Lifetime of ETRS89 Coordinates

A. Caporali

University of Padova, Dept. of Geosciences, Via Gradenigo 6, 35131 Padova, Italy

M. Lidberg

Lantmateriaet, SE-801 82 Gaevle, Sweden

G. Stangl

Austrian Academy of Sciences and Bundesamt fuer Eich und Vermessungswesen, Schmiedlstr., 6, A-8042 Graz, Austria

Abstract

The coordinates assigned by EUREF to stations belonging to a national network complying with the ETRS89 system have no expiration date, since it is assumed that the rigid 7/14 parameter Helmert transformation connecting te ETRS to the ITRS compensates for every possible temporal change of coordinates, as required by National Mapping Agencies. As the velocities of several European stations have been determined with sub mm accuracy, it appears clear that the pattern of velocities in Europe is reproduced by a Helmert transformation only in the central part of the Continent, the so called 'stable part'. Elsewhere ETRF velocities of several mm/yr determine the epoch coordinates of approved stations to depart proportionally by the value they had at the time of the campaign approved by EUREF. In this paper we examine on the one hand the epoch of the last EUREF approved campaign for a number of Countries, and on the other hand the average velocity in that Country estimated by the latest densification of the ITRF in Europe. We set, as a working hypothesis, a threshold of discrepancy of 3 cm and estimate by linear extrapolation average time required by stations of a national network to have their coordinates departing by more than the threshold, due to the non rigid average velocity in that area.

1 Introduction

The definition of ETRS89, as well as the part of the EU Directive INSPIRE, make reference to the 'stable part' of Europe. By 'stable' it is meant that ITRF velocities of geodetic markers are very well approximated by a rigid transformation relative to the ITRF, so that it is sufficient to apply a Helmert transformation to the ITRF coordinates to obtain coordinates which will not change with time relative to the measurement epoch. If this concept were applicable everywhere in Europe, then a declaration of a set of coordinates as, e.g., Class B would have no expiration date. However residual velocities (horizontal <u>and</u> vertical) relative to the Eurasian pole do exist in various part of Europe. Because coordinates of campaigns are validated as realization of the ETRS89 *at the epoch of the campaign,* it makes sense to think about an expiration date, due to the drift cased by such residual velocities. On behalf of the TWG, Elmar Brockmann of Swisstopo is continuously monitoring the departure of the epoch coordinates of EPN stations computed weekly by the EPN Analysis Centers relative their expected ETRF2000 value.

2 Approach

National Mapping Agencies generally require coordinates which remain time invariant for a long time. On the other hand, local velocities of the order of few mm/yr can introduce distortions of the surveyed national networks of several cm after a few years, thus above the accuracy of the network at the epoch of measurement. Moreover, such distortions are laterally varying, mostly in response to the local tectonic properties, so that the distortion is not constant across the surveyed country.

Two possible countermeasures for the ‘non stable’ parts of Europe:

- Introduce local velocities so that the frame realization at epoch t=0 can be linearly mapped to any other epoch
- Do the realization more often, depending on the ‘intensity’ of the local velocity relative to the rigid body rotation of Eurasia

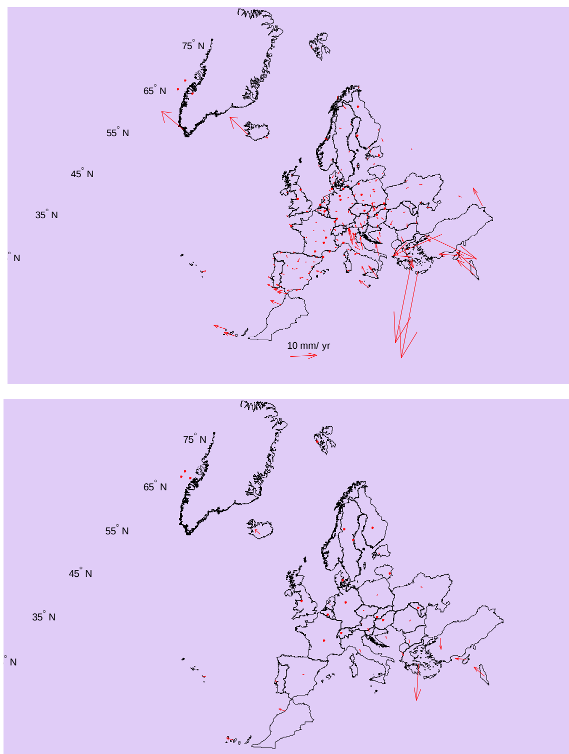

Figure 1 . Horizontal velocities of class A stations (above)and their average across the nations they belong to (bottom).

The first option is used e.g. by the Nordic Countries for the vertical coordinate, because the effect of the Glacial Isostatic Adjustment (GIA) on the local velocities is outside the scope of the transformation ITRF→ETRF.

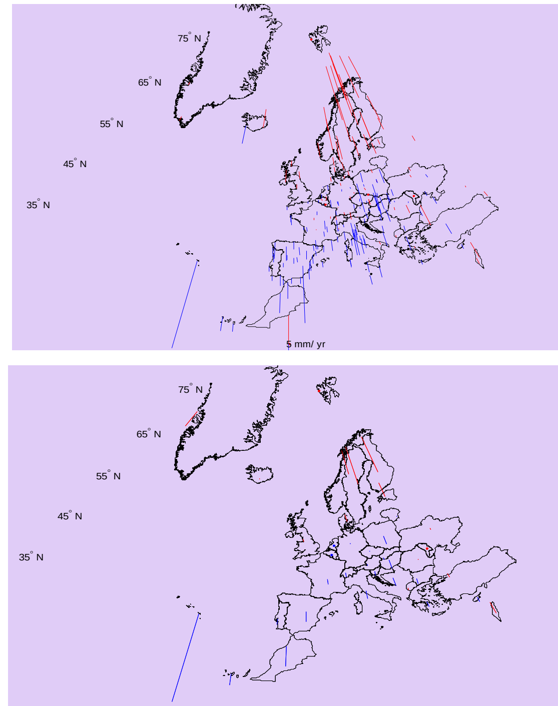

Figure 2. Vertical velocities of individual stations of class A (above), and average vertical velocities for each nation (below).

The second option is also a valid alternative but clearly requires an updating process which NMA’s may find hard to implement.

But regardless of the countermeasures one is going to adopt, the problem of expiration of validity of the coordinates needs to be studied more quantitatively and in more detail. To this purpose we map in Figure 1 the horizontal velocities relative to ETRF2000, as they result from a recent cumulative solution done at the EPN and identified as EPN_A_ETRF2000.SSC, and an average value for stations falling within one nation. Likewise in Figure 2 for the vertical part.

We associate one average velocity for all the EPN stations falling within one country, with the exception of Denmark (Greenland is treaded separately), Portugal (Azores have own velocity relative to Continental Portugal) and Spain (Canary islands have own velocity). For Iceland we introduce one velocity, in spite of the fact that the country is located in two adjacent tectonic units (North America and Eurasia) and, in a theoretical sense, would require two different frames.

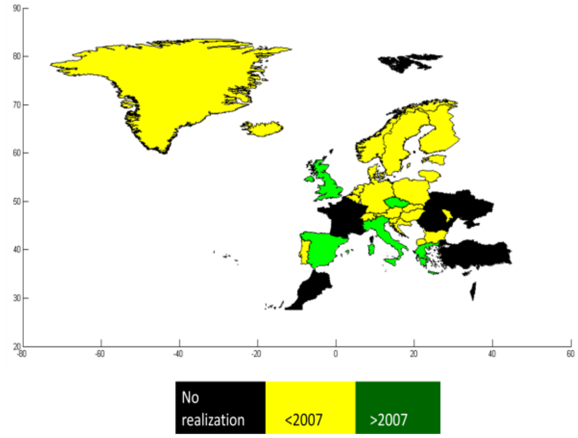

Figure 3. Summary (qualitative) of the status of the realization of ETRS89 in different Countries.

As a second input we require the epoch of realization of the ETRS89 for each country, when it exists. The data we have available are those archived for EUREF at the Data Center in Graz, and are as complete as possible, depending clearly also on the data providers. To avoid an excessive detail, we have considered in Figure 3 the cases in which a realization was done before or afterr the introduction of the ETRF2000, an epoch which we define as 2007.

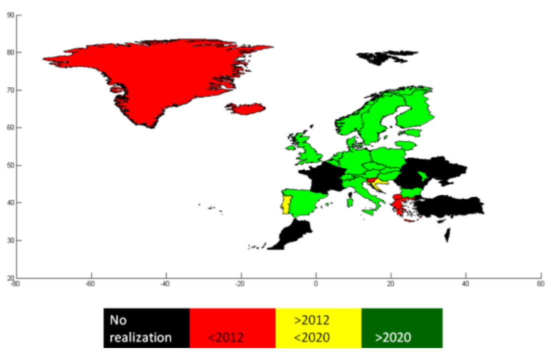

Figure 4. Expected lifetime of ETRS89 realizations in different Countries (horizontal part).

4 Results

Based on the data presented in the previous section we summarize in Figure 4 and 5 our estimates, for the horizontal and vertical part respectively, having set a threshold of discrepancy from the approved coordinates of 3 cm.

The intensity of the local velocity and the year of realization of frame play a comparable role when estimating the time at which the limit offset is reached. Generally, the countries affected in the vertical are different from those affected in the horizontal. More specifically we conclude that:

- Assuming 3 cm tolerance, we expect, for example
    - Nordic countries: ETRS89 at 2003; vertical excess in 2010; horizontal excess in 2052
    - Estonia: ETRS89 at 1997; vertical excess in 2008; horizontal excess in 2042
    - Poland:ETRS89 at 2001; vertical

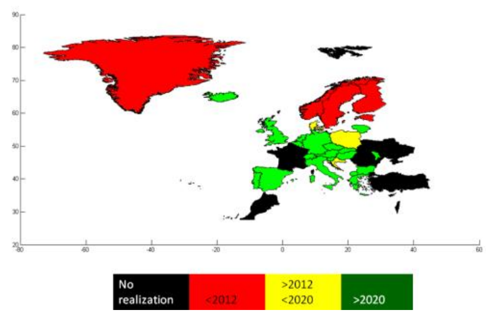

Figure 5 Expected lifetime of vertical ETRS89 coordinates.

    - excess in 2020; horizontal excess in 2031
    - Denmark:ETRS89 at 1994; vertical excess in 2015; horizontal excess in 2026
    - Greece: ETRS89 at 2010; vertical excess in 2037; horizontal excess in 2011

  - Croatia: ETRS89 at 1996; vertical excess in 2016; horizontal excess in 2013
  - Slovenia: ETRS89 at 1994; vertical excess in 2032; horizontal excess in 2006
  - Portugal: ETRS89 at 1995; vertical excess in 2021; horizontal excess in 2012
- All others >2020