



Realisation of ETRS89 in German State Survey

Heinz Habrich

EPN Analysis Coordinator

Federal Agency for Cartography and
Geodesy, Frankfurt, Germany

Scope

- ETRS89 Realisation in general
- Introduction of ETRS89 into German reference frame

Conclusions from ETRS89 Definition (1/2)

- Definition: „ETRS89 is coincident with ITRS at epoch 1989.0“
- Definition does **not** include a „**continuity restriction**“ for successive ETRF realisations
 - Discontinuity between particular ETRFs is permitted
 - Realisation of particular ETRF is possible without consideration of any former ETRF
- ETRF coordinates could be considered „static“ within **only one** particular realisation, e.g., the ETRF that was adopted as national reference

Conclusions from ETRS89 Definition (2/2)

- A pan-European and static ETRF may be realised with not better than a few cm accuracy
 - Alternatively the definition of ETRS89 must be changed (respectively extended)
 - We may expect that future ETRF realisations will coincide more and more between each other. The adoption of a new ETRF as national reference by the European countries will lead to better pan-European coincidence.

ETRF Labelling ?

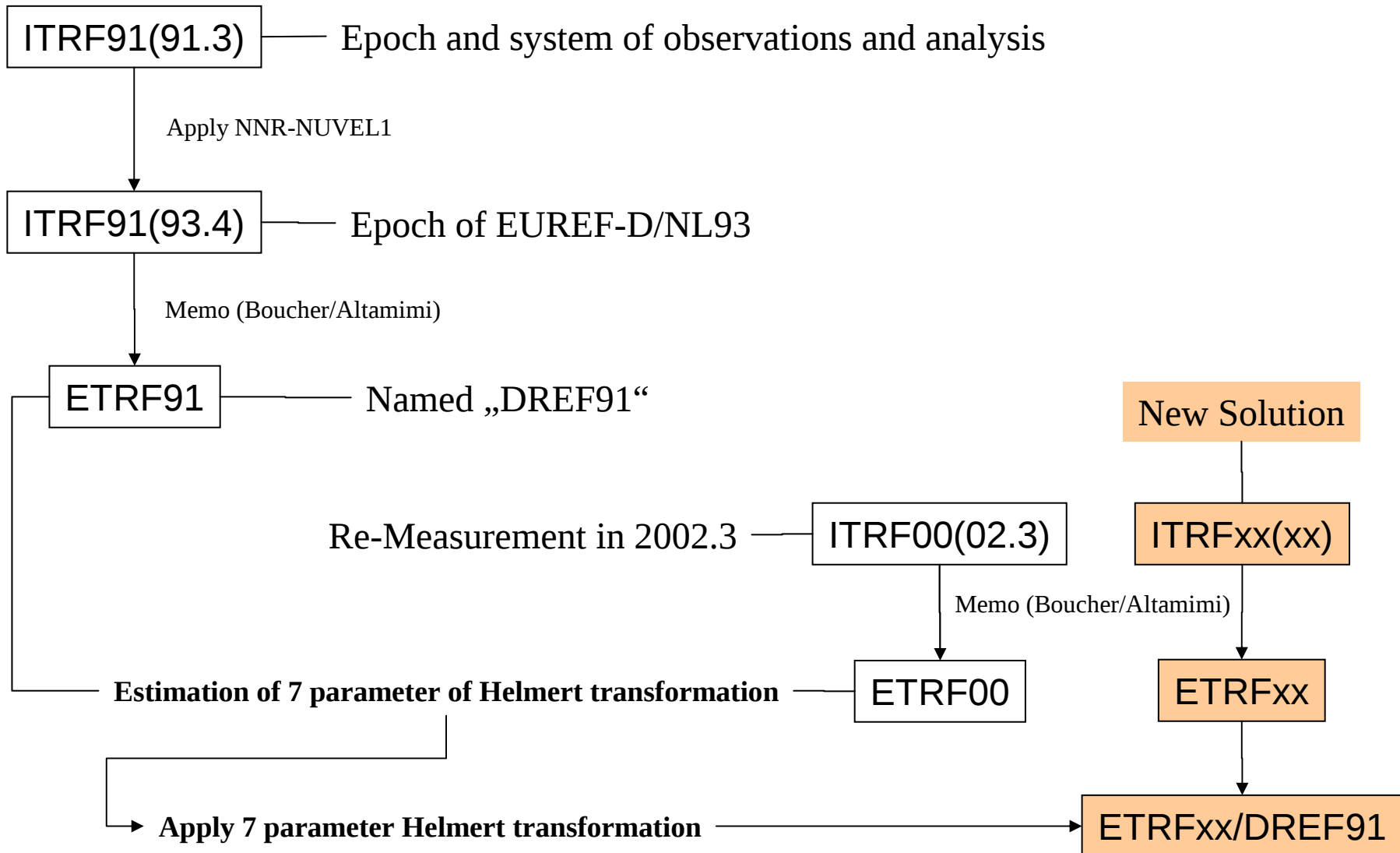
■ ETRF_{xx}

- xx = Epoch of realisation (adoption of datum), not measurement epoch
- Example:
 - ❖ Measurement in 2007 → ITRF05(07)
 - ❖ Transformation → ITRF00(07)
 - ❖ Transformation → **ETRF00 ?**

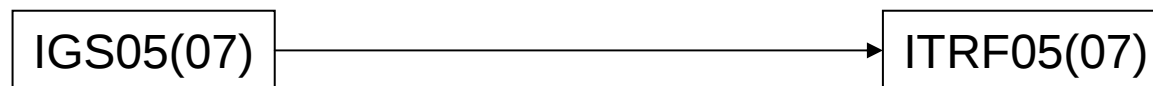
Adoption of ETRF for EPN

- EPN should adopt the most recent ITRF realisation to meet the highest scientific accuracy
- We could easily transform existing EPN solutions into a new EPN reference and thus provide always consistent time series
- Example:
 - Adopt ITRF2005 as reference for EPN
 - Use transformation ITRF05 → ETRF05 for new products
 - Transform existing products following ITRFxx → ITRF05 → ETRF05

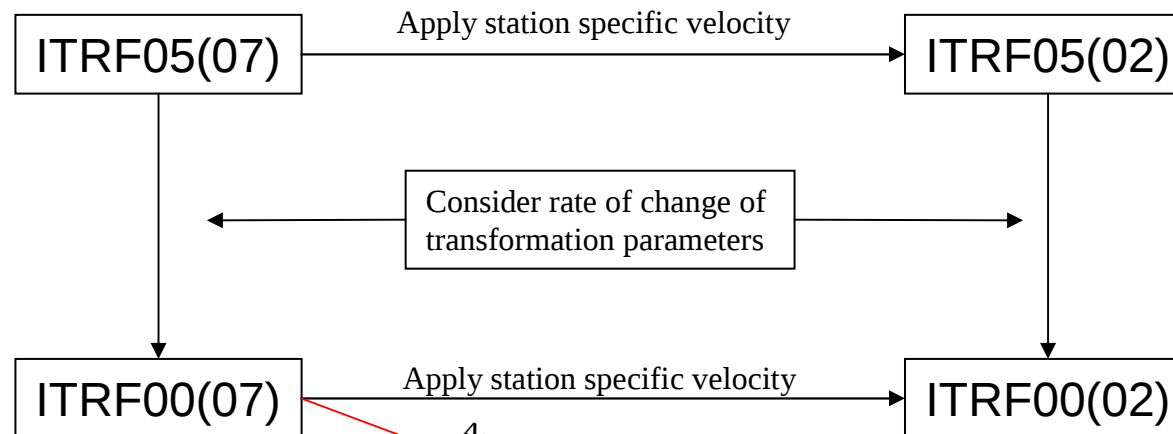
ETRS89 in German State Survey



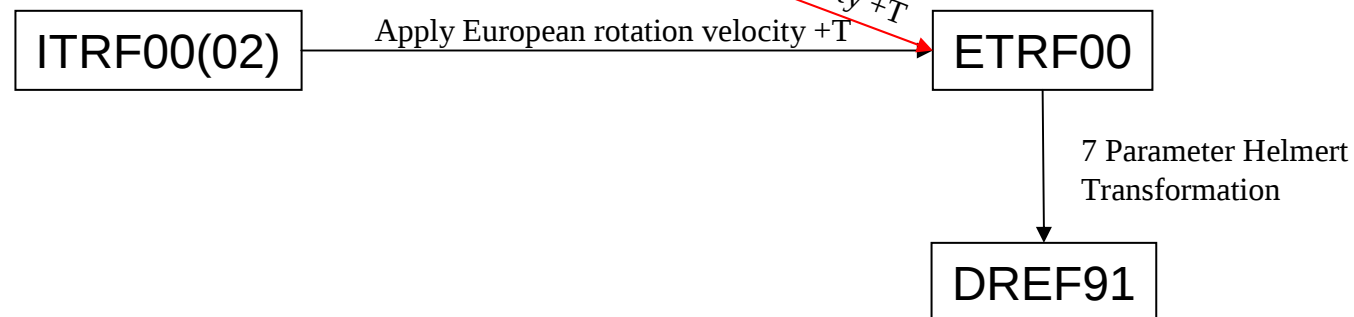
A



B



C

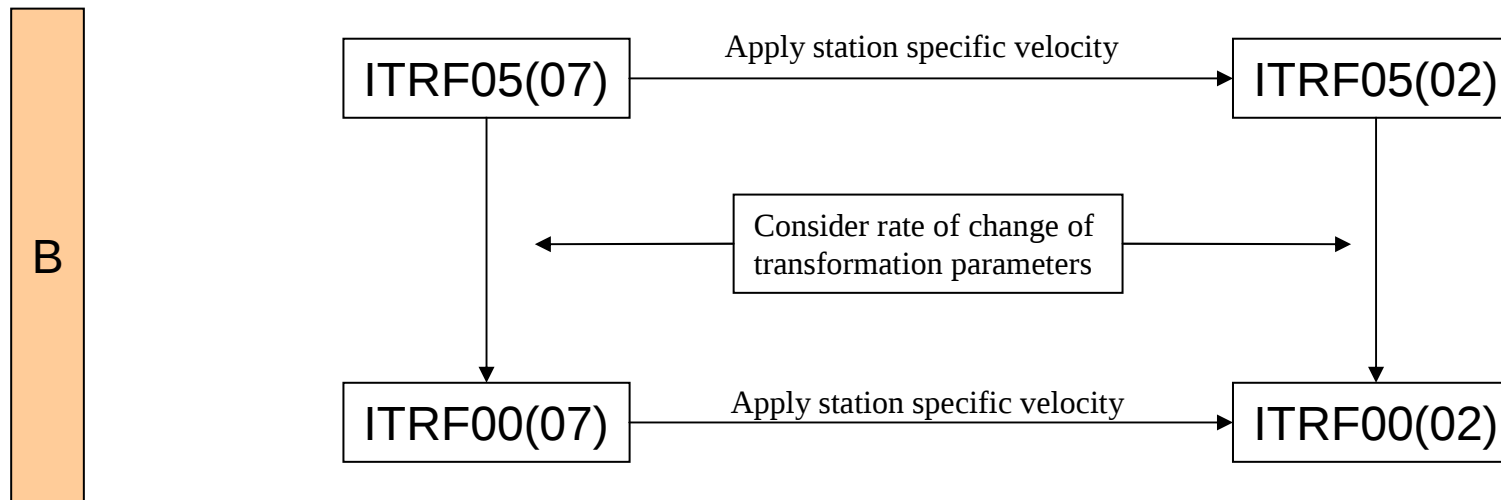


A

IGS05(07)

ITRF05(07)

- IGS05 and ITRF05 aligned on the global level
- „zero“ transformation parameters
- Station-specific height differences
- Recommendation:
 - Apply IGS05 reference coordinates if absolute PCVs are applied in data analysis
 - Apply ITRF05 reference coordinates, if relative PCVs are applied in data analysis

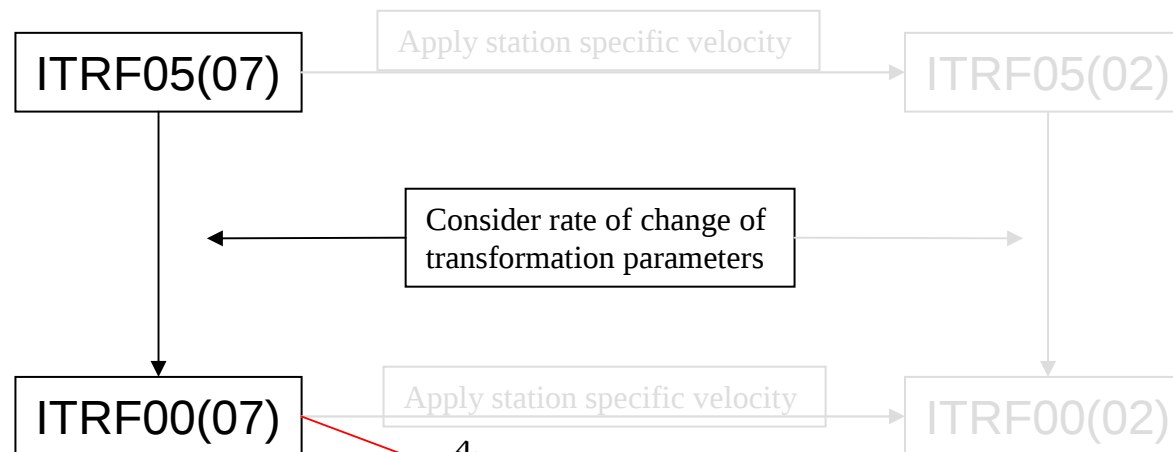


- For most consistent ITRF-to-ETRF transformation start from ITRF00(02) (the system ***and*** epoch adopted for ETRS89 in Germany)
- Transformation from ITRF05(07) to ITRF00(02) applying ITRF05 or ITRF00 velocities, which consider even intra-plate movements of the stations for the epochs 2007 to 2005, but are not available for new stations. Thus,
 - we need a general velocity field for Europe or
 - we start transformation from ITRF00(07)

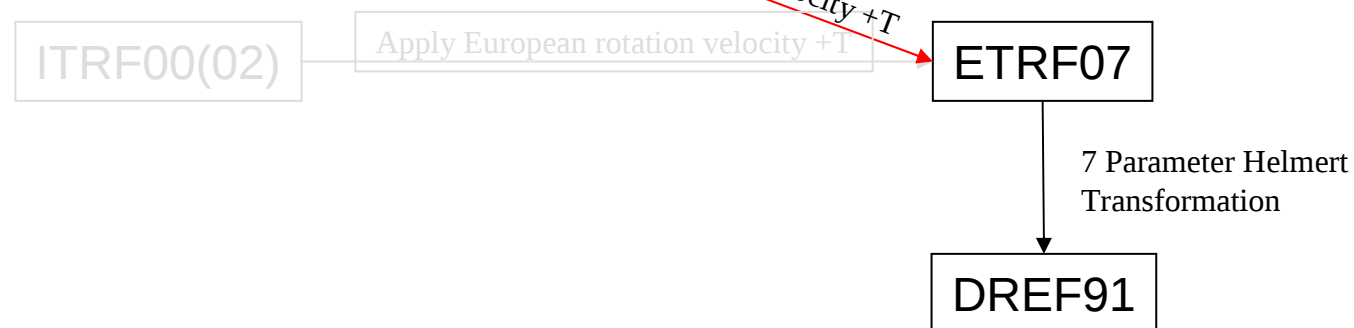
A



B



C



ETRS89 in German State Survey – 3 Steps

	T1	T2	T3	D	R1	R2	R3
	mm	mm	mm	10-9	mas	mas	mas
	0.1	-0.8	-5.8	0.40	0.000	0.000	0.000
+/-	0.3	0.3	0.3	0.05	0.012	0.012	0.012
Rates	-0.2	0.1	-1.8	0.08	0.000	0.000	0.000
+/-	0.3	0.3	0.3	0.05	0.012	0.012	0.012

Transformation parameters at epoch 2000.0 and their rates from ITRF2005 to ITRF2000
(ITRF2000 minus ITRF2005)

convert in ETRS89 at t_c :

$$X^E(t_c) = X_{YY}^I(t_c) + T_{YY} + \begin{pmatrix} 0 & -\dot{R}_{3YY} & \dot{R}_{2YY} \\ \dot{R}_{3YY} & 0 & -\dot{R}_{1YY} \\ -\dot{R}_{2YY} & \dot{R}_{1YY} & 0 \end{pmatrix} \times X_{YY}^I(t_c) \cdot (t_c - 1989.0)$$

05	A	5.6	4.8	-3.7
----	---	-----	-----	------

05	0.054	0.518	-0.781
	±0.009	±0.006	±0.011

T1= -6.39 cm
T2= 9.39 cm
T3= -5.32 cm
SCL = 0.0109 mm/km
R1= -2.40 mas
R2= -0.80 mas
R3= 2.30 mas

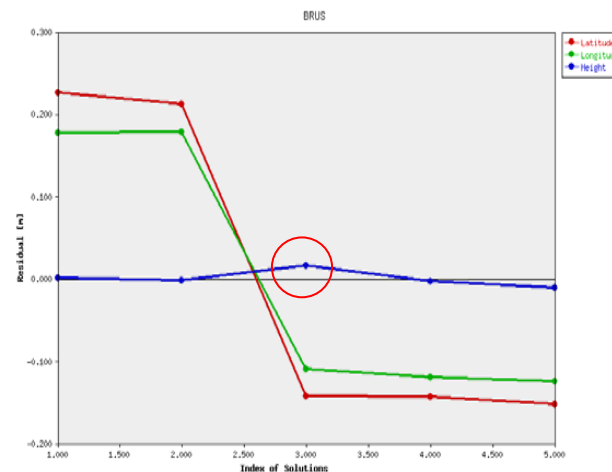
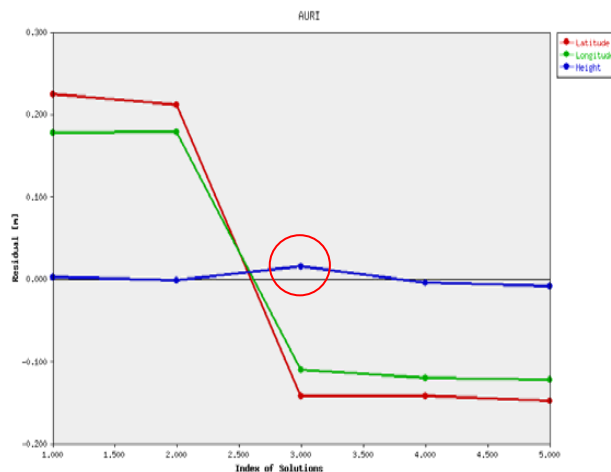
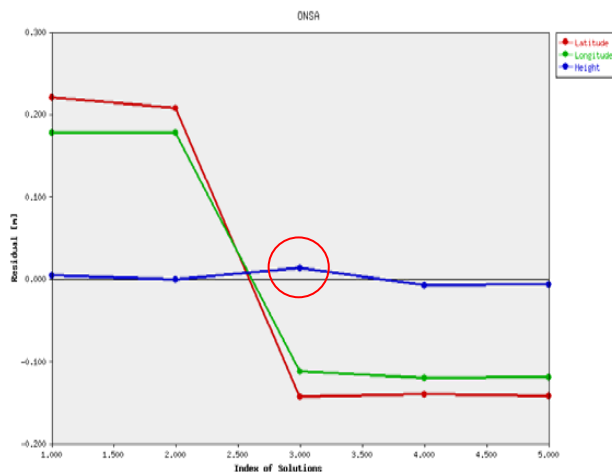
Merge 3 steps into one formula, within 1 mm accuracy?

Example DREF-Online

- Currently 5 coordinate solutions available per week :
 - IGS05
 - ITRF2000
 - ETRF/ITRF05 (ITRF2005 → ETRF05)
 - ETRF/ITRF00 (ITRF2000 → ETRF00)
 - DREF91/ITRF00 (ITRF2000 → ETRF00 → DREF91)
- In the following:
 - The 5 solutions are compared for 6 selected stations.

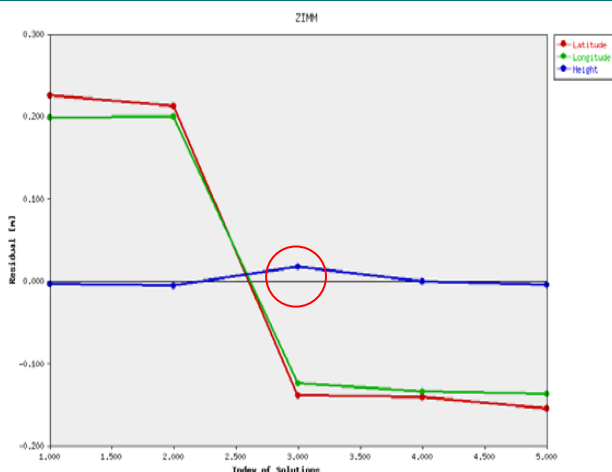
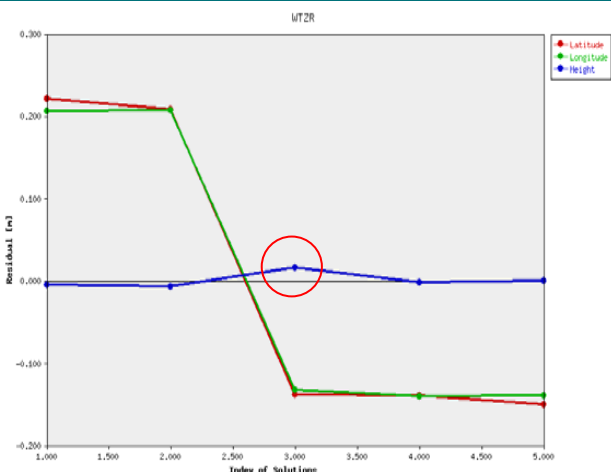
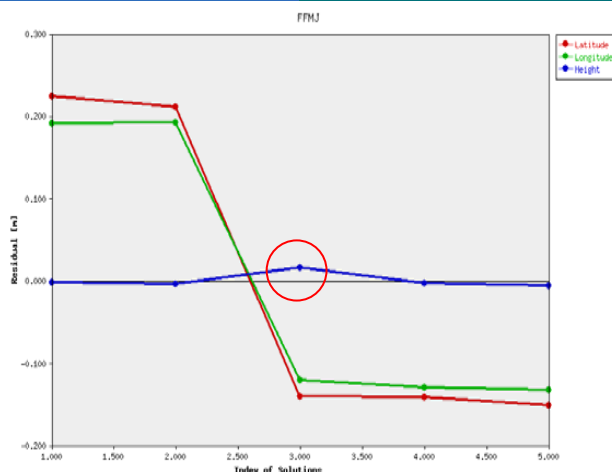
DREF-Online

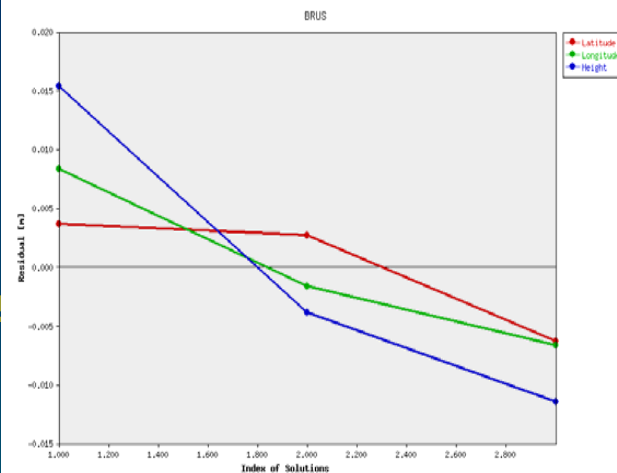
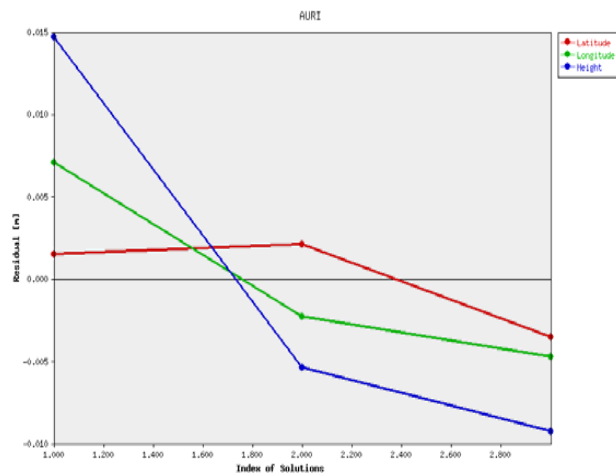
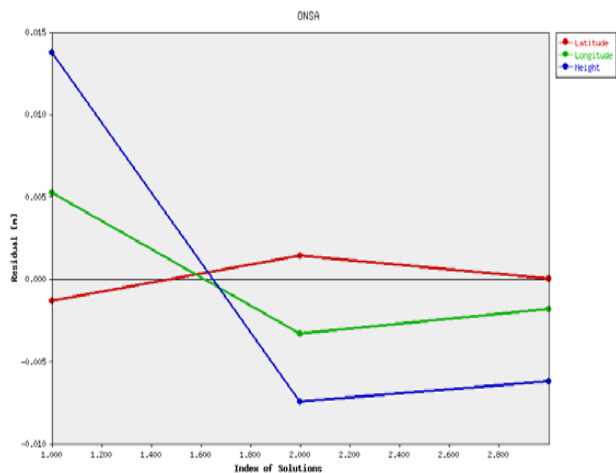




IGS05
ITRF2000
ETRF/ITRF05
ETRF/ITRF00
DREF91/ITRF00

Even for identical heights in IGS05 compared to ITRF2000, the heights change significantly for the ITRF2005 to ETRF transformation



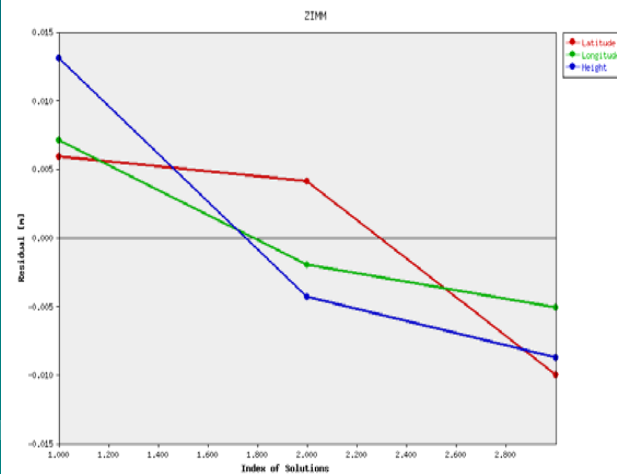
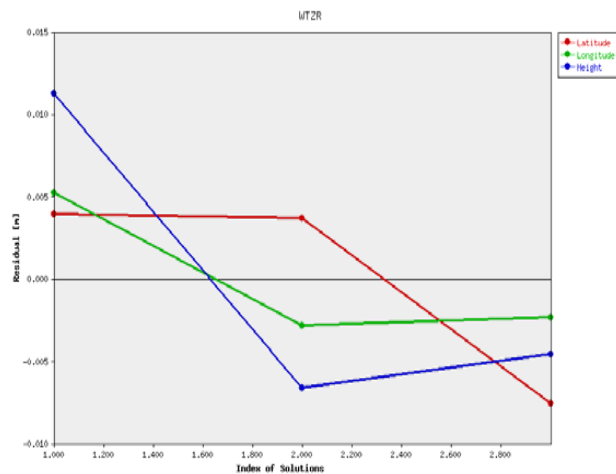
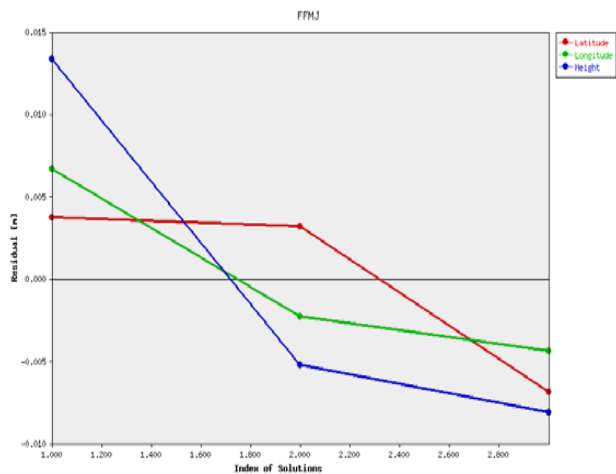


ETRF/ITRF05

ETRF/ITRF00

DREF91/ITRF00

Differences in ETRF realisations:
 Max Δ Latitude 1.3 cm
 Max Δ Longitude 1.6 cm
 Max Δ Height 2.5 cm



Note

- The coordinate differences as shown in the comparison result from the different network alignment, as could be confirmed by the following Helmert transformations.

IGS05 → ITRF2000

Helmert Transformation

NUMBER OF PARAMETERS : 7

NUMBER OF COORDINATES : 195

RMS OF TRANSFORMATION : 0.0 MM

PARAMETERS:

TRANSLATION IN X : -11.6 +- 0.1 MM

TRANSLATION IN Y : -3.4 +- 0.2 MM

TRANSLATION IN Z : 13.9 +- 0.1 MM

ROTATION AROUND X-AXIS: 0 0 0.00004 +- 0.00001 "

ROTATION AROUND Y-AXIS: - 0 0 0.00014 +- 0.00000 "

ROTATION AROUND Z-AXIS: - 0 0 0.00001 +- 0.00000 "

SCALE FACTOR : -0.0000 +- 0.0000 MM/KM

ETRF/ITRF05 → ETRF/ITRF00

Helmert Transformation

NUMBER OF PARAMETERS : 7

NUMBER OF COORDINATES : 195

RMS OF TRANSFORMATION : 0.1 MM

PARAMETERS:

TRANSLATION IN X : 3.8 +- 0.2 MM

TRANSLATION IN Y : 7.2 +- 0.3 MM

TRANSLATION IN Z : -30.6 +- 0.2 MM

ROTATION AROUND X-AXIS: - 0 0 0.00057 +- 0.00001 "

ROTATION AROUND Y-AXIS: 0 0 0.00066 +- 0.00001 "

ROTATION AROUND Z-AXIS: 0 0 0.00023 +- 0.00001 "

SCALE FACTOR : 0.0003 +- 0.0000 MM/KM

Thank you