3.6 ITRS Combination Centres

3.6.1 Deutsches Geodätisches Forschungsinstitut (DGFI)

In 2010, the focus of the ITRS Combination Centre at DGFI was on the finalization of the ITRS realization DTRF2008, internal validations of the DTRF2008 solution as well as the comparisons of the realizations DTRF2008 and ITRF2008 in order to assess their accuracy.

One of the most challenging issues to be solved in the context of ITRF realization are seasonal signals in station position time series, which are neglected so far. Thus, different model combinations for atmospherical and hydrological loading are compared in order to investigate their potential to reduce the seasonal signals and hence to improve future ITRS realizations.

Computation of DTRF2008

In the IERS Annual Report 2008/2009 the computation strategy for the ITRS realization was described. The solution was finished and provided to the IERS community in May 2010. The solution contains station coordinates, coordinates of the terrestrial and the celestial pole, UT1–UTC and LOD parameters. The time range of the EOP is from 1983.0 to 2009.0. Figure 1 shows the distribution of the stations. In Fig. 2 the horizontal station velocities of the solution are displayed. The solution is available in different file

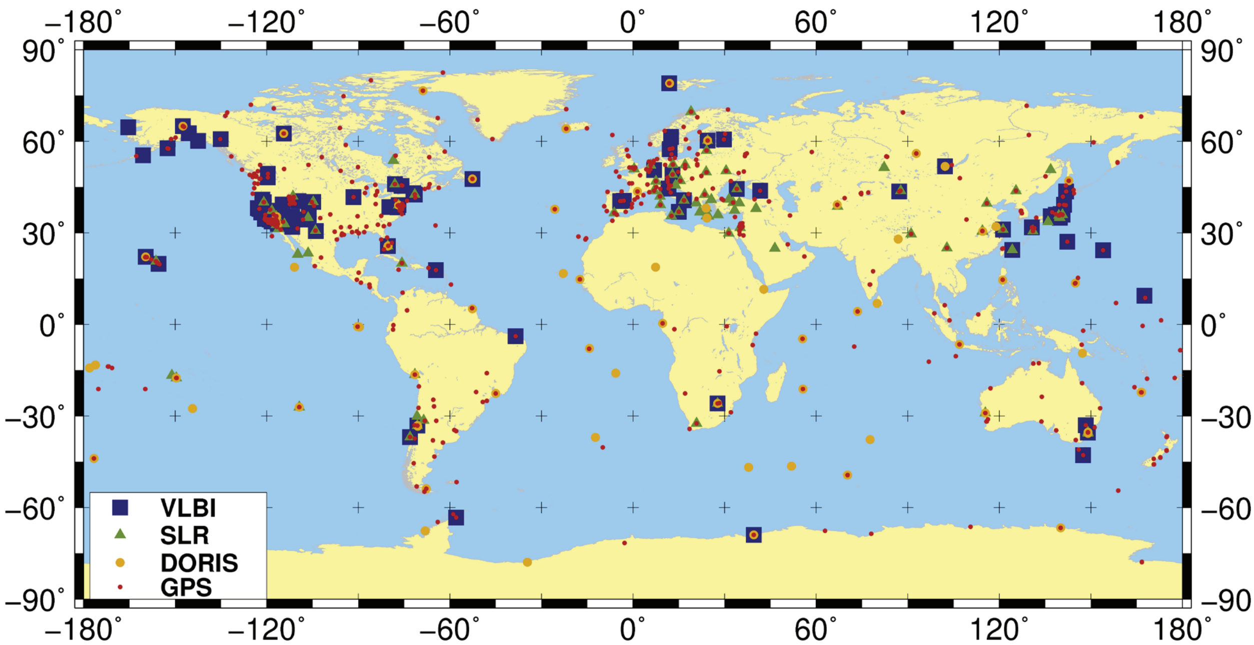

Fig. 1: Global station distribution of DTRF2008.

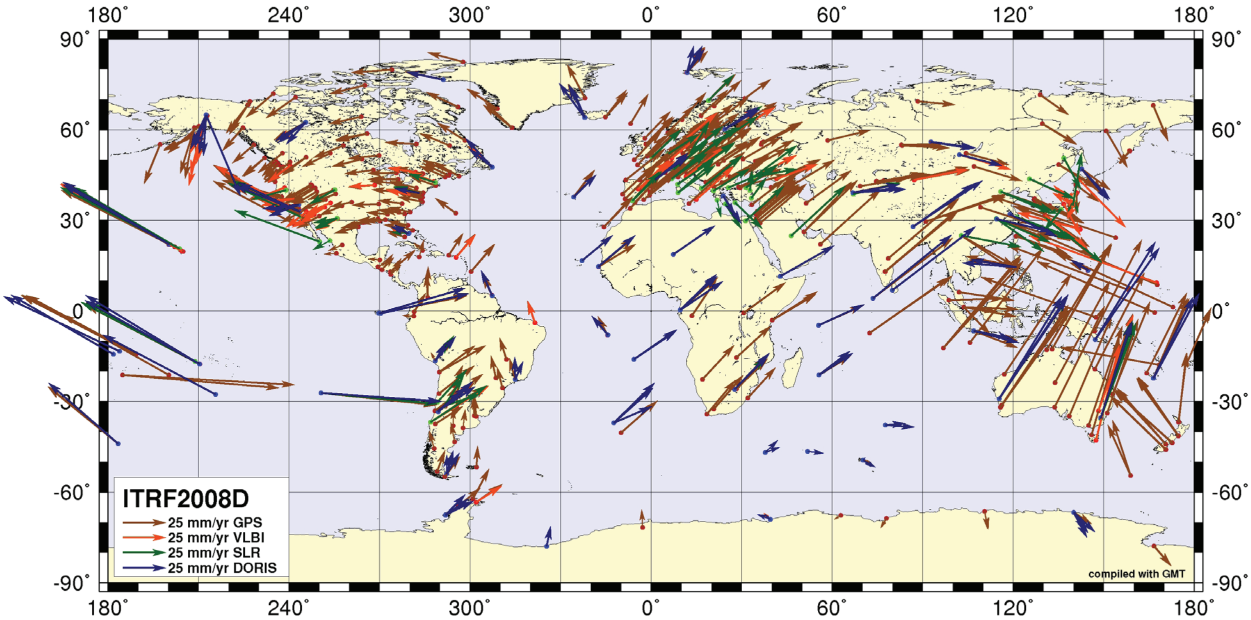

Fig. 2: Horizontal station velocities of DTRF2008.

formats under <ftp.dgfi.badw.de/pub/DTRF2008>, a short description of the solution on the website <http://www.dgfi.badw.de/index.php?id=258>. A detailed publication is given by Seitz et al. (2012).

Internal validation of DTRF2008

In order to assess the accuracy of DTRF2008, internal validation procedures are performed with respect to the network geometry and the geodetic datum, in particular the origin and the scale which are realized from the observations of the space geodetic techniques. Figure 3 shows exemplarily the time series of SLR and VLBI scale. The SLR time series shows a long-term systematic behavior at the beginning when only LAGEOS1 was in orbit. But because of the periodic character of the effect and the larger standard deviations at this time, the mean scale of SLR is not affected. In case of VLBI a drift can be seen at the beginning. But the noise is quite high and the mean scale is also not affected. Thus, the complete SLR and VLBI input data series are used for determining the scale of DTRF2008.

The origin of the DTRF2008 is realized from SLR data only. In order to assess the stability of the origin, also the translation time series are investigated. Especially, for z-translation a periodic effect for the LAGEOS1-only era was detected, which is in its characteristic very similar to the effect in the scale series. But also the effects in translation do not affect the mean origin significantly.

Furthermore, the conservation of the datum within the combination process was investigated. For this, the DTRF2008 was compared to the single-technique solutions. Table 1 and 2 summarize

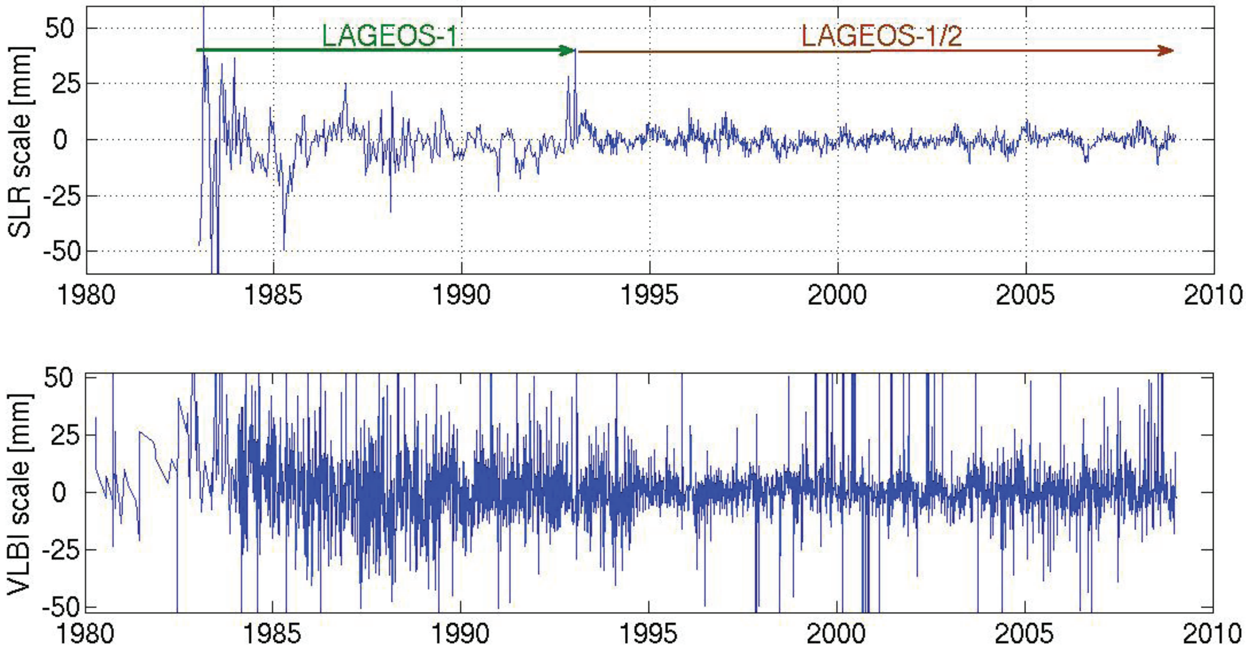

Fig. 3: Time series of SLR (upper plot) and VLBI scale (lower plot) for ITRF2008/DTRF2008 input series.

the results for origin and scale. The results show that the origin and the scale are not significantly affected by the combination. The estimated values are not larger than 0.3 mm and 0.1 mm/a for the origin and in maximum 0.02 mm and 0.02 mm/a for the scale.

Tab. 1: Translation parameters of DTRF2008 w.r.t. SLR-only multi-year solution.

SLR	tx	ty	tz
pos [mm]	0.1 ± 0.21	-0.3 ± 0.21	0.2 ± 0.21
vel [mm/a]	0.1 ± 0.05	0.1 ± 0.05	0.1 ± 0.05

Tab. 2: Scale parameters of DTRF2008 w.r.t. SLR- and VLBI-only multi-year solution. The scale is expressed as a radial distance [mm] at the Earth's surface.

SLR	scale	VLBI	scale
pos [mm]	0.02 ± 0.03	pos [mm]	0.01 ± 0.03
vel [mm/a]	-0.02 ± 0.008	vel [mm/a]	0.00 ± 0.002

A measure of the change of the network geometry due to the combination is the RMS of the transformation between DTRF2008 and the single-technique solutions (see Tab. 3). The RMS values are small for GPS and VLBI and reach a few millimetres for SLR and DORIS because of the larger variance level of these two techniques.

Tab. 3: RMS values of the similarity transformation between DTRF2008 and the technique specific multi-year solutions.

	position [mm]	velocity [mm/a]
GPS	0.6	0.09
VLBI	0.3	0.05
SLR	1.9	0.42
DORIS	3.3	0.83

Comparison of DTRF2008 and ITRF2008

The comparison of the DTRF2008 and the ITRF2008 is a validation step, which is important in order to assess the accuracy of the solutions (Seitz et al. 2013). Figure 4 shows the transformation parameters between the two solutions. The transformations are performed technique-wise. The results indicate, that DTRF2008 and ITRF2008 agree within 4–5 mm (rotation and scale change are transformed into distances at the Earth's surface). However, the difference between the values derived for the techniques are partly larger. E.g. in case of z-orientation, there is a difference between SLR and VLBI of about 7 mm. It can be summarized that the agreement of the DTRF2008 and ITRF2008 w.r.t. the geodetic datum is within one centimetre per component.

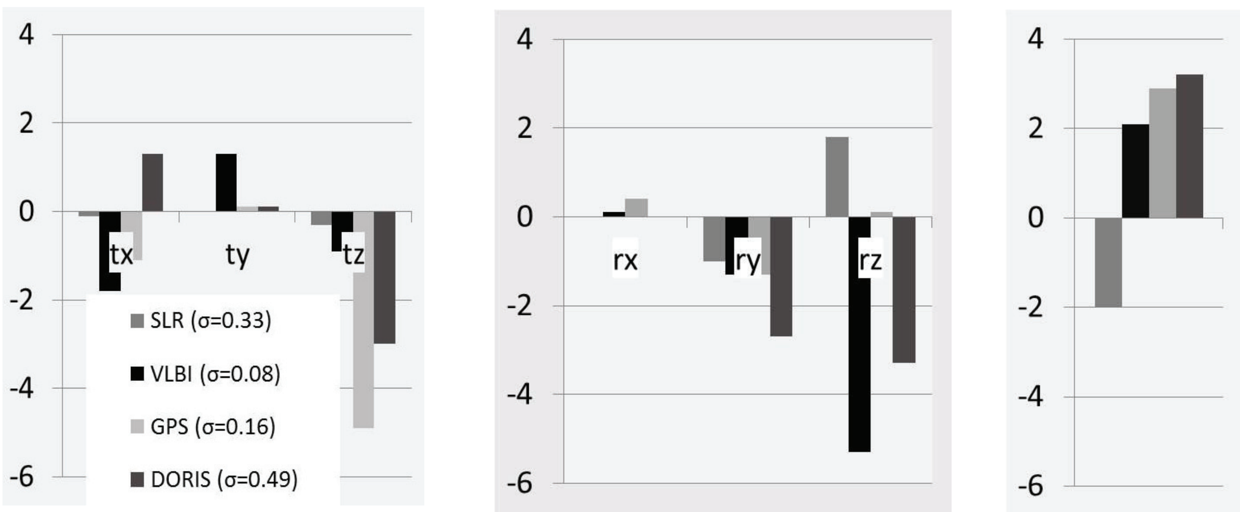

Fig. 4: *Translation (left), rotation (middle) and scale (right) parameters [mm] for the transformation from DTRF2008 to ITRF2008. The transformation epoch is 2000.0.*

In order to compare the network geometry of the two frames, the RMS values of the transformation are analyzed. Table 4 summarizes the corresponding values. While the agreement for the GPS and the VLBI part of the network is very good, for SLR and DORIS differences of 2–3 mm and 1 mm/a are obtained. The reason for the larger differences is the larger standard deviation for most of the SLR and DORIS station positions and velocities.

Tab. 4: RMS values of the 14 parameter similarity transformation between DTRF2008 and ITRF2008. Core stations are used for the transformation.

	position [mm]	velocity [mm/a]	# core stations
GPS	1.33	0.19	66
VLBI	0.38	0.09	25
SLR	2.00	0.82	37
DORIS	3.20	0.98	43

Comparison of different model combinations for atmospherical and hydrological loading

One of the most important challenges for future ITRS realizations is the handling of annual variations of station position time series (especially of the height component), which are mainly caused by atmospherical, non-tidal oceanic or hydrological mass load changes. We compared the RMS values of station height positions obtained for GPS stations (i) without applying loading models, (2) corrected by different geophysical model combinations and (3) corrected by an estimated annual and semi-annual signal. The models used for the approach (2) are NCEP and ECMWF for atmospheric mass load changes, ECCO for non-tidal oceanic contributions and LAD, GLDAS and WGHM for the hydrological component. Figure 5 shows the RMS values derived from the different approaches (1), (2) and (3). The solid line connects the RMS values of the original (non-corrected) series. It becomes apparent, that the reduction by an annual+semi-annual sinus fit leads to the largest reduction of the RMS for all stations. This leads to the conclusion, that the geophysical models used might not provide loading signals with very high accuracy. With respect to the geophysical models it can be seen, that the consideration of hydrological loading (solutions NEL, NEG and EEW) leads to a reduction of the RMS compared to a solution for which only atmospherical and non-tidal oceanic loading are applied.

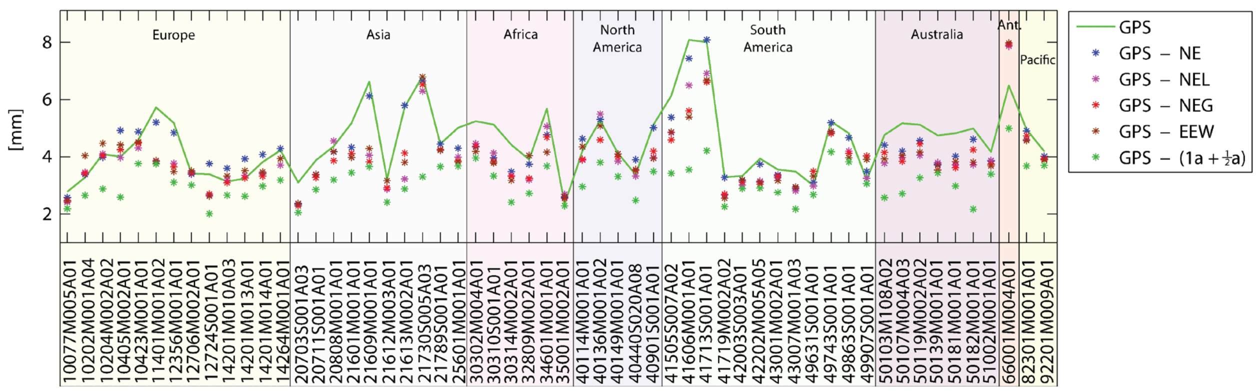

Fig. 5: RMS values for GPS station height position time series for series without loading correction (solid line) and for series corrected by different combinations of atmospherical, non-tidal oceanic and hydrological loading models (NE: NCEP-ECCO, NEL: NCEP-ECCO-LAD, NEG: NCEP-ECCO-GLDAS, EEW: ECMWF-ECCO-WGHM) and corrected by an annual plus semi-annual sinus fit.

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