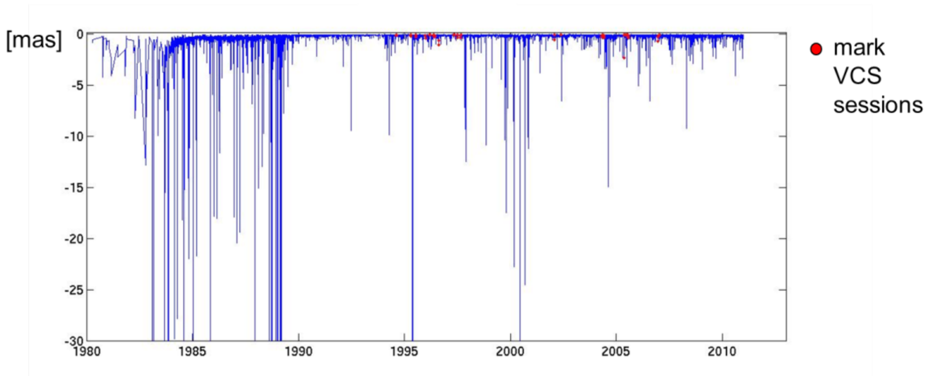

Fig. 1: Change of standard deviation of x-component of the terrestrial pole of combined solution w.r.t. VLBI-only solution.

at the epochs with the largest distance to a VLBI epoch. This behaviour underlines the appearance of a larger scatter.

Due to the decreasing of EOP standard deviations also the standard deviations of the sources decrease. Positions changes are mainly visible for VCS sources and sources observed in RDV sessions. Detailed investigations of the CRF results are still under work.

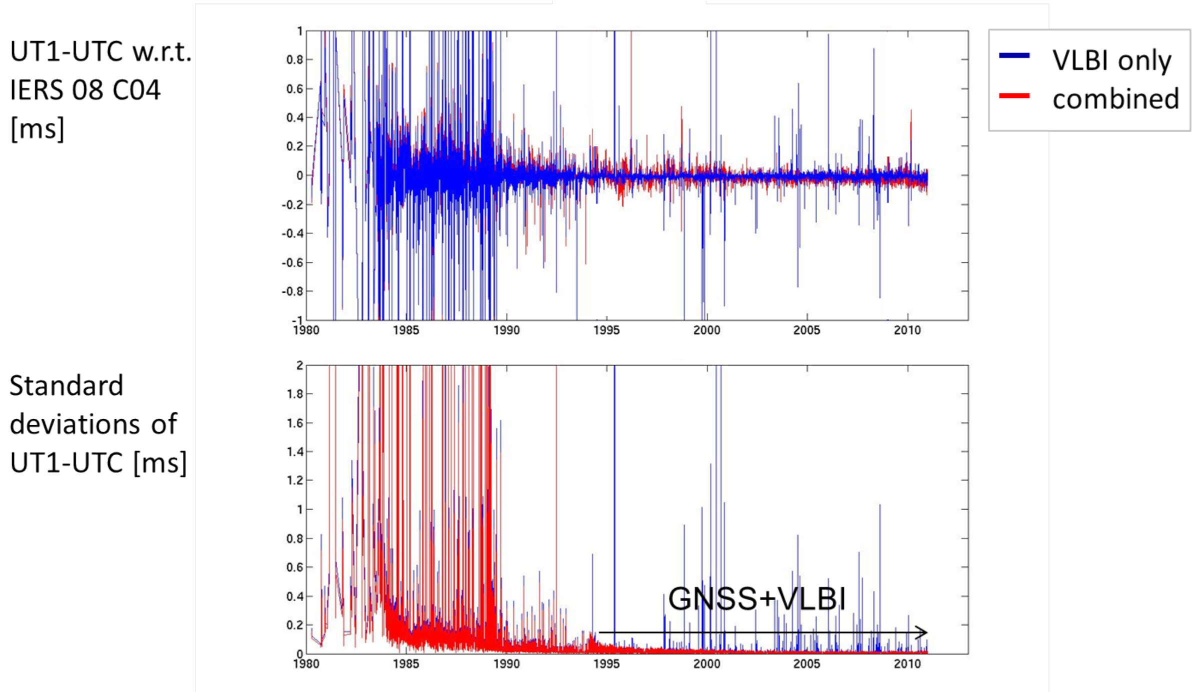

Fig. 2: UT1–UTC time series w.r.t. IERS 08 C04 (upper panel) and the related standard deviations (lower panel).

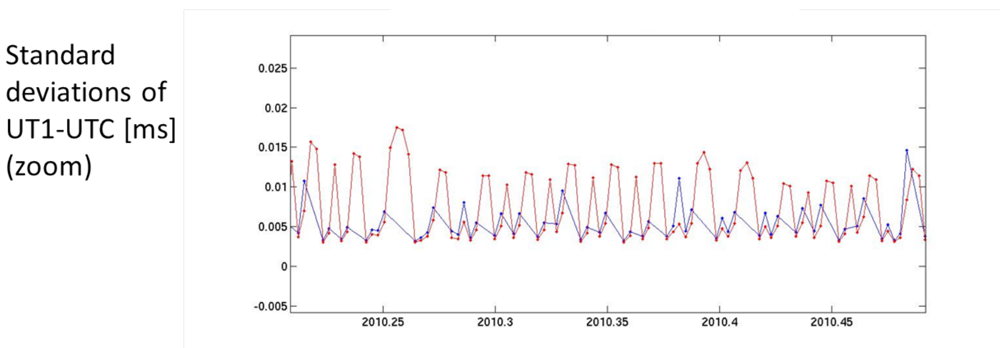

Fig. 3: UT1–UTC standard deviation time series (zoomed). Legend as in Fig. 2.

Epoch reference frames (ERFs)

Conventional global terrestrial reference system realizations take only linear variations of crust-fixed station positions into account. Non-linear station motions are handled by conventional models (e.g., Earth tides). In this kind of realizations, the instantaneous station position can only be computed if, besides other effects, the common translations (often named geocenter motion in the geodetic literature) and non-tidal atmospheric and hydrologic loading effects are modeled. Nowadays, a conventional model for the geocenter motion is still missing and also for loading not one unique conventional model is defined and applied. Furthermore, the individual station motions due to local environmental (geophysical or anthropogenic) effects are neglected, which are very hard to model.

One possibility to approximate the instantaneous station position more accurately is the frequent (e.g., weekly) estimation of station positions from an epoch-wise combination of different geodetic space techniques. These reference frames are named Epoch Reference Frames (ERFs). DGFI computed a time series of ERFs based on a homogeneous reprocessing of GNSS, VLBI and SLR using common a priori models and common parameterizations. The geodetic datum of the ERFs is realized consistently to the conventional approach: the origin is realized by SLR, the scale is realized as a weighted mean scale of SLR and VLBI and the orientation is aligned to a previous reference frame by a No-Net-Rotation (NNR) condition using a selected subnet of well-determined GNSS stations. Due to a varying global station network (especially in the case of SLR and VLBI), the datum of the weekly reference frames varies from week to week. Due to the sparse station distribution, only a subset of the available local ties can be applied. Therefore, the accuracy of the transfer of the datum information (e.g., SLR origin to GPS) is limited. Furthermore, the poor network geometries cause correlations between common station translations and rotations. Therefore, the neglected translational variations (mainly with an annual period) propagate partly into the orientation. Through the NNR condition, these variations are forced into the complementary parameters of the network orientation, the terrestrial pole coordinates. The effects of the non-linear station motions on the terrestrial pole coordinates is investigated in detail by Bloßfeld et al. (2014).

In order to stabilize the geodetic datum of the ERFs, DGFI investigated the impact of the length of the sampling interval on the datum stability and its tradeoff w.r.t. the ERF ability to monitor short-term non-linear station motions. In total, three different test time series of ERFs with a combination interval of 7-days, 14-days and 28-days have been computed and compared to a conventional reference frame based on identical input data. Figure 4 shows the translation time series in x-direction (upper plot) and the corres-

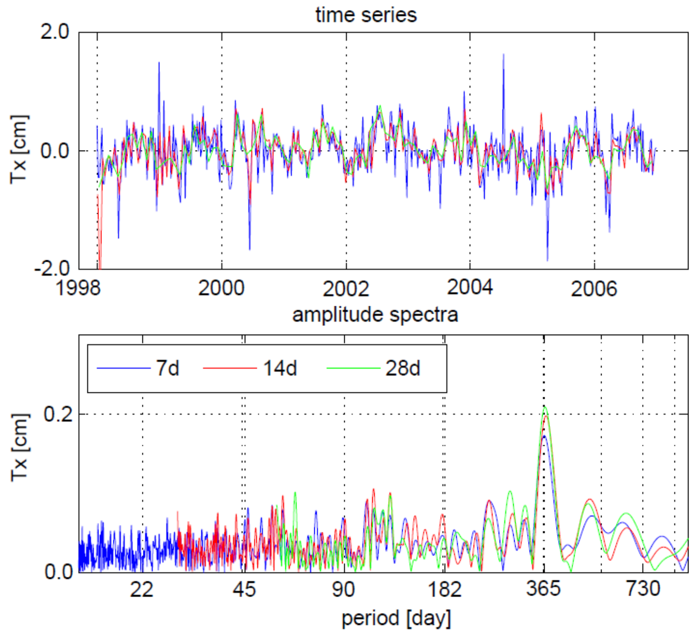

Fig. 4: Time series and spectra of x-translations of weekly (blue), 2-weekly (red) and 4-weekly (green) combined ERFs w.r.t. a conventional reference frame based on identical input data.

ponding spectra (lower plot). The scatter of the x-translations is reduced when the combination interval is enlarged. The significantly determined amplitude of the annual variation nearly remains the same for all three test time series. The obtained values for the annual amplitudes and the scatter (RMS) of the time series are summarized in Bloßfeld et al. (2015).

Besides the datum stability, also the ERF ability to monitor short-term non-linear station motions is investigated. If the sampling interval is enlarged, the ERFs are not able to monitor these variations any more. Figure 5 shows exemplarily a snapshot of the Russian GPS station Yakutsk, where the antenna is deflected due to snow coverage (local effect). Compared to the daily GPS-only time series (green), only the 7-day ERF time series (blue) is able to monitor this deflection with appropriate amplitude. The 14-day and 28-day ERFs show a smaller deflection compared to the GPS-only solution.

More details on the investigation of epoch reference frames and possible applications can be found in Bloßfeld et al. (2014) and Bloßfeld et al. (2015). The results show that a high datum stability and the absolute accuracy of the estimated parameters have to be balanced or the computation of different ERF series for different applications have to be considered.

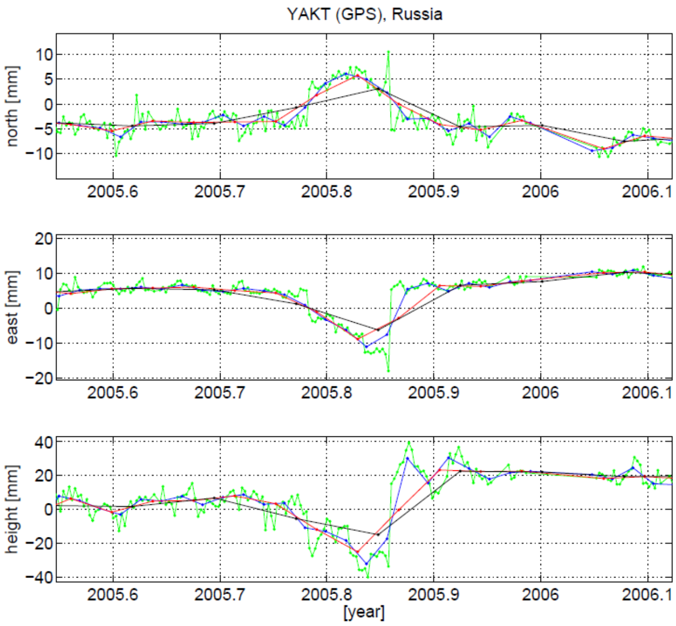

Fig. 5: Daily individual GPS-only (green) time series of the station Yakutsk (Russia). In addition, the weekly (blue), 2-weekly (red) and 4-weekly (black) individual time series of the combined ERFs are shown.

References

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