The EUREF Densification of the ITRF2005

IAG Sub-commission for the European Reference Frame (EUREF)

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Introduction

The ITRF2005 (Altamimi et al, 2007a) includes coordinates and velocities for only part of the stations included in the EUREF Permanent Network (EPN, http://www.epncb.oma.be/), as in shown in **Figure 1**.

This document describes the densification of the ITRF2005 published by EUREF and based on the data from the EPN. The solution was validated by the EUREF Technical Working Group (TWG) at its meeting of Nov 3-4, 2008 in Munich (for details of the presented solution, see Kenyeres, 2008).

The EUREF ITRF2005 densification solution includes the list of ITRF2005 and ETRF2000 coordinates and velocities for the full EPN network (status Dec. 2005, up to GPS week 1355) and the associated SINEX file.

For the future updates of this densification solution, including ITRF2005 and ETRF2000 coordinates of recent EPN stations and taking into account station coordinate discontinuities occurring after Jan 1st, 2006, we refer to the "Remarks" section. These future updates will replace the present release.

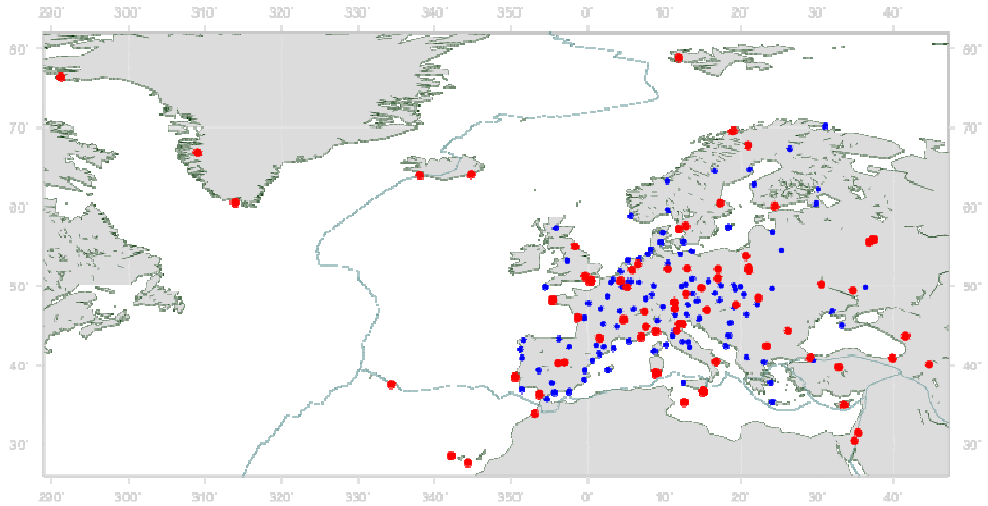


Figure 1- In red: ITRF2005 stations in the EPN region; in blue: stations included in the EPN until December 2005.

Methodology

Input

The weekly combined EPN solutions (available in SINEX format from the regional EPN data center at BKG, ftp://igs.bkg.bund.de/EUREF/products) between GPS week 860 and 1355 have been used as input. The solutions before GPS week 860 (June 1996) were not considered because of their lower quality. The upper limit of GPS week 1355 (Dec. 2005) was defined to be identical to the upper limit of the solutions contributing to ITRF2005. A full description of the weekly combined EPN solutions is available from http://www.epncb.oma.be/_dataproducts/products/combinedeurefsolution.php. As up to GPS week 1303, heavy constraints were used to tie the solution to the ITRF, these constraints were first removed before using the solution (details in Kenyeres, 2008).

Computation

The CATREF software (Altamimi et al, 2007b) was used to compute a long-term EPN solution from the weekly combined EPN solutions.

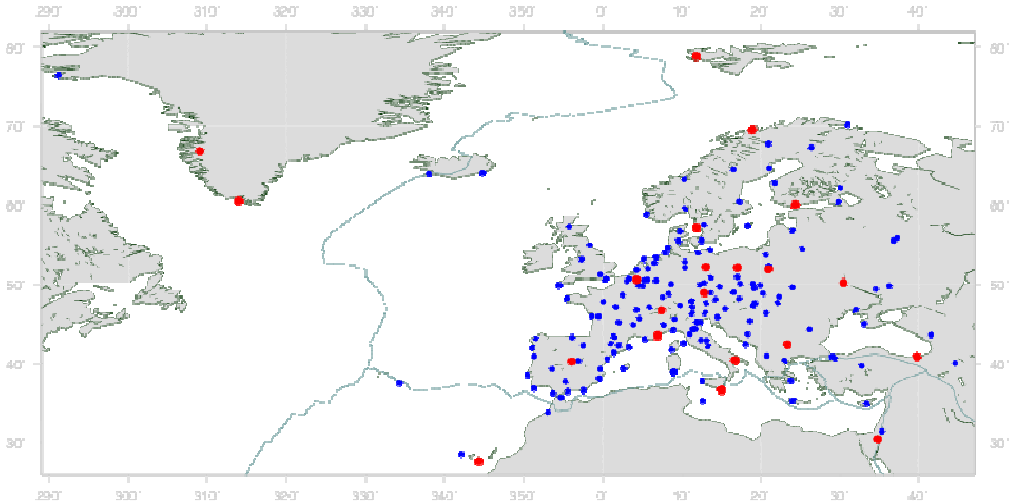


Figure 2 –In blue: stations included in the EPN until December 2005; in red: ITRF2005 reference stations used to tie the cumulative EPN solution to the ITRF2005 using minimal constraints.

The long-term EPN solution is tied to the ITRF2005 using minimal constraints on a selected set of ITRF2005 stations of the highest quality (with respect to spatial distribution, observation length, and coordinate repeatability); the reference stations are shown in Figure 2. In addition, this selection of reference stations guarantees an optimal agreement (negligible coordinate and velocity biases) with ITRF2005 (see "Validation"). The minimal constraints are applied on coordinates as well as velocities (each time 7 parameters).

To ensure the consistency with the ITRF2005, Figure 3 shows that during the computation, the station discontinuities identified by the IGS/ITRF (ftp://macs.geod.nrcan.gc.ca/pub/requests/sinex/discontinuities/ALL.SNX) were applied, resulting, for each ITRF2005 station in a set of solution numbers identifying the validity of a specific coordinate and/or velocity set.
For the EPN stations not included in the ITRF2005 and the IGS, the discontinuity table outcome of the EPN time series analysis was used (ftp://epncb.oma.be/pub/station/coord/EPN/EPNsoln.snx).

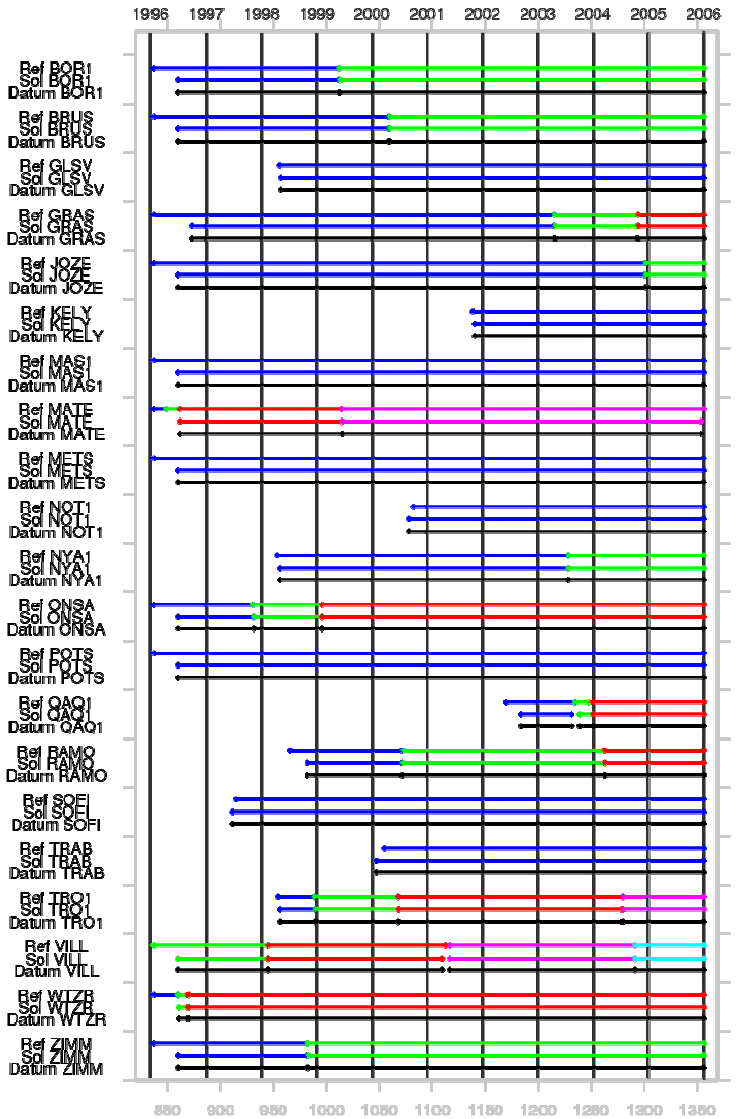


Figure 3 – ITRF2005 reference stations and their solution numbers as used within the EUREF densification of the ITRF2005 for each GPS week. For each reference station: line 1 shows the solution numbers as defined in the ITRF2005, line 2 shows the solution numbers as used in the long-term EPN solution, and line 3 indicates the GPS weeks that the station was used as a reference station in the minimal constraints. The different colors indicate when a new solution number is introduced (epochs with a station coordinate discontinuity).

Validation

The ITRF2005 densification validated by the EUREF TWG, agrees with the ITRF2005 within the 1 to 2 mm level for the horizontal and 8 mm for the vertical (comparison of coordinates at epoch 2000.0 as shown in Figure 4).

The comparison of the coordinates and velocities for the ITRF2005/EPN stations common between ITRF2005 and the long-term EPN solution also shows that there is no significant bias between the ITRF2005 and the EUREF densification of the ITRF2005 (see 4 for the comparison of the coordinates and 5 for the comparison of the velocities). In addition, no significant transformation parameters exist between both (see Table 1).

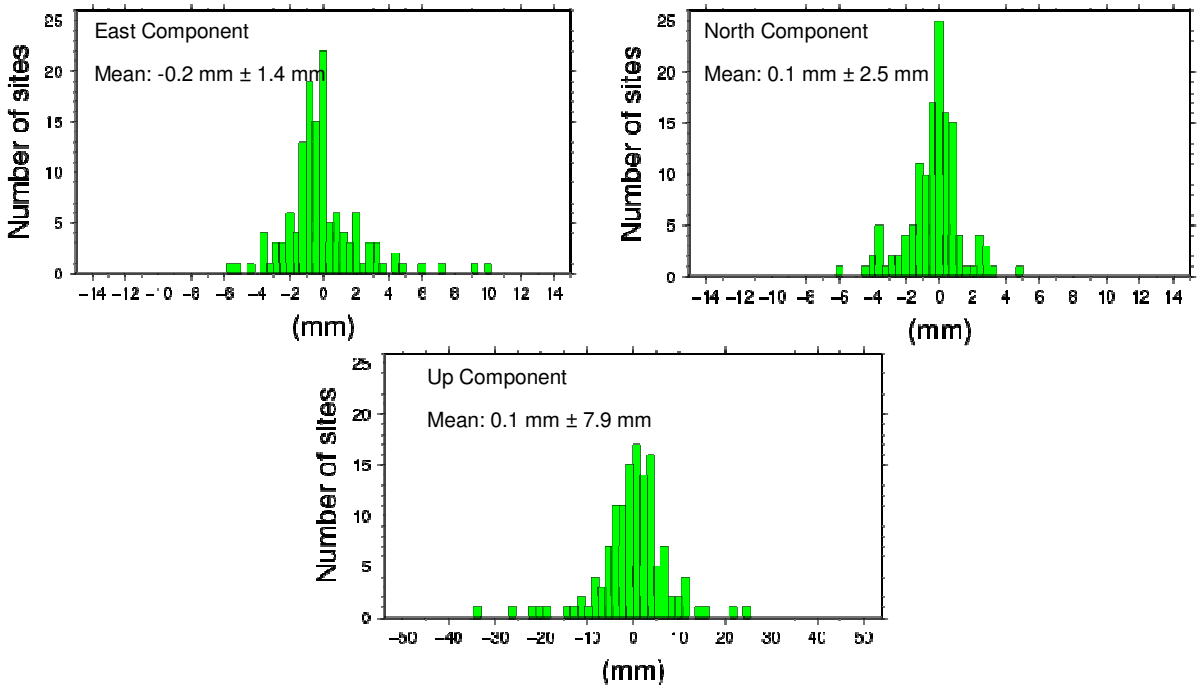
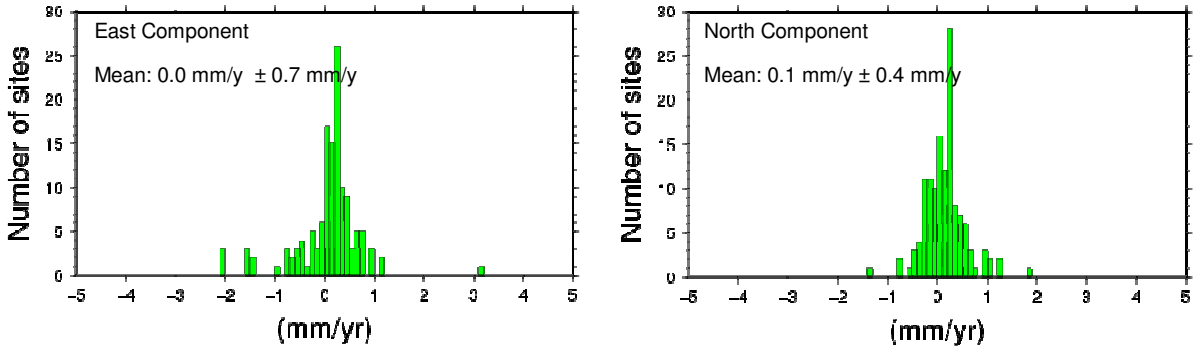


Figure 4- Histogram of the coordinate differences between the ITRF2005 and the EUREF densification of the ITRF2005 (epoch 2000.0)



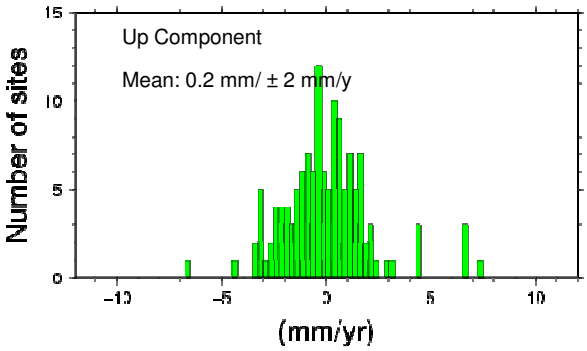


Figure 5- Histogram of the velocity differences between the ITRF2005 and the EUREF densification of the ITRF2005.

	TX cm	*TY* cm	*TZ* cm	*S* 10-9	*RX* mas	*RY* mas	*RZ* mas
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
stdev	0.282	0.313	0.243	0.332	0.094	0.102	0.083

	$\dot{TX}$ cm/yr	$\dot{TY}$ cm/yr	$\dot{TZ}$ cm/yr	$\dot{S}$ 10-9/yr	$\dot{RX}$ mas/yr	$\dot{RY}$ mas/yr	$\dot{RZ}$ mas/yr
	-0.123	0.039	0.076	0.038	0.008	0.046	-0.012
stdev	0.282	0.313	0.243	0.332	0.094	0.102	0.083

Table 1- Transformation parameters between the EUREF densification of the ITRF2005 and the ITRF2005 itself.

Access and Terminology

The official EUREF densification of ITRF2005 is available from the EPN Central Bureau:

- In the ITRF2005 frame:
  - Coordinate and velocity list, referred to as "EPN_C1355(ITRF2005)": ftp://epncb.oma.be/pub/station/coord/EPN/EPN_ITRF_C1355.SSC
  - SINEX file: ftp://epncb.oma.be/pub/station/coord/EPN/EPN_ITRF_C1355.SNX.Z
- In the ETRF2000 frame:
  - Coordinate and velocity list referred, to as "EPN_C1355(ETRF2000)": ftp://epncb.oma.be/pub/station/coord/EPN/EPN_ETRF_C1355.SSC

Since the EUREF symposium 2008, Brussels, the ETRF2000 is considered as the conventional reference frame for the ETRS89. The ITRF2005 coordinates and velocities have been transformed to ETRF2000 according to procedure described in (Altamimi and Boucher, 2008).

Remarks

Usage of the coordinates and velocities of the EUREF Densification:

Antenna models

The EUREF densification of the ITRF2005 is based on relative antenna phase models. As since GPS week 1400 (Nov. 2006), absolute antenna models are used by the EPN analysis centers, the comparison/combination of the published coordinates with the actual coordinates from the EPN weekly solutions is critical (vertical differences up to 3 cm due to the different antenna models). A complete reprocessing of the EPN using absolute antenna models will be performed in the future in order to provide long-term EPN products compatible with the absolute antenna models.

Extrapolation of the published coordinates

When extrapolating the published coordinates to an ulterior epoch, it is mandatory to verify the formal errors of the velocity estimates (they are included in the SSC file). Stations with less than 2 years observation history, velocity formal errors higher than 1 mm/year in any component (they are listed in the bottom of the SSC file), or ETRF2000 velocities higher than 2 mm/year for the horizontal component should be used with care.

In addition, the EUREF densification of the ITRF2005 does not include any EPN data after Jan 1, 2006 and does not take into account any coordinate jumps (e.g. the ones caused by the change of the antenna model at GPS week 1400). Consequently, before using the published coordinates and velocities for observation epochs after Jan 1, 2006, it is necessary to check the time series of these stations (see http://www.epncb.oma.be/_dataproducts/products/timeseriesanalysis/) to inspect if the station behaved in a stable manner since Jan 1st, 2006 and no significant coordinate or velocity discontinuities were introduced for this station after that date (ftp://epncb.oma.be/pub/station/coord/EPN/EPNsoln.snx).

Future updates of the EUREF densification of the ITRF2005:

The present release of the ITRF2005 densification does not take into account any of the EPN data gathered after Jan 1st, 2006 and consequently does not reflect the most recent status of the EPN. As explained above, its usage is therefore limited. To remedy to this problem, the EUREF TWG decided at its meeting of Nov 3-4, 2008 in Munich, to release in the future regular official updates of the ITRS/ETRS89 coordinates/velocities of the EPN stations. Once published, the updated values will replace those from the presently published SSC and SINEX files. More information, including the exact location of the updated solutions and the frequency of the updates, will follow later.

References

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Altamimi, Z., Sillard, P., Boucher, C., 2007b. CATREF software: Combination and Analysis of Terrestrial Reference Frames. LAREG Technical, Institut Géographique National, Paris, France.

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Kenyeres, A., 2008. Analysis and validation of the ITRF2005 densification solution created by the EPN Time Series Analysis Project, available from http://www.euref.eu/TWG/EUREF TWG minutes/ .