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ETRS89 Realizations

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ETRS89 Definition

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- Resolution No 1, Firenze 1990
  - "recommends that the system to be adopted by EUREF will be coincident with ITRS at the epoch 1989.0 and fixed to the stable part of the Eurasian Plate and will be known as European Terrestrial Reference System 89 (ETRS89)"
  - "accepts that … for most applications, the coordinates will have no time variation"
- Resolution No 1, Bern 1992
  - "recommends that this solution *(Bernese solution of EUREF GPS 1989 campaign)* be accepted as the current realiastion of the ETRS89 under the name of EUREF89"

Conclusions from the definition

- "*fixed to the stable part*" implies that the ETRS is rotating "somehow" with the Eurasian plate
- "*no time variation*" implies the desire to avoid changes in time of the positions of European stations within the *stable part*
- The definition does not say anything about the realizations nor the reference epoch of the realizations

- The first realization (EUREF89) was based on SLR/VLBI-derived "fiducial stations" given in ITRF89 at epoch 1989.0

Main Topics

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- Source/basis of ETRS89 realizations
  - Campaigns
  - Distinct ITRFyy solution
  - EPN long-term solutions
  - ...
- Target function: What do we want to obtain?
  - Geodynamic link between ETRS89 and ITRS
  - Subsequent realizations independent from each other
  - Minimum "jumps" (residuals) between subsequent realizations at a specific epoch (or epochs?)

Most simple realization *based on a ITRFyy*

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Just fulfilling the requirement "fixed to the stable part":

- Take a realization of ITRS → ITRFyy
- Determine "somehow" rotation pole and rotation rate dr/dt of the Eurasian plate from this solution
- Select a reference epoch for the realization
- Move all European reference stations into the reference epoch by their ITRFyy-velocities
- Rotate them by the rotation angle r = dr/dt*(tref-1989.0) into the ETRS89 → ETRFyy

Remarks to the *Most simple realization*

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- Such a realization is completely independent from earlier realizations (unless the ITRFyy datum depends on earlier datums)
- In the early days the applied rotation was based on plate motion models
- Changes/uncertainties in the applied rotation *rate* will become more disturbing with time
- On the other hand the accuracy of the rate should increase with time (enough to cancel above effect?)
- Changes/uncertainties related to the datum realizations of subsequent ITRFyy may also lead to significant variations of positions in the ETRFyy counterpart

Improvements (1)

- Include additional parameters into the transformation ITRFyy→ETRFyy
  - To attenuate e.g., effects from changes in the datum
  - Mainly translations, proposal by Zuheir to also include translation rates
  - Proposal by Zuheir to leave the rotations as they are
- Various ways how to determine such additional parameters
  - Proposal by Zuheir to base these additional parameters on the values determined in the "memo"

Improvements (2)

- Refer all subsequent realizations ETRFyy to a reference realization, e.g., ETRF2000, i.e. extract and combine parameters from the memo in a way that they take into account the datum differences to ETRF2000 (actually between ITRFyy and ITRF2000)

Remark: The "memo values" are results from the global analysis, they are not specifically optimized for Europe

Rigorous Solution

- Select a reference realization ETRF00, e.g., ETRF2000
- Select max number of European stations
  - Present in both ETRF00 and ITRFyy with sufficiently long history
  - Lie in the "stable part" of Europe
- Move the stations into common reference epoch using respective velocities (ETRF00 and ITRFyy)
- Determine Helmert transformation parameters between the two sets of coordinates (least squares adjustment)
- Introduce the smallest possible number of parameters, e.g., 3 translations, 3 rotations
- Transform ALL European stations from ITRFyy → ETRFyy

Remarks to *Rigorous Solution*

- Rotation angles divided by (reference epoch – 1989.0) → approximate rotation rate of Euroasian plate
- They also contain contributions of systematic errors
- Translation parameters soak up systematic errors of datum realizations and errors of regional nature

- Parameters are mathematical transformation parameters and don't have to be physically interpreted → Formal errors are unimportant.

- Maintains full internal accuracy of the original ITRFyy solution
- Yields the smallest possible residuals/jumps w/r to the reference solution (vtPv = min) → closest to the users' needs

Open questions

- Introduction of additional reference stations into the parameter estimation (→ densified ITRF → EPN)

- Will ETRF01 replace ETRF00, ETRF02 replace ETRF01 etc as reference solution or
- ETRF00+ETRF01 be the next reference, then ETRF00+ETRF01+ETRF02 etc etc

- What to do with effects of time derivatives in the datum parameters of ITRFyy? Add additional parameters into the least squares adjustment?