3.6 Combination Centres

3.6.1 ITRS Combination Centres

3.6.1.1 Deutsches Geodätisches Forschungsinstitut (DGFI)

This report summarizes the DGFI activities in its function as ITRS Combination Centre during the year 2004. For more information refer to other TRF related publications (see references), and to the DGFI reports in the previous IERS Annual Reports.

TRF realization 2003

Input are multi-year solutions with station positions and velocities of the different space geodetic techniques (VLBI, SLR, GPS, and DORIS). The TRF computations were finished at the end of the year 2003. During this year the work concentrated on a detailed analysis and validation of the TRF results. The input data, the combination methodology, and first results were presented in the IERS Annual Report 2003. A detailed documentation of the TRF realization 2003 is provided in Angermann et al., 2004.

TRF validation and accuracy assessment

The TRF computations provide valuable results to assess the current accuracy of the terrestrial reference frame. The combined intra-technique solutions were used to evaluate the TRF accuracy by comparing the space geodetic solutions with local ties, and the velocity estimations of co-located instruments. Since GPS is the dominant technique regarding the number and spatial distribution of co-locations with the other techniques we consider the GPS solution as reference for this specific TRF accuracy evaluation. We used the co-locations and local ties selected within the inter-technique combination to refer the DORIS, SLR and VLBI solutions to the GPS reference frame. This was done by adding the local tie components to the DORIS, SLR and VLBI station coordinates. Then we applied a 14 parameter Helmert transformation between the GPS solution and the „transformed“ solutions of the other techniques. A great advantage of this approach is, that the transformation results are independent from a specific TRF datum (e.g., ITRF2000), as the comparisons are performed in an (arbitrary) GPS reference frame. However, as also for any other accuracy evaluation method, it is not possible to fully separate local tie errors from errors in the space geodetic solutions. This again underlines the importance of accurate local tie information.

The transformation results between GPS and the other techniques are summarized in Table 1. In the case of VLBI and SLR the discrepancies are in the order of a few mm for the transformation parameters. The RMS residuals of station positions and velocities for the co-located instruments are 5 mm and 1 mm/yr, respectively. Larger discrepancies do exist for co-locations between GPS and DORIS.

Table 1: Helmert-transformation results of the DORIS, SLR and VLBI network w.r.t. the GPS network.

Parameter	DORIS	SLR	VLBI
Tx [mm]	-9.6 ± 3.4	2.7 ± 1.4	-0.4 ± 1.7
Ty [mm]	8.4 ± 3.3	0.0 ± 1.3	-2.8 ± 1.7
Tz [mm]	2.9 ± 3.3	-2.2 ± 1.3	3.1 ± 1.7
Rx [mm]	3.2 ± 4.1	-3.3 ± 1.6	-4.6 ± 2.2
Ry [mm]	2.1 ± 4.0	-1.2 ± 1.6	1.8 ± 2.2
Rz [mm]	-18.9 ± 5.2	-2.2 ± 1.6	1.8 ± 2.2
Scale [mm]	-3.0 ± 3.2	1.9 ± 1.2	-4.7 ± 1.6
Pos RMS [mm]	8.2	4.1	5.4
Vel RMS [mm/yr]	1.5	0.87	0.92

Comparison with ITRF2000

A comparison of the TRF realization with ITRF2000 provides an optimal basis for a quasi-independent validation and quality control of the ITRS products. Figure 1 shows the RMS residuals of a similarity transformation between both TRF realizations for station positions and velocities. The agreement for VLBI and GPS station positions is better than for the other techniques. The discrepancies are largest for DORIS. Figure 2 represents histograms for the distribution of station position and velocity differences between both TRF realizations for the 369 common VLBI, SLR, GPS and DORIS stations in north, east, and height component. For about 60% of the stations the position and velocity differences are below 1 cm and 2.5 mm/yr, respectively. But on the other hand, there are too many stations (10%) with position and velocity differences larger than 5 cm and 1 mm/yr, which is not tolerable for a precise reference frame.

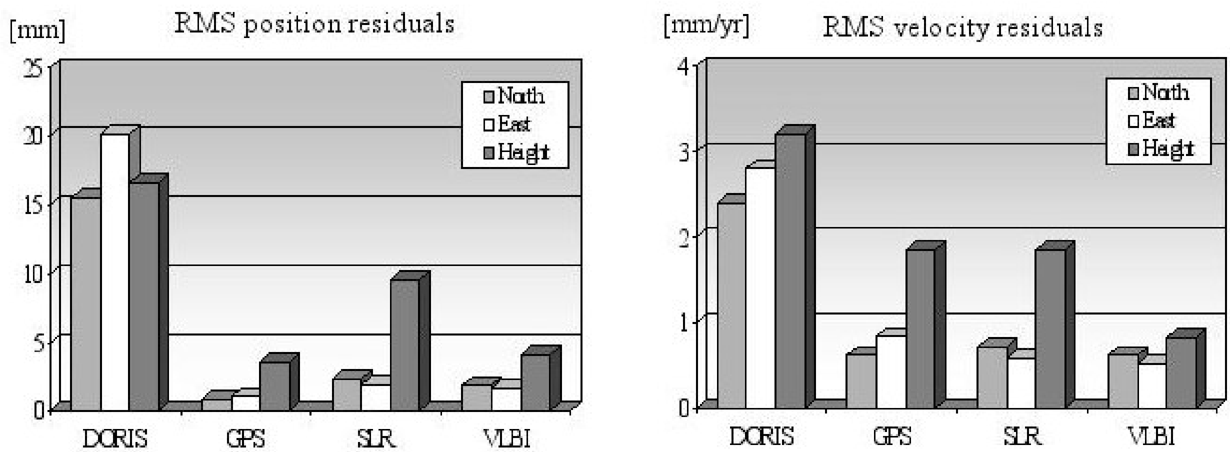

Fig. 1: RMS station position and velocity residuals in North, East, and Up component obtained from a similarity transformation between the combined DGFI solution and ITRF2000.

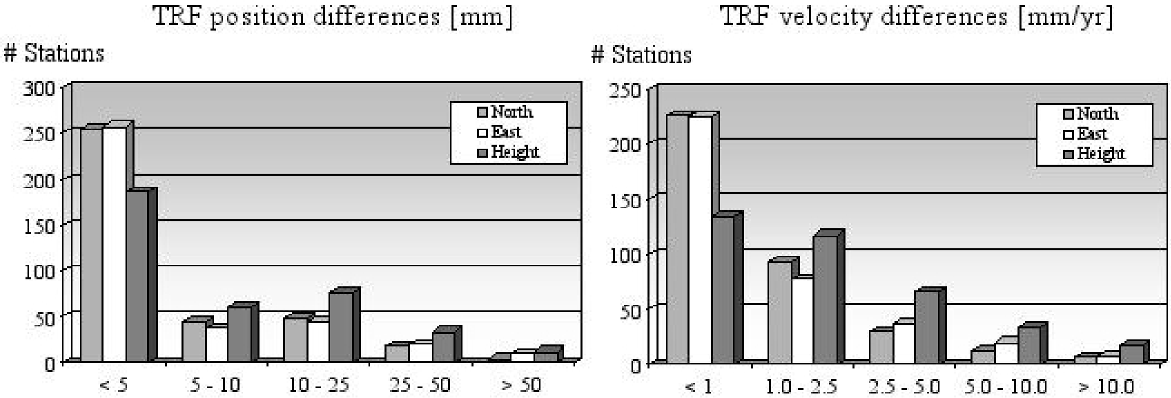

Fig. 2: Histograms representing the differences between the combined DGFI solution and ITRF2000 in station positions (left) and velocities (right) for the 369 common stations (75 VLBI, 69 SLR, 172 GPS and 53 DORIS).

Towards a refined TRF realization

The high accuracy of the space geodetic observations is not reflected by current realizations of the terrestrial reference frame. A major error source are remaining systematic effects (biases) between different space techniques, which have to be investigated and minimized. An additional problem is that non-linear station motions (among others post-seismic deformations, periodic movements) are not taken into account in previous ITRF realizations. As a first step towards a refined TRF realization we analysed the time series of station positions and datum parameters derived from weekly solutions. The position time series show non-linear motions and discontinuities for a large number of sites. The reasons are manifold, e.g.:

- seasonal signals caused by loading effects;
- effects of seismic deformation processes;
- equipment changes due to system upgrades, etc.;
- changes of softwares, models, and processing strategies.

We computed a first TRF realization based on weekly normal equations of the different space techniques. This new approach has major advantages compared to past TRF realizations based on multi-year solutions with station positions and constant velocities. First results obtained from an accumulated five years solution using data from 1999 until 2004 are promising (see Meisel et al., 2004).

Conclusions and outlook

The TRF computations at DGFI provide valuable results to assess the current accuracy of the terrestrial reference frame, to identify remaining deficiencies and to enhance the combination methodology. With the high accuracy of the space geodetic techniques time-variable effects of station positions and datum parameters (e.g., TRF origin) become detectable, that were not considered in past

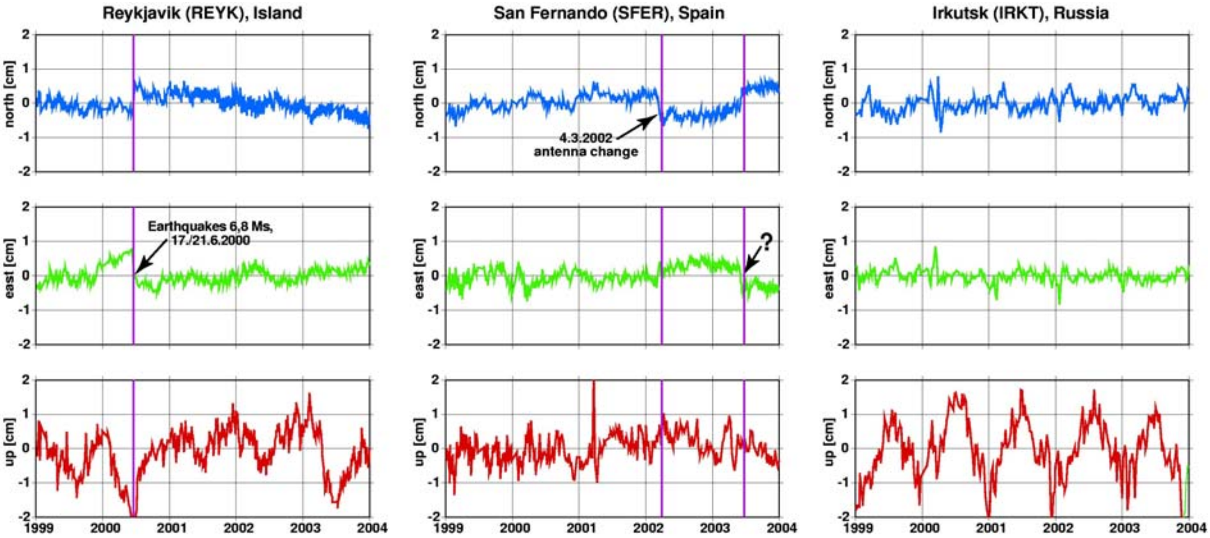

Fig. 3: Examples of position time series of three GPS stations that show jumps (earthquakes or instrumental changes) and annual signals.

TRF realizations. These time-variable effects have to be identified and properly modelled in future TRF computations.

A call for long-time series of "weekly" SINEX files for a new ITRF2004 and a supplement for the IERS Combination Pilot Project has been released in December 2004. The ITRF2004 will be based on the combination of time series of station positions and EOPs. The ITRS Combination Centres, namely DGFI, IGN, and NRCan, coordinated by the ITRS Centre, will perform the computation of the ITRF2004 solution.

Acknowledgement

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