Comparison of the ITRF2000 and ITRF96 Space Displacements of the Stations for Europe

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Abstract:

Residual horizontal and vertical movements were computed for individual tectonic plates from the velocity vectors published for ITRF2000. These values were compared with the same ones, published for ITRF96. Detailed comparisons were made for the territory of Europe (part of the EURA plate).

1. INTRODUCTION

Conventional Terrestrial Reference System (CTRS) is defined by the set of all conventions, algorithms and constants which provide the origin, scale and orientation of that system and their time evolution.

Conventional Terrestrial Reference Frame (CTRF) is defined as a set of physical points with precisely determined coordinates in a specific coordinate system as a realization of an ideal Terrestrial Reference System. Seven parameters are needed to fix a TRF at a given epoch, to which are added their time-derivatives to define the TRF time evolution.

International Terrestrial Reference System (ITRS)
The IUGG Resolution No.2 adopted in Vienna 1991 (*Geodesist's Handbook 1992)* recommends the following definitions of the TRS:

1. CTRS to be defined from a geocentric non-rotating system by a spatial rotation leading to a quasi-Cartesian system,
2. the geocentric non-rotating system to be identical to the Geocentric Reference System (GRS) as defined in the IAU resolutions,
3. the coordinate-time of the CTRS as well as the GRS to be the Geocentric Coordinate Time (TCG),
4. the origin of the system to be geocenter of the Earth's masses including oceans and atmosphere,
5. the system has to have no global residual rotation with respect to horizontal motions at the Earth's surface.

Realizations of the ITRS are produced by the IERS ITRS Product Center (ITRS-PC) under the name **International Terrestrial Reference Frame (ITRF).**

The history of the ITRF goes back to 1984, when for the first time a combined TRF was established using station coordinates derived from VLBI, LLR, SLR and Doppler/TRANSIT (the predecessor of GPS) observations. Until the present time 10 versions of the ITRF were published, starting with ITRF88 and ending with ITRF2000, each of which superseded its predecessor.

2. ITRF96

This contribution issued from (Kostelecký, Zeman, 2000).

Recapitulation:

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- reference frame ITRF96 was chosen because this frame is the first where the velocities were determined from real observations. Some stations, however, showed significant dispersion in their results. Therefore the stations which showed rms of the displacements greater than 3 cm/year or if the magnitude of their vector was greater than 10 cm/year, were eliminated from the analysis,

- statistically significant vertical change was detected for no tectonic plate; the same was valid for the whole Earth in global extent. Due to accuracy, characterized by the rms error 10.5 mm for global solution, we could state that if some secular vertical changes (secular expansion/contraction of the Earth) exist, their absolute value must be less than 1 cm/year.

- in the case of horizontal changes geophysical model responses well to the motions verified by observations. We tried to confront observed values with the theoretical ones and carry out prospective corrections to existing model NUVEL – 1A - see Fig. 1.

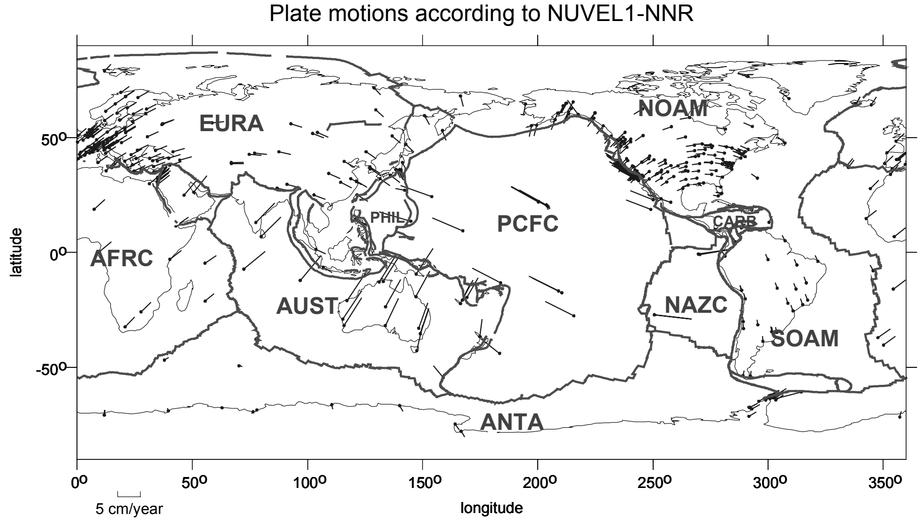

Figure 1

Figure 2 describes residual vertical motions of European stations. No statistically significant motions were detected due to accuracy of determination.

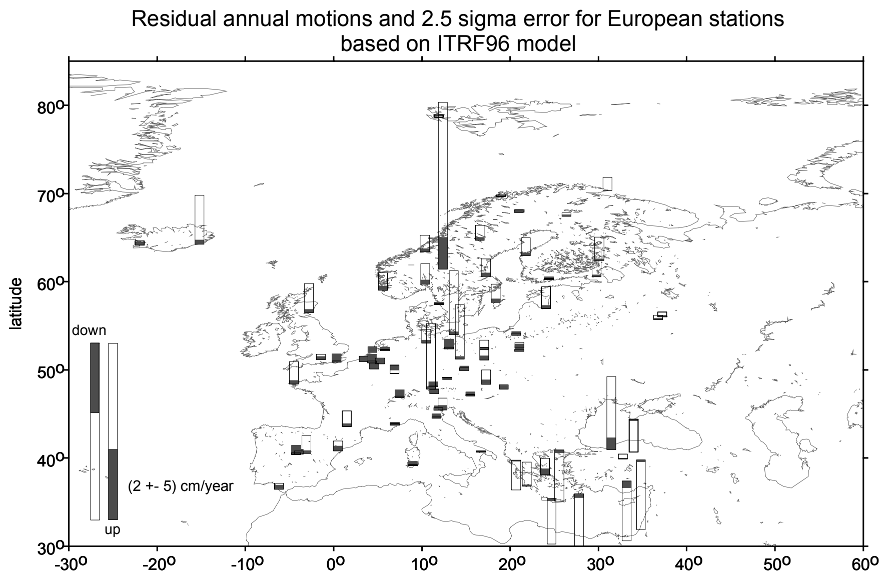

Figure 2

At Fig. 3 the annual horizontal displacements for the European continent were charted. These displacements are residual shift after removing *recomputed* NUVEL1 values – see Kostelecký, Zeman, 2000. On the base of obtained accuracy of the estimation of the changes, it is again not enough to find statistically significant residual horizontal displacements.

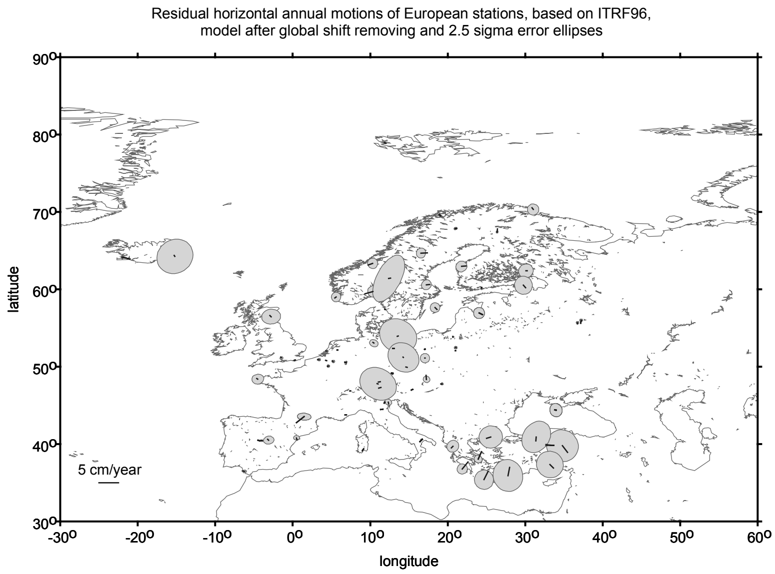

Figure 3

3. ITRF2000

ITRF2000 (Current Reference Realization of the ITRS) is intended to be a standard solution for geo-referencing and all Earth science applications. In addition to primary core stations observed by VLBI, LLR, SLR, GPS and DORIS, the ITRF2000 is densified by regional GPS networks in Alaska, Antarctica, Asia, Europe, North and South America and the Pacific.

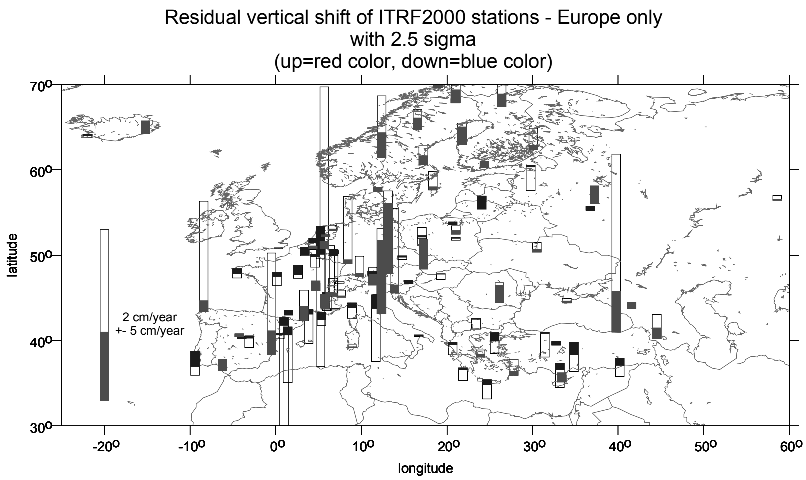

Figure 4

The ITRF2000 results show significant disagreement with the geological model NUVEL – 1A in terms of relative plate motions (*Altamimi et al., 2002a,b)*. Although the ITRF2000 orientation rate alignment to NNR-NUVEL-1A is ensured at the 1 mm/year level, regional site velocity diferrences between the two sites may exceed 3 mm/year. It should be emphasized that these differences do not at all disrupt the internal consistency of the ITRF2000, simply because the alignment defines the ITRF2000 orientation rate and nothing more. Moreover, angular velocities of tectonic plates which would be estimated using ITRF2000 velocities may significantly differ from those predicted by the NNR-NUVEL-1A model.

4. COMPARISON

Comparing the ITRF96 data – see Fig. 2 with residual vertical shifts of ITRF2000, we can see in Fig. 4, the same tendencies above all for the region of Fennoscandia and also for the region which can be delimited as the Turkey and eastern part of the Mediterranean Sea.

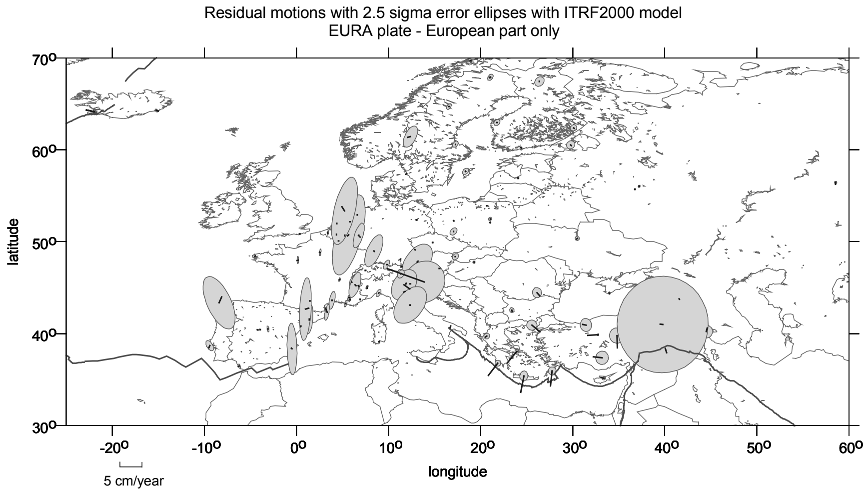

Figure 5

In Fig. 5, there are the same tendencies for horozontal shifts as in the Fig. 3 (ITRF96), still with greater probability. These tendencies are also residual shifts after *recomputation* of NUVEL1 by the method discussed in *Kostelecký, Zeman, 2000*. Evident it is above all also for the region of Turkey and eastern Mediterranean Sea. There is suspicious the border between Euroasian and African plates (red-coloured lines).

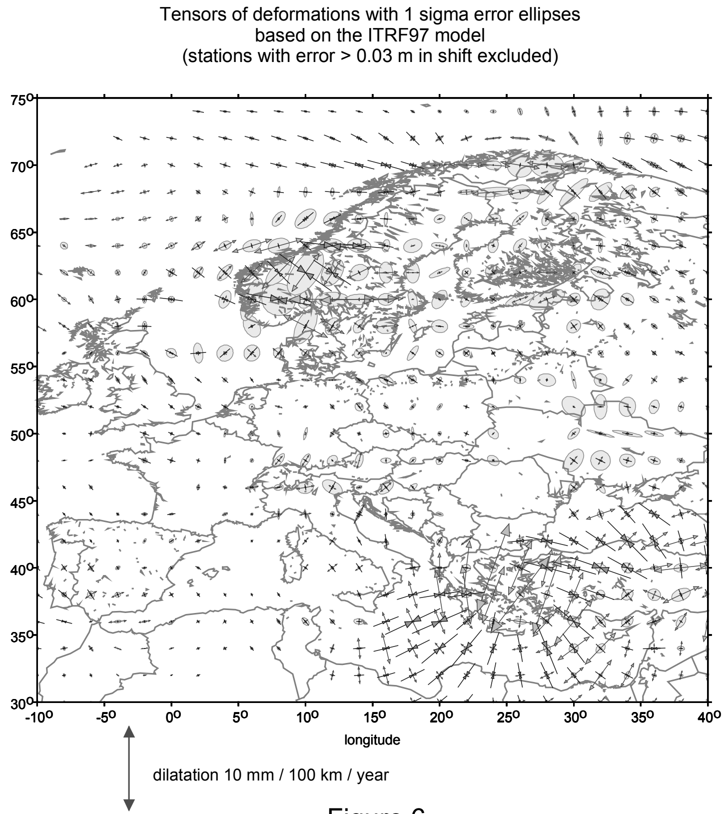

Figure 6

For comparison with ITRF96 still the data from realization of the ITRF97 reference frame were used – see (*Kostelecký (jr.), Kostelecký, Zeman, 2000*). Values of tensors of deformation at ITRF97 network in the region of Eastern Mediterranean (Turkey) follow from the fact that the stations are on the boundaryline of continental plates (African and Euroasian and along the meaningful North-Anatolian fault) – see Figs. 3, 5, 6 and 7. The ITRF2000 has, in contradiction to older models ITRF96 and ITRF97, new stations in Alpine region. Greater changes in this region based on ITRF2000 are detected due to these new GPS stations. The values of horizontal displacements at the region of Mediteranean (Apennines peninsula and the vicinity), show the same tendencies as contributed in tha papers *Devoti et al., 2000, Caporali et al., 2000, Anzidei et al., 2000* on the EGS General Assembly in 2000.

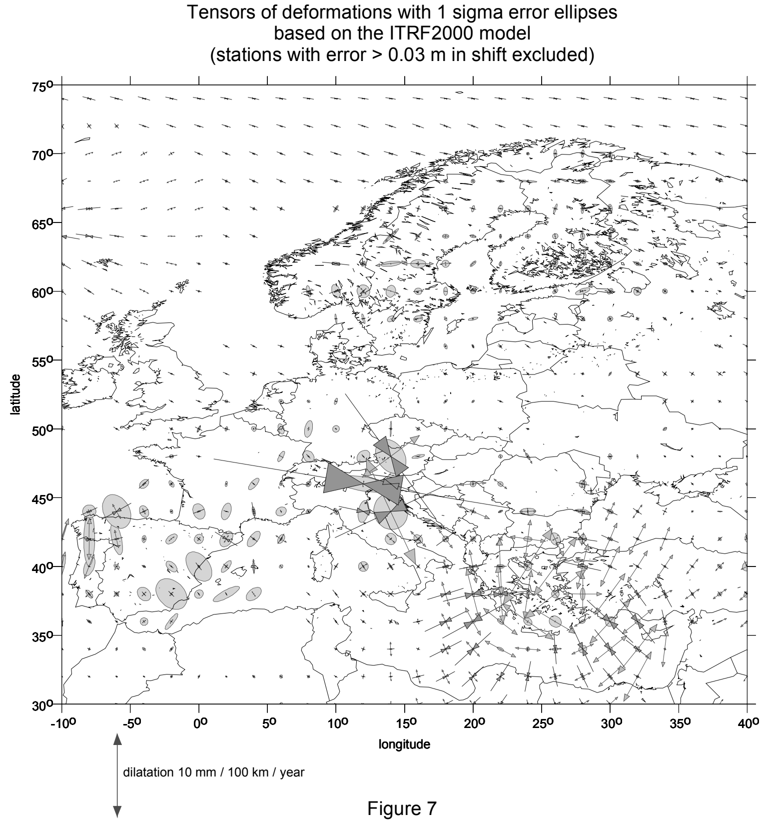

Figure 7

Relative vertical displacements from the Figure 8 are considerable. Dominant tendency to uplifts at the region of Fennoscandia is evident. This information is confirmed by interpolated areal expressions at the Figure 9.

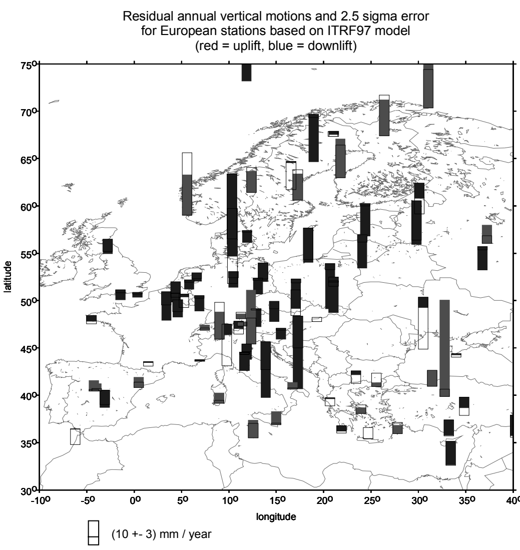

Figure 8

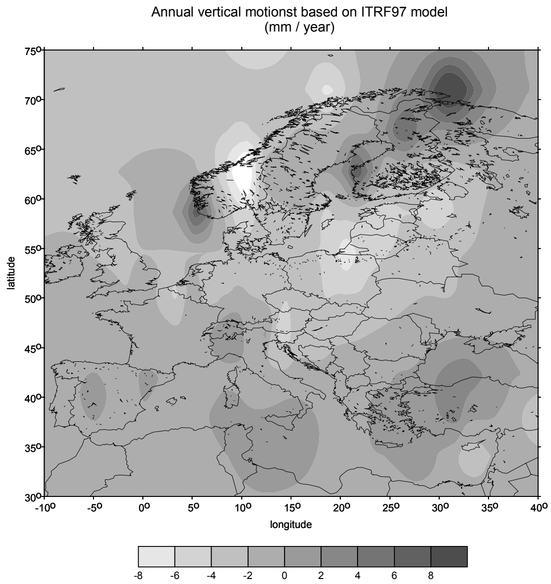

Figure 9

ACKNOWLEDGMENT

Authors are grateful appreciated to Ministry of Education, Youth and Sports of the Czech Republic for support of this work in the frame of projects LN00A005 and MSM210000007.

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