IAG/FIG Commission 5/ICG Technical Seminar

Reference Frame in Practice

Rome, Italy 4–5 May 2012

SESSION 1.2

REGIONAL AND NATIONAL REFERENCE SYSTEMS

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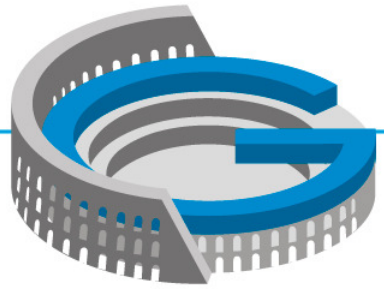
SUMMARY

- ***About Sub-commission 1.3***
  "Regional Reference Frames"
- ***Similarity transformations in space:***
  a short review
- ***The case of ETRS89:***
  definition and realization (ETRF)
- ***Practical examples:***
  computation and comparison of realizations
- ***Discussion***



IAG COMMISSIONS

- *Commission 1 Reference Frames*
- *Commission 2 Gravity Field*
- *Commission 3 Earth Rotation and Geodynamics*
- *Commission 4 Positioning and Applications*

COMMISSION 1 – REFERENCE FRAMES

SUBCOMMISSIONS

- *SC1.1: Coordination of Space Techniques*
- *SC1.2: Global Reference Frames*
- *SC1.3: Regional Reference Frames*
- *SC1.4: Interaction of Celestial and Terrestrial Reference Frames*

1- About Sub-commission 1.3

Main objectives:

- Develop specifications for the **definition and realization of regional reference frames**, including the **vertical component**…

- Coordinate activities of the regional sub-commissions focusing on **exchange and share of competences and results**

- Develop and promote **operation of GNSS permanent stations** … to be the basis for the long-term … of **regional reference frames**

- Promote the actions for the **densification of regional velocity fields**

- Encourage and assist, within each regional sub-commission, **countries to re-define** and modernize their **national geodetic systems**, compatible with the **ITRF**

1- About Sub-commission 1.3

Working Group
Integration of Dense Velocity Fields into the ITRF

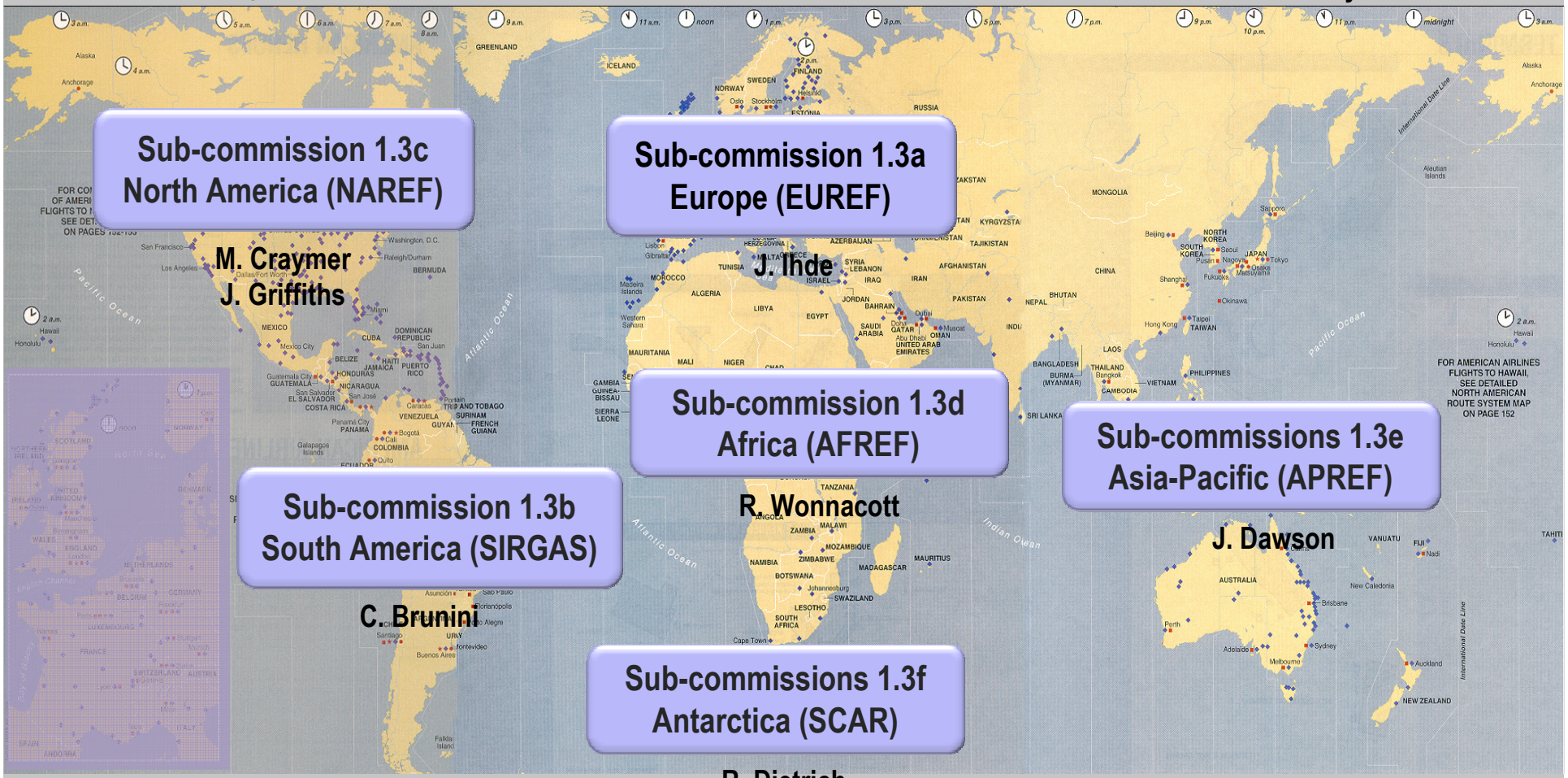
C. Bruyninx

Sub-commission 1.3
Regional Reference Frames

J. Torres

Working Group
Deformation Models for Reference Frames

R. Stanaway



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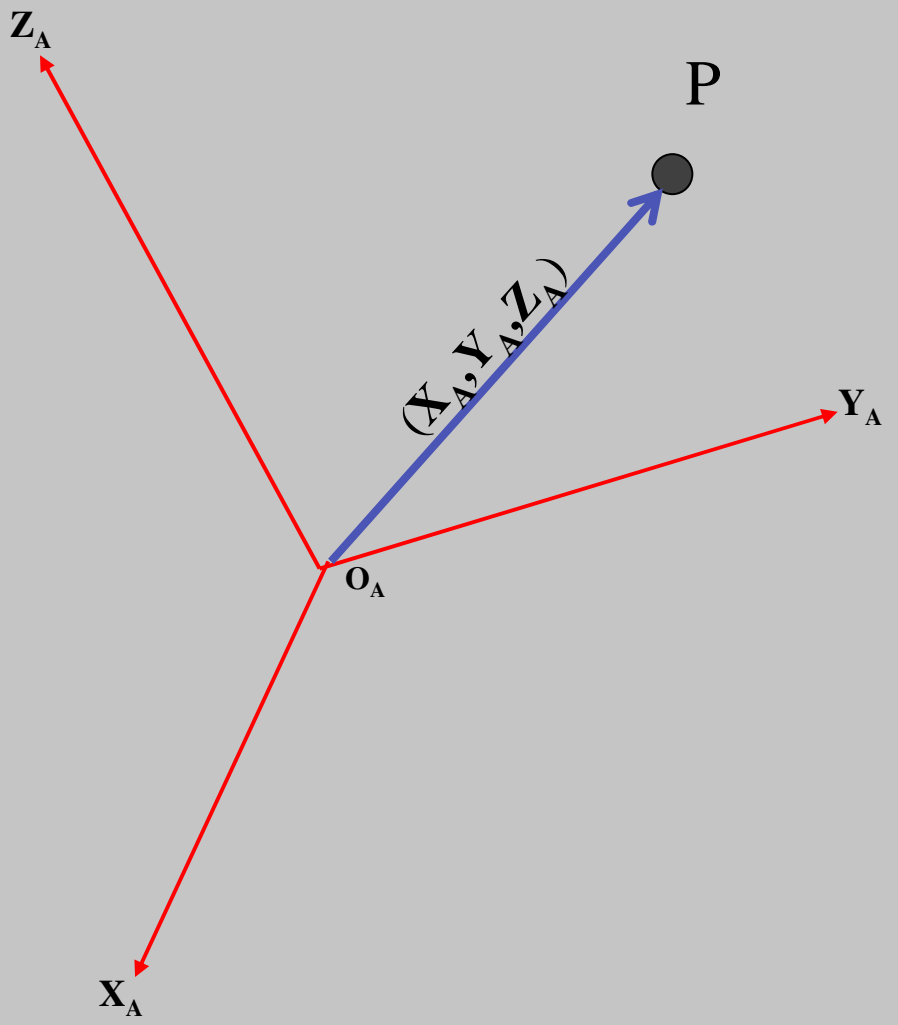
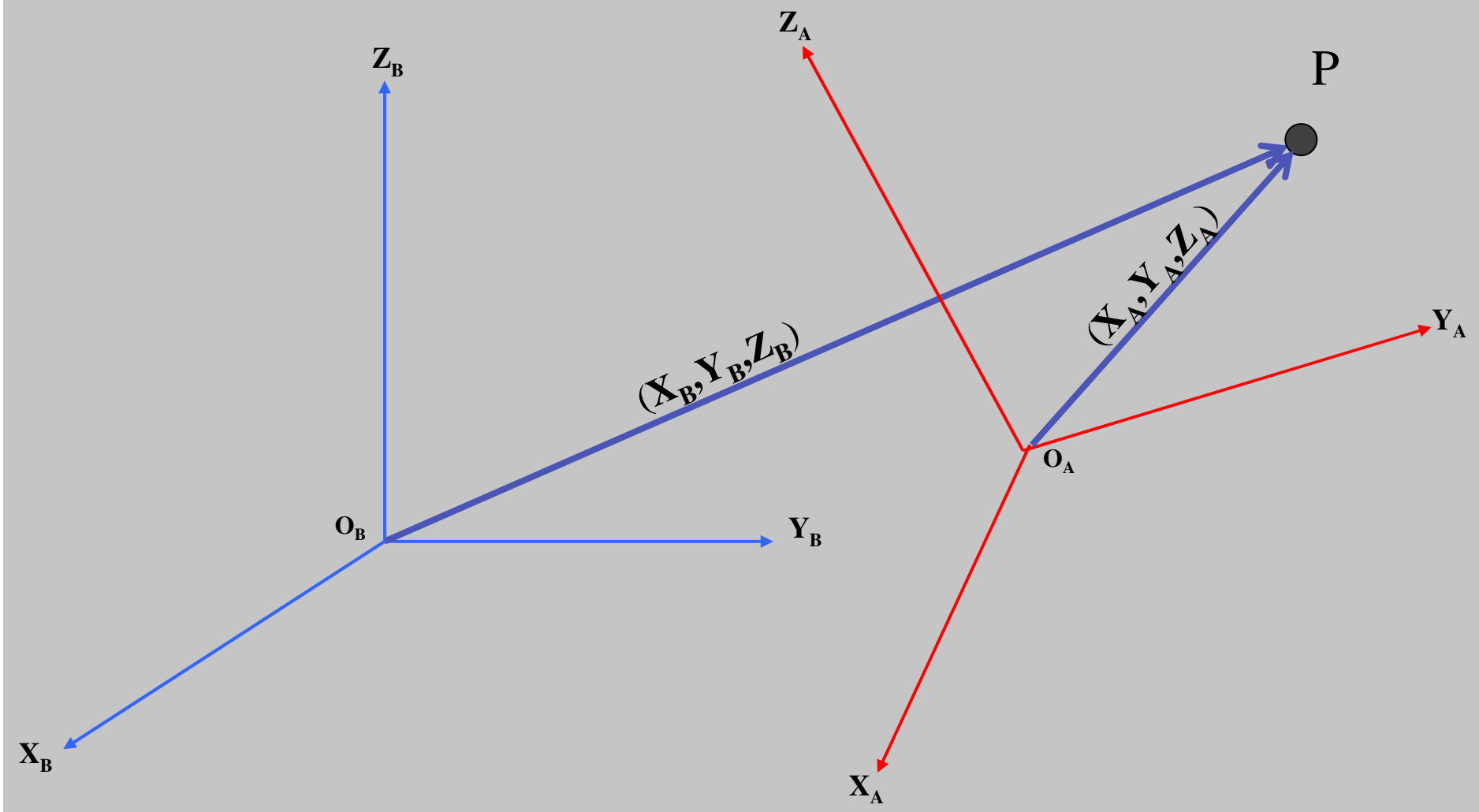
2- Similarity transformations in space



2- Similarity transformations in space



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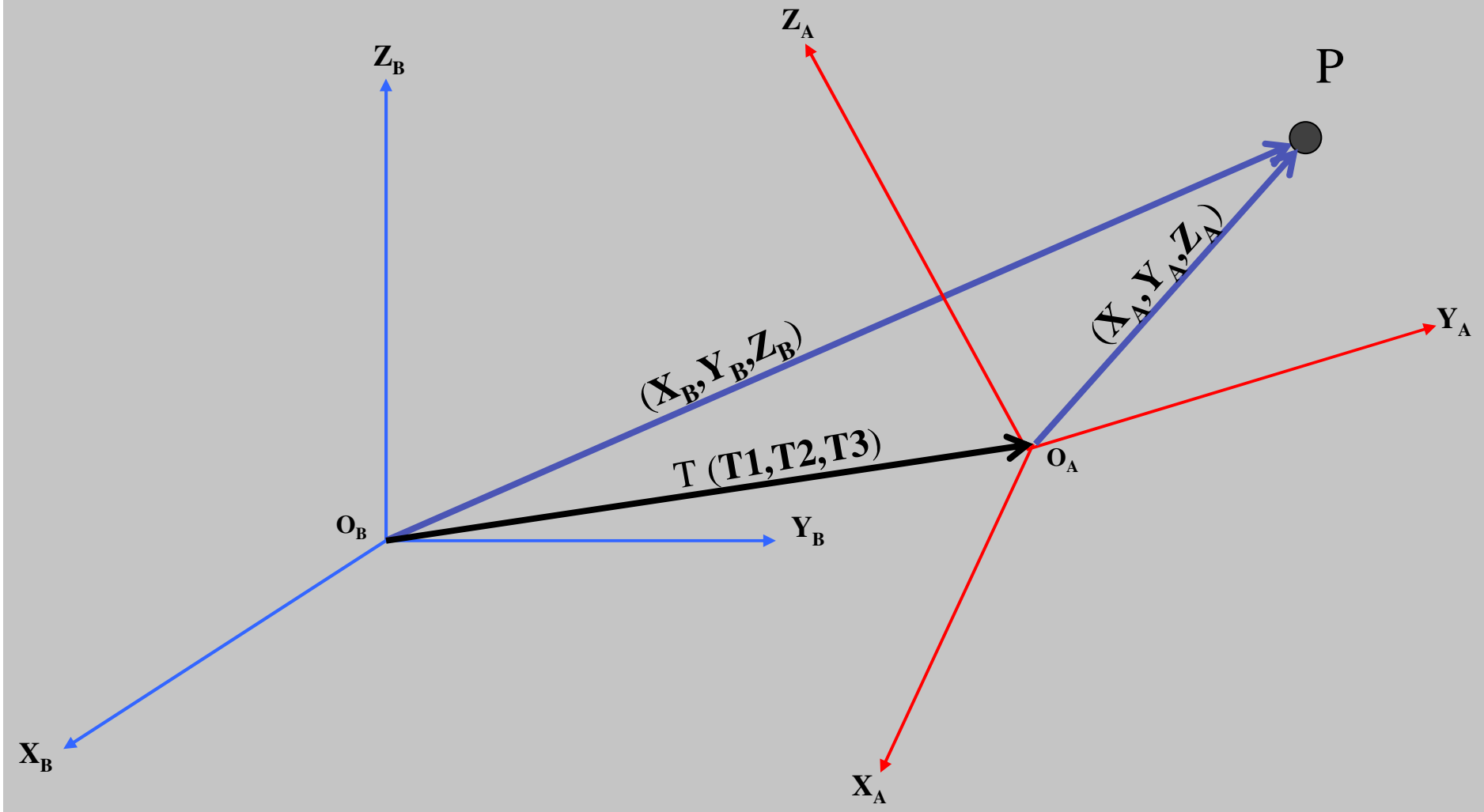
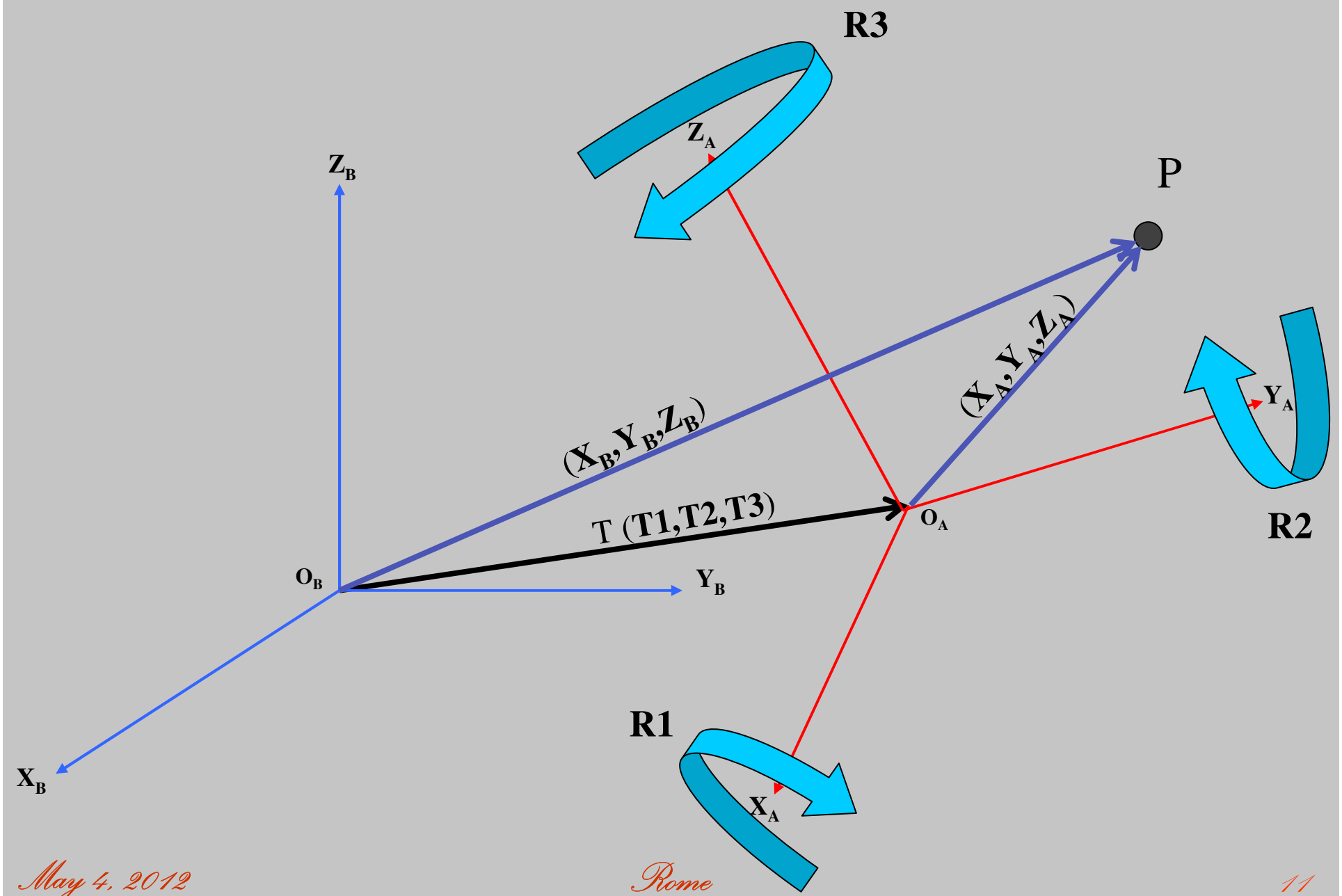


2- Similarity transformations in space



TRANSFORMATION PARAMETERS (HELMERT)

$$X^B = T + (1 + D) \cdot R \cdot X^A$$

$$X^A = \begin{bmatrix} X_A \\ Y_A \\ Z_A \end{bmatrix} \qquad X^B = \begin{bmatrix} X_B \\ Y_B \\ Z_B \end{bmatrix} \qquad T = \begin{bmatrix} T1 \\ T2 \\ T3 \end{bmatrix}$$

$$R = \begin{bmatrix} 1 & -R3 & R2 \\ R3 & 1 & -R1 \\ -R2 & R1 & 1 \end{bmatrix}$$

SOME REMARKS ON R

- *Independent on the order of the rotations*
- *Skew-symmetric* ($R = -R^T$)
- *Not orthogonal* (*$R R^T \neq R^T R \neq I$, not invertible)*
- *It is valid only for small rotations*

BECAUSE…

- *It is obtained by neglecting some terms*

THE ELEMENTARY ROTATION MATRICES

$$RX = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos R1 & -\sin R1 \\ 0 & \sin R1 & \cos R1 \end{bmatrix}$$

$$RY = \begin{bmatrix} \cos R2 & 0 & \sin R2 \\ 0 & 1 & 0 \\ -\sin R2 & 0 & \cos R2 \end{bmatrix}$$

$$RZ = \begin{bmatrix} \cos R3 & -\sin R3 & 0 \\ \sin R3 & \cos R3 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

PROPERTIES

- ***Skew-symmetric***

$$RX = -RX^T$$
$$RY = -RY^T$$
$$RZ = -RZ^T$$

- ***Orthogonal***

$$RX \cdot RX^T = I$$
$$RY \cdot RY^T = I$$
$$RZ \cdot RZ^T = I$$

THE COMPLETE ROTATION MATRIX

depends on the order of the rotations

Examples

(1) R = RX . RY . RZ

$$\begin{bmatrix} \cos R2\cos R3 & -\cos R2\sin R3 & \sin R2 \\ \cos R1\sin R3 + \sin R1\sin R2\cos R3 & \cos R1\cos R3 - \sin R1\sin R2\sin R3 & -\sin R1\cos R2 \\ \sin R1\sin R3 - \cos R1\sin R2\cos R3 & \sin R1\cos R3 + \cos R1\sin R2\sin R3 & \cos R1\cos R2 \end{bmatrix}$$

(2) R = RY . RX . RZ

$$\begin{bmatrix} \cos R2\cos R3 + \sin R1\sin R2\sin R3 & -\cos R2\sin R3 + \sin R1\sin R2\cos R3 & \cos R1\sin R2 \\ \cos R1\sin R3 & \cos R1\cos R3 & -\sin R1 \\ -\sin R2\cos R3 + \sin R1\cos R2\sin R3 & \sin R2\sin R3 + \sin R1\cos R2\cos R3 & \cos R1\cos R2 \end{bmatrix}$$

FROM THE COMPLETE ROTATION MATRIX…

Small angles ⟶ *sinα = α (rad); cosα = 1*

(1) $R = RX \cdot RY \cdot RZ$

$$\begin{bmatrix} 1 & -R3 & R2 \\ R3 + R1\,R2 & 1 - R1\,R2\,R3 & -R1 \\ R1\,R3 - R2 & R1 + R2\,R3 & 1 \end{bmatrix}$$

(2) $R = RY \cdot RX \cdot RZ$

$$\begin{bmatrix} 1 + R1\,R2\,R3 & -R3 + R1\,R2 & R2 \\ R3 & 1 & -R1 \\ -R2 + R1\,R3 & R2\,R3 + R1 & 1 \end{bmatrix}$$

…TO THE "POPULAR" "ROTATION" MATRIX

2nd and 3rd order terms = 0

(1) $R = RX \cdot RY \cdot RZ$

$$\begin{bmatrix} 1 & -R3 & R2 \\ R3 + \cancel{R1\,R2} & 1 - \cancel{R1\,R2\,R3} & -R1 \\ \cancel{R1\,R3} - R2 & R1 + \cancel{R2\,R3} & 1 \end{bmatrix}$$

(2) $R = RY \cdot RX \cdot RZ$

$$\begin{bmatrix} 1 + \cancel{R1\,R2\,R3} & -R3 + \cancel{R1\,R2} & R2 \\ R3 & 1 & -R1 \\ -R2 + \cancel{R1\,R3} & \cancel{R2\,R3} + R1 & 1 \end{bmatrix}$$

MANIPULATING THE TRANSFORMATION FORMULA

$$X^B = T + (1 + D) \cdot R \cdot X^A$$

$$X^B = T + R \cdot X^A + D \cdot R \cdot X^A$$

if $R = I + R'$

$$X^B = T + (I + R') \cdot X^A + D \cdot (I + R') \cdot X^A$$

$$X^B = X^A + T + R' \cdot X^A + D \cdot X^A + \cancel{D \cdot R' \cdot X^A}$$

where

$$R' = \begin{bmatrix} 0 & -R3 & R2 \\ R3 & 0 & -R1 \\ -R2 & R1 & 0 \end{bmatrix}$$

News
CRS Overview
- Definition of a CRS
- Transformation / Conversion

CRS Description
References
Links

Legal & Privacy

Transformation and Conversion - Change of CRS by Coordinate Operations

The change of coordinate from one Coordinate Reference System to another is a so called coordinate operation. There exist two kinds of operations - coordinate transformation and coordinate conversion.

Transformation

The change of coordinates from one CRS to another CRS based on different datum is only possible via a coordinate transformation. The transformation parameters could only be derived empirically by a set of points common to both coordinate reference systems it means by identical points. Choice, allocation, number and the quality of coordinates of the points affect extensive the results and the accuracy. Therefore different realisations for transformations from one datum to another exist.

For 3-dimensional CRS in a 7-Parameter Helmert Transformation is used for coordinate transformations. The figure shows the formula, which is used in this information system.

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{(T)} = \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{(S)} + \begin{bmatrix} T_X \\ T_Y \\ T_Z \end{bmatrix} + \begin{bmatrix} 0 & -R_Z & R_Y \\ R_Z & 0 & -R_X \\ -R_Y & R_X & 0 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{(S)} + D \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{(S)}$$

(T)	Target Datum	
(S)	Source Datum	
T_X, T_Y, T_Z	geocentric X/Y/Z translations	[m]
R_X, R_Y, R_Z	rotations around X/Y/Z axis	[radian]
D	correction of scale	[ppm]

Remark: the rotations R_X, R_Y, R_Z must be small

Unfortunately there exists different versions of this formula with inverse definition of the signs of rotations and/or inverse sequence of the rotations. Inverse sequence means Rx = Rz, Ry = Ry, Rz = Rx. It should be considered for use of transformation parameters and software packages.

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EUROPEAN TERRESTRIAL REFERENCE SYSTEM 89 (ETRS89)

The IAG Subcommision for the European Reference Frame, following its Resolution 1 adopted in Firenze in 1990, recommends that ***the terrestrial reference system to be adopted by EUREF will be coincident with the ITRS at the epoch 1989.0 and fixed to the stable part of the Eurasian Plate****.*

It will be named

European Terrestrial Reference System 89 (ETRS89)

MOTIVATION FOR CREATION OF ETRS89

ITRS coordinates : ~2,5 cm/y in Europe

→ ***unusable for day-to-day geo-referencing activities***

ETRS89 coordinates : minimal time-dependency

→ ***are consequently useable for geo-referencing in Europe***

REALIZATION OF ETRS89

- *using ITRS realizations:*
  for each frame labelled ITRF$_{yy}$ a corresponding frame in ETRS89 can be computed and labelled ETRFyy.

  Ex: *ETRF89*
  ETRF93
  ETRF97
  ETRF2000

- *positioning with GNSS (campaign or permanent stations):*
  using recent ITRFyy station coordinates and IGS precise ephemerides following the procedure described in (Boucher and Altamimi, 2011)

48 CAMPAIGNS SINCE 1990

Memo : Specifications for reference frame fixing in the analysis of a EUREF GPS campaign

Claude Boucher and Zuheir Altamimi

Version 1 : 30-09-1993
Version 2 : 07-03-1995
Version 3 : 10-02-1997
Version 4 : 08-01-1998
Version 5 : 12-04-2001
Version 6 : 27-03-2007
Version 7 : 24-10-2008
Version 8 : 18-05-2011

1 - DIRECTLY FROM ITRF$_{YY}$ TO ETRF$_{YY}$

- compute coordinates (epoch t_0) in ITRS at epoch 89.0

$$X^I_{YY}(89.0) = X^I_{YY}(t_0) + \dot{X}^I_{YY} \times (89.0 - t_0) \qquad (1)$$

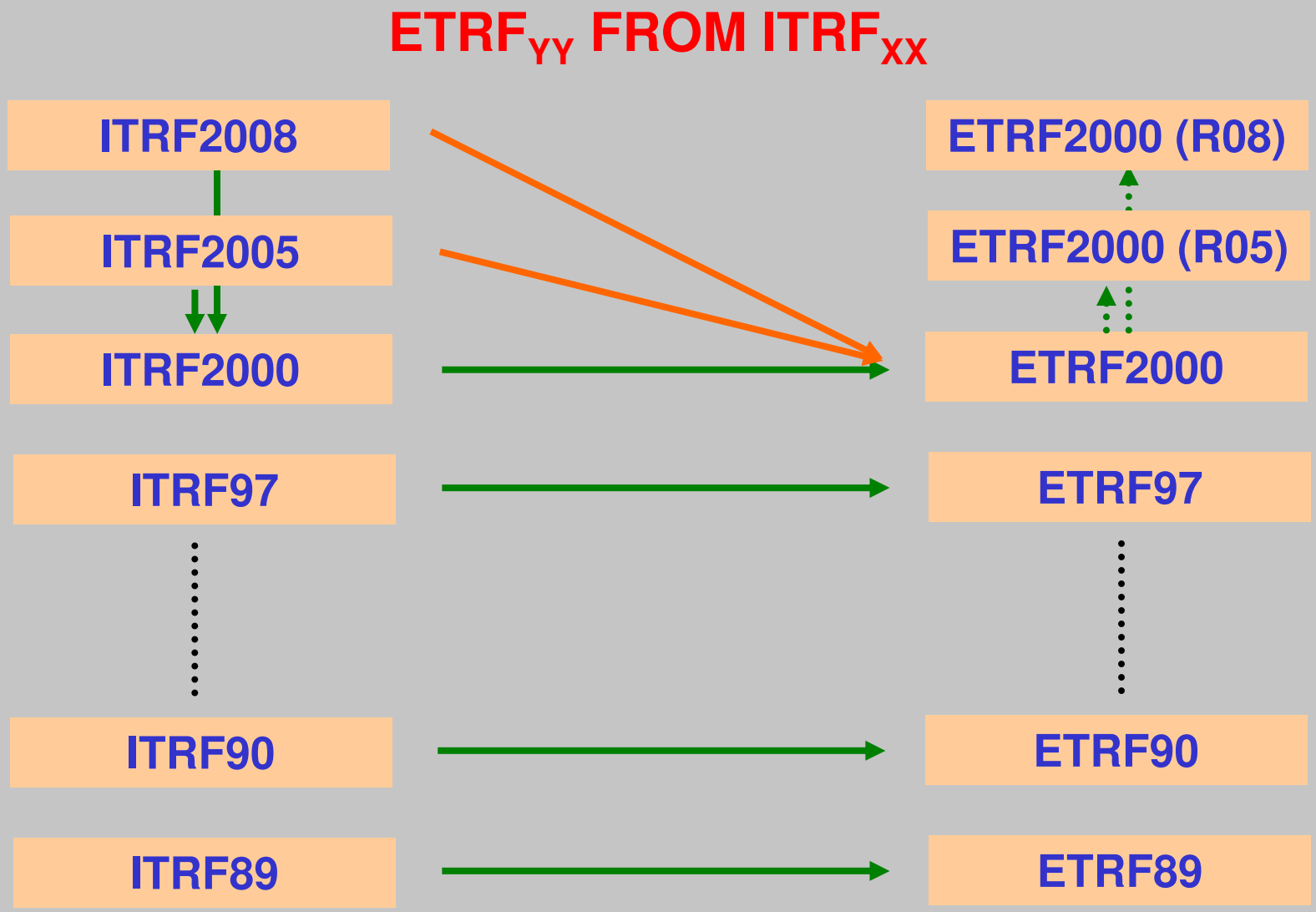
- transform coordinates from ITRS to ETRS89 at epoch 89.0

$$\begin{pmatrix} X^E_{YY}(89.0) \\ Y^E_{YY}(89.0) \\ Z^E_{YY}(89.0) \end{pmatrix} = \begin{pmatrix} X^I_{YY}(89.0) \\ Y^I_{YY}(89.0) \\ Z^I_{YY}(89.0) \end{pmatrix} + \begin{pmatrix} T1_{YY} \\ T2_{YY} \\ T3_{YY} \end{pmatrix} \qquad (2)$$

- transform velocities from ITRS to ETRS89

$$\begin{pmatrix} \dot{X}^E_{YY} \\ \dot{Y}^E_{YY} \\ \dot{Z}^E_{YY} \end{pmatrix} = \begin{pmatrix} \dot{X}^I_{YY} \\ \dot{Y}^I_{YY} \\ \dot{Z}^I_{YY} \end{pmatrix} + \begin{pmatrix} 0 & -\dot{R}3_{YY} & \dot{R}2_{YY} \\ \dot{R}3_{YY} & 0 & -\dot{R}1_{YY} \\ -\dot{R}2_{YY} & \dot{R}1_{YY} & 0 \end{pmatrix} \times \begin{pmatrix} X^I_{YY} \\ Y^I_{YY} \\ Z^I_{YY} \end{pmatrix} \qquad (3)$$

3- The case of ETRS89



2 - REALIZATION OF ETRS89 FROM CAMPAIGNS

- ***process GNSS data (epoch t_c) in ITRS ($ITRF_{XX}$ or $ITRF_{YY}$)***

2 - REALIZATION OF ETRS89 FROM CAMPAIGNS

- *process GNSS data (epoch t_c) in ITRS ($ITRF_{XX}$ or $ITRF_{YY}$)*
- *transform coordinates in ITRS from $ITRF_{XX}$ to $ITRF_{YY}$ at epoch t_c (if needed)*

2 - REALIZATION OF ETRS89 FROM CAMPAIGNS

- *process GNSS data (epoch t_c) in ITRS ($ITRF_{XX}$ or $ITRF_{YY}$)*
- *transform coordinates in ITRS from $ITRF_{XX}$ to $ITRF_{YY}$ at epoch t_c (if needed)*
- *transform coordinates from ITRS ($ITRF_{YY}$) to ETRS89*

$$X^E(t_c) = X^I_{YY}(t_c) + T_{YY} + \begin{pmatrix} 0 & -\dot{R}3_{YY} & \dot{R}2_{YY} \\ \dot{R}3_{YY} & 0 & -\dot{R}1_{YY} \\ -\dot{R}2_{YY} & \dot{R}1_{YY} & 0 \end{pmatrix} \times X^I_{YY}(t_c).(t_c - 1989.0) \quad \textbf{(4)}$$

- **$\dot{R}1_{YY}$, $\dot{R}2_{YY}$, $\dot{R}3_{YY}$ and T_{YY} components published in the Memo**

✓ **the last two steps may be combined in one step**

EUREF CAMPAIGNS - 1

CAMPAIGN	COMMENTS	ADOPTION
EUREF 89	Class C	R1 - Berne 1992
EUREF 1992 Baltic States	Class C - Estonian points replaced by EUREF-Estonia-1997	R2 - Budapest 1993
EUREF-CS/H 91	Some H points replaced by EUREF-Hungary-2002 S points replaced by EUREF-Slovakia-2001	R1 - Warsaw 1994
EUREF-POL 92	Replaced by EUREF-POL-2001	R1 - Warsaw 1994
EUREF-D/NL 93		R1 - Warsaw 1994
EUREF-GB92	Replaced by EUREF GB2001	R1 - Helsinki 1995
EUREF-Cyprus93		R1 - Helsinki 1995
EUREF-LUXBD94		R1 - Helsinki 1995
EUREF-CRO/SLO94	Croatian points replaced by EUREF-CRO-94/95/96	R1 - Helsinki 1995
EUREF-DK94		R1 - Helsinki 1995
CH92/93		R1 – Ankara 1996
EUREF-BG92/93		R1 - Ankara 1996
EUREF-Iceland93		R1 - Ankara 1996
EUREF-A94/95	Some points replaced by EUREF-Austria-2002	R1 - Ankara 1996
EUREF-EIR/GB95	GB points replaced by EUREF GB2001	R1 - Ankara 1996

EUREF CAMPAIGNS - 2

CAMPAIGN	COMMENTS	ADOPTION
Iberia 95		R1 - Bad Neuenahr – Ahrweiler 1998
Malta 96		R1 - Bad Neuenahr – Ahrweiler 1998
FYROM 96		R1 - Bad Neuenahr – Ahrweiler 1998
EUREF-NOR94/NOR95	Subset of points	R2 - Bad Neuenahr – Ahrweiler 1998
EUVN97		R1 - Prague 1999
EUREF-FIN-96/97	Subset of points	R2 - Prague 1999
EUREF-Estonia-1997	Subset of points (EUREF 1992 no longer acceptable)	R2 - Prague 1999
EUREF-Balkan-98	Wait for publication due to political reasons	R3 - Prague 1999
Moldavia-99	3 points in Ukrania not included (bad quality)	R1 - Tromsoe 2000
EUREF-SWEREF-99	Old points deleted from the database	R1 - Tromsoe 2000
EUREF-Balear-98		R1 - Tromsoe 2000
EUREF-CRO-94/95/96	Old points deleted from the database	R1 - Dubrovnik 2001
EUREF-Slovakia-2001	Old points deleted from the database	R1 - Toledo 2003
EUREF-POL-2001	Old points deleted from the database	R1 - Toledo 2003
EUREF-Austria-2002	Old points deleted from the database	R1 - Toledo 2003
EUREF-Hungary-2002	Old points deleted from the database	R1 - Toledo 2003
EUREF GB2001	Old points deleted from the database Re-processing in 2004	R1 - Ponta Delgada 2002

EUREF CAMPAIGNS - 3

CAMPAIGN	COMMENTS	ADOPTION
EUREF-Slovakia-2001	Old points deleted from the database	R1 - Toledo 2003
EUREF-POL-2001	Old points deleted from the database	R1 - Toledo 2003
EUREF-Austria-2002	Old points deleted from the database	R1 - Toledo 2003
EUREF-Hungary-2002	Old points deleted from the database	R1 - Toledo 2003
EUREF-Armenia- 2002		R1 - Bratislava 2004
EUREF-GB-2001	Re-processing; previously accepted in 2002	R1 - Bratislava 2004
EUREF-BG-2004	Combined EUREF-BG92/93, previously accepted in 1996	R1 - Riga 2006
EUREF-NKG-2003	Only points from Latvia and Lithuania in the database	R1 - Riga 2006
Rete Dinamica Nazionale (RDN)	Subset of points	R1 - Florence 2009
EUREF Czech 2009		R1 - Gävle 2010
EUREF EIR/UK 2009		R1 - Gävle 2010
EUREF GR 2007		R1 - Gävle 2010
EUREF SERBIA 2010		R1 - Chisinau 2011
EUREF MAKPOS 2010		R1 - Chisinau 2011
EUREF Faroe Islands 2007		R1 - Chisinau 2011

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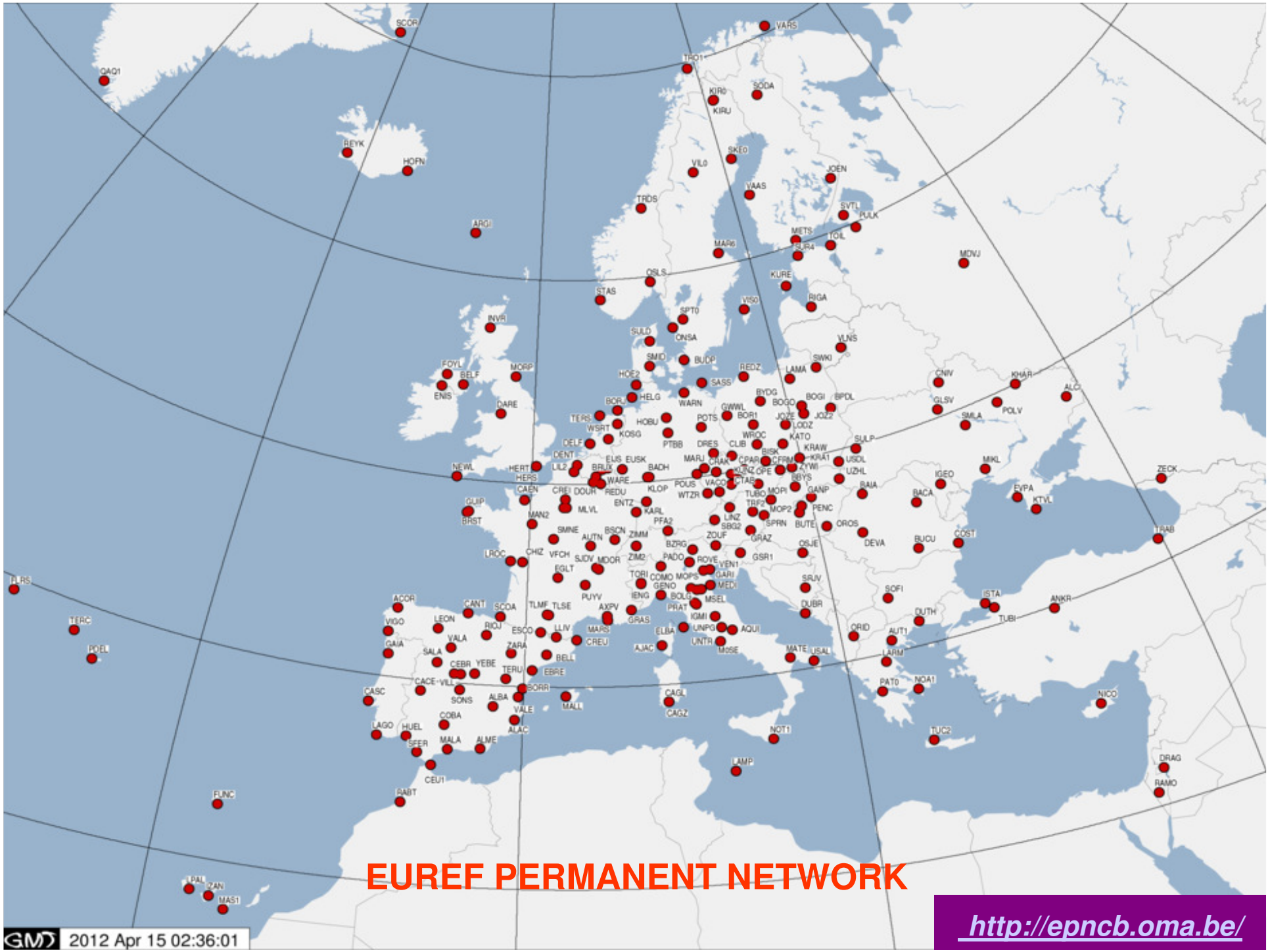
OVERVIEW

1) $ETRF_{YY}$ from $ITRF_{YY}$
   - ✓ coordinates and velocities
   - ✓ the EPN infrastructure

2) Computation of 'campaigns' in ETRS89 (from $ITRF_{YY}$ to $ETRF_{YY}$)
   - ✓ coordinates
   - ✓ equation (4)

3) Computation of 'campaigns' in ETRS89 (from $ITRF_{XX}$ to $ETRF_{YY}$)
   - ✓ coordinates
   - ✓ equation (4)

4) Analysis of the ETRS89 realizations consistency
   - ✓ time series (ITRS versus ETRS89)
   - ✓ project 'Monitoring of EUREF coordinates'


EUREF PERMANENT NETWORK
http://epncb.oma.be/
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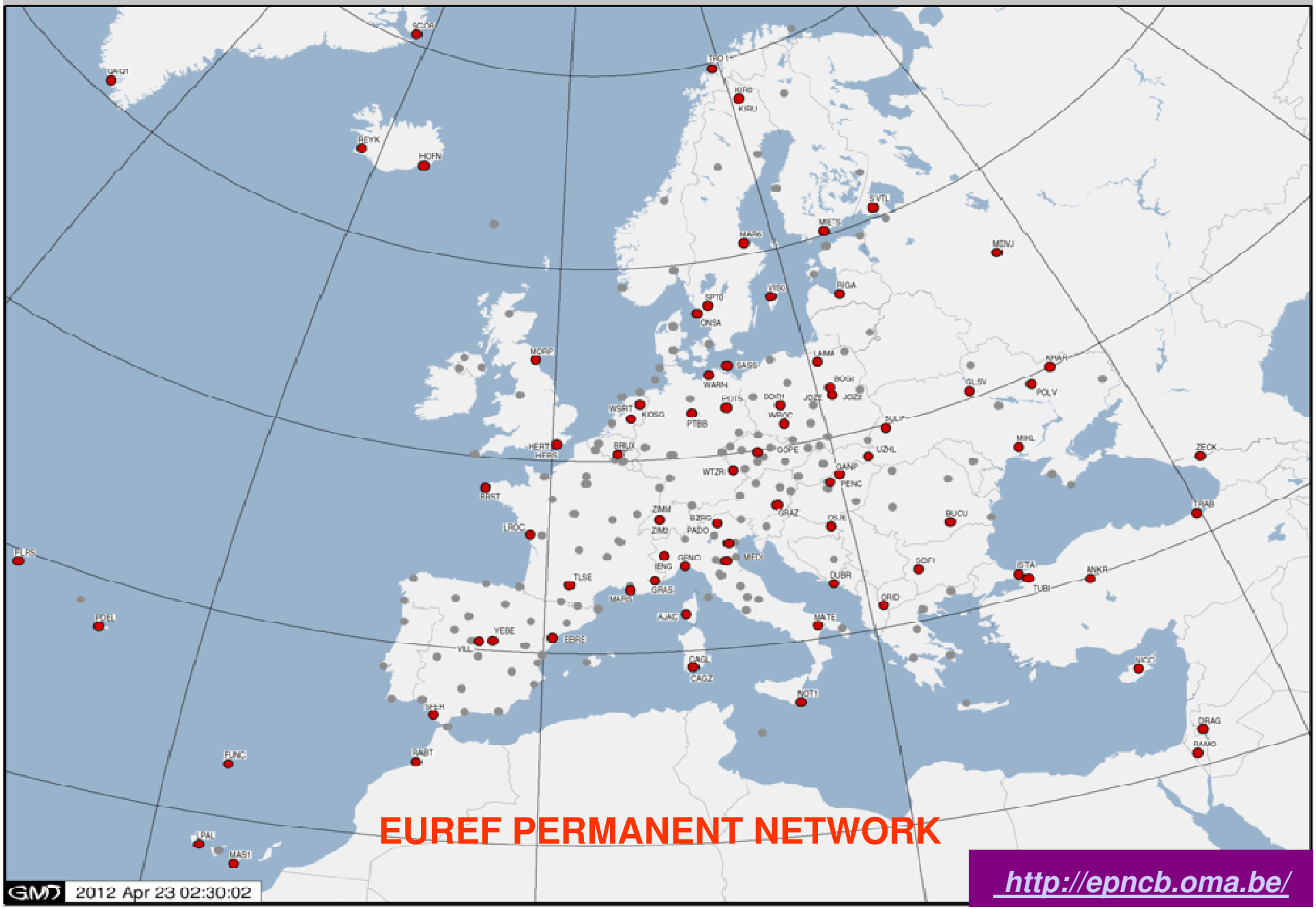
EUREF Permanent Tracking Network

Stations belonging to the IGS network



EUREF PERMANENT NETWORK

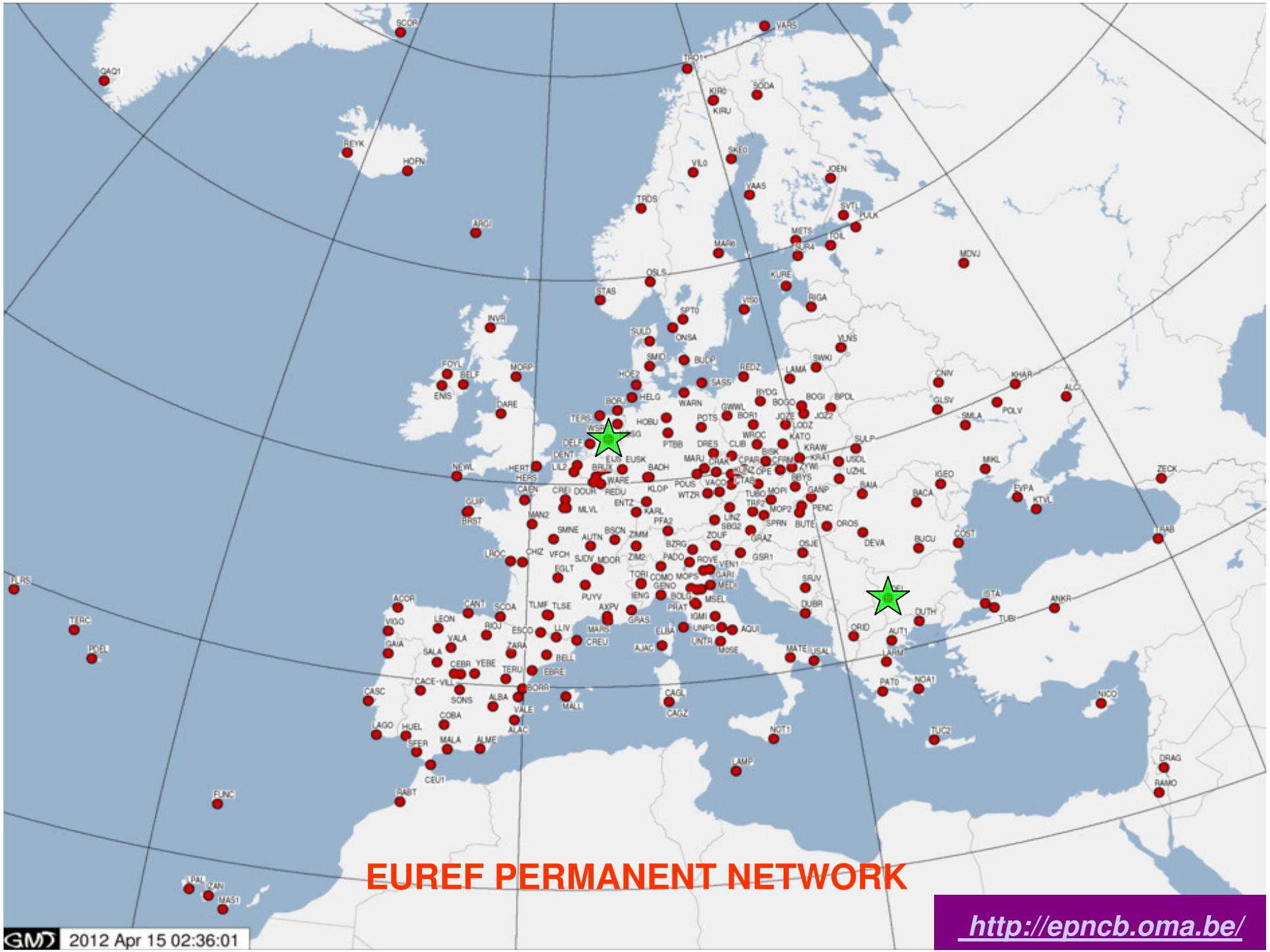
http://epncb.oma.be/

THE EPN INFRASTRUCTURE

"Guidelines for EUREF Densifications" (Bruyninx et al, 2010)

- ✓ *EUREF updates each 15 weeks the original EUREF densification of the ITRF2005 in a multi-year adjustment of all the weekly combined EPN solutions in which outliers have been eliminated and station discontinuities were applied*
  - ➢ *Class A: station positions have a 1 cm accuracy at all epochs of the time span of the used observations*
  - ➢ *Class B: station positions have a 1 cm accuracy at the epoch of minimal variance of each station.*
- ✓ *Only Class A stations are suitable as fiducial stations*

epncb.oma.be - tracking network - coordinates


EUREF PERMANENT NETWORK
http://epncb.oma.be/
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1) $ETRF_{YY}$ FROM $ITRF_{YY}$

1. POSITIONS/VELOCITIES PUBLISHED BY EUREF

Latest release

EUREF has classified SOFI (Sofia, Bulgaria) as a class A station

ETRF2000	epoch t_0	Position (m)			Velocity (m/y)		
		X	Y	Z	V_X	V_Y	V_Z
187/1997 - 254/2010	001/2005	4319372.425 ± 0.000	1868687.542 ± 0.000	4292063.725 ± 0.000	0.0004 ± 0.0000	0.0004 ± 0.0000	-0.0020 ± 0.0000

EUREF has classified WSRT (Westerbork, Netherlands) as a class A station

ETRF2000	epoch t_0	Position (m)			Velocity (m/y)		
		X	Y	Z	V_X	V_Y	V_Z
229/1997 - 254/2010	001/2005	3828736.141 ± 0.000	443304.741 ± 0.000	5064884.510 ± 0.000	-0.0004 ± 0.0000	-0.0008 ± 0.0000	0.0003 ± 0.0000

4- Practical examples

SOFIA (SOFI)

3. POSITIONS/VELOCITIES PUBLISHED BY THE IERS

Latest release

ETRF2000(R08)	epoch t_0	Position (m)			Velocity (m/y)		
		X	Y	Z	V_X	V_Y	V_Z
start - 001/2000	001/2005	4319372.427 ± 0.001	1868687.543 ± 0.001	4292063.725 ± 0.001	0.0008 ± 0.0001	0.0008 ± 0.0000	-0.0021 ± 0.0001

Previous releases

ETRF2000(R05)	epoch t_0	Position (m)			Velocity (m/y)		
		X	Y	Z	V_X	V_Y	V_Z
start - 365/2005	001/2000	4319372.419 ± 0.003	1868687.539 ± 0.001	4292063.732 ± 0.002	0.0013 ± 0.0005	0.0010 ± 0.0003	-0.0016 ± 0.0005

ETRF2000	epoch t_0	Position (m)			Velocity (m/y)		
		X	Y	Z	V_X	V_Y	V_Z
start - 365/2000	001/1989	4319372.413 ± 0.025	1868687.532 ± 0.013	4292063.759 ± 0.024	0.0009 ± 0.0020	0.0004 ± 0.0010	-0.0022 ± 0.0020

ETRF97	epoch t_0	Position (m)			Velocity (m/y)		
		X	Y	Z	V_X	V_Y	V_Z
start - 365/1998	001/1989	4319372.415 ± 0.027	1868687.528 ± 0.024	4292063.755 ± 0.024	-0.0005 ± 0.0030	0.0011 ± 0.0020	-0.0026 ± 0.0020

4- Practical examples

WESTERBORK (WSRT)

3. POSITIONS/VELOCITIES PUBLISHED BY THE IERS

Latest release

ETRF2000(R08)	epoch t_0	Position (m)			Velocity (m/y)		
		X	Y	Z	V_X	V_Y	V_Z
start - 365/2008	001/2005	3828736.142 ± 0.001	443304.741 ± 0.001	5064884.511 ± 0.001	-0.0012 ± 0.0001	-0.0006 ± 0.0000	-0.0008 ± 0.0001

Previous releases

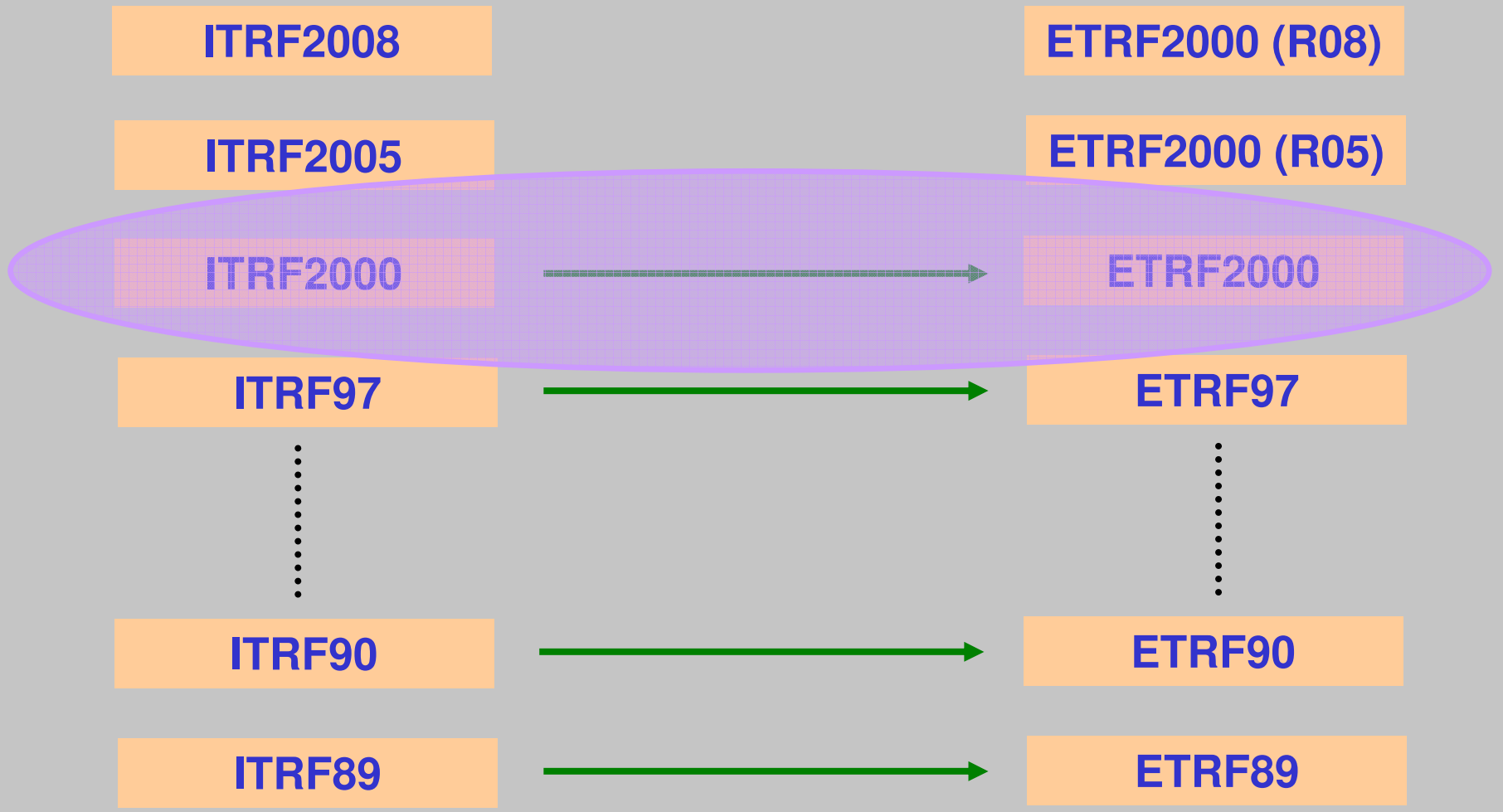
ETRF2000(R05)	epoch t_0	Position (m)			Velocity (m/y)		
		X	Y	Z	V_X	V_Y	V_Z
start - 365/2005	001/2000	3828736.148 ± 0.001	443304.744 ± 0.000	5064884.514 ± 0.001	-0.0007 ± 0.0001	-0.0007 ± 0.0001	0.0000 ± 0.0001

ETRF2000	epoch t_0	Position (m)			Velocity (m/y)		
		X	Y	Z	V_X	V_Y	V_Z
start - 365/2000	001/1989	3828736.148 ± 0.009	443304.747 ± 0.003	5064884.509 ± 0.011	0.0001 ± 0.0000	-0.0003 ± 0.0000	0.0005 ± 0.0010

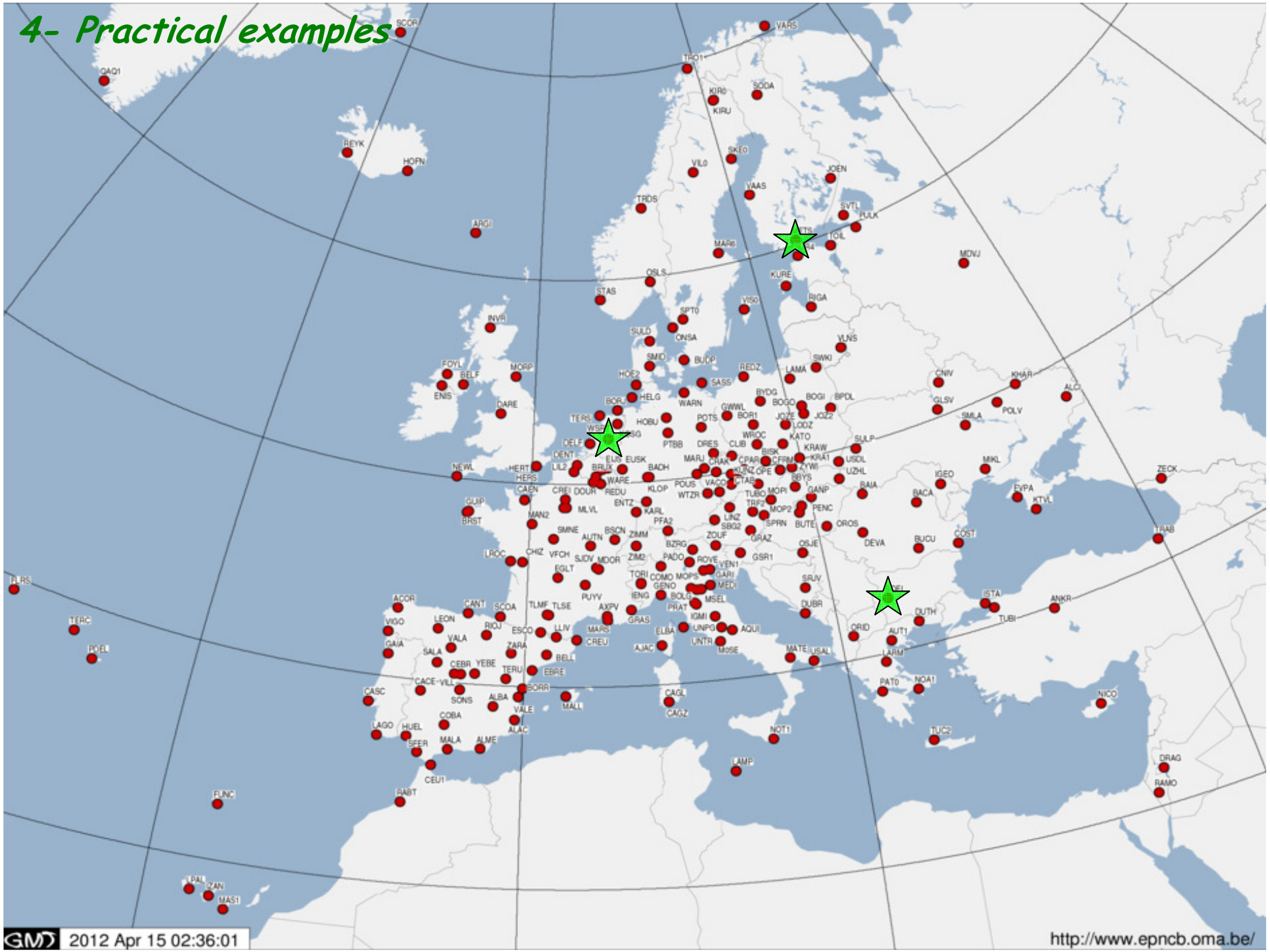
ETRF97	epoch t_0	Position (m)			Velocity (m/y)		
		X	Y	Z	V_X	V_Y	V_Z
start - 365/1998	001/1989	3828736.140 ± 0.011	443304.745 ± 0.009	5064884.497 ± 0.012	0.0008 ± 0.0010	-0.0009 ± 0.0010	0.0004 ± 0.0010

2) COMPUTATIONS OF CAMPAIGNS ($ITRF_{YY}$ TO $ETRF_{YY}$)

- *ITRF2000 to ETRF2000 (epoch 2007.75)*



4- Practical examples



2) COMPUTATIONS OF CAMPAIGNS ($ITRF_{YY}$ TO $ETRF_{YY}$)

- *ITRF2000 to ETRF2000 (epoch 2007.75)*

3. POSITIONS/VELOCITIES PUBLISHED BY THE IERS

Previous releases

EUREF has classified METS (Kirkkonummi, Finland) as a class A station

ETRF2000	epoch t_0	Position (m)			Velocity (m/y)		
		X	Y	Z	V_X	V_Y	V_Z
start - 365/2000	001/1989	2892571.104 ± 0.003	1311843.262 ± 0.002	5512633.939 ± 0.005	0.0021 ± 0.0000	0.0016 ± 0.0000	0.0024 ± 0.0000

ITRF2000	epoch t_0	Position (m)			Velocity (m/y)		
		X	Y	Z	V_X	V_Y	V_Z
start - 365/2000	001/1997	2892570.923 ± 0.001	1311843.330 ± 0.001	5512634.057 ± 0.002	-0.0160 ± 0.0003	0.0149 ± 0.0002	0.0088 ± 0.0006

2) COMPUTATIONS OF CAMPAIGNS ($ITRF_{YY}$ TO $ETRF_{YY}$)

- **ITRF2000 to ETRF2000 (epoch 2007.75)**

"Memo: Specifications for…" (Boucher and Altamimi, 2011)

Table 3: Estimation of T_{YY}

YY		T1 cm	T2 cm	T3 cm
89		0	0	0
90	A	1.9	2.8	-2.3
	B	2.6	2.5	-2.6
	±	0.7	0.7	0.7
91	A	2.1	2.5	-3.7
	B	2.3	2.1	-3.1
	±	0.7	0.7	0.7
92	A	3.8	4.0	-3.7
	B	4.3	3.4	-3.2
	±	0.8	0.8	0.8
93	A	1.9	5.3	-2.1
	B	1.0	5.9	-1.4
	±	0.5	0.5	0.6
94	A	4.1	4.1	-4.9
	B	2.9	4.3	-3.6
	±	0.4	0.5	0.5
96	A	4.1	4.1	-4.9
	B	3.9	4.1	-3.9
	±	0.4	0.4	0.4
97	A	4.1	4.1	-4.9
	B	3.4	4.4	-4.3
	±	0.4	0.4	0.4
00	A	5.4	5.1	-4.8
	B	4.2	5.1	-4.6
	±	0.4	0.4	0.4
05*	A	5.6	4.8	-3.7
	B	3.6	4.2	-4.1
	±	0.4	0.4	0.4

* See TWG recommendation §4

Table 4: Estimation of R_{YY}

YY	R1 mas/y	R2 mas/y	R3 mas/y
89	0.11	0.57	-0.71
90	0.11	0.57	-0.71
91	0.21	0.52	-0.68
92	0.21	0.52	-0.68
93	0.32	0.78	-0.67
94	0.20	0.50	-0.65
96	0.20	0.50	-0.65
97	0.20	0.50	-0.65
00	0.081	0.490	-0.792
	±0.021	±0.008	±0.026
05*	0.054	0.518	-0.781
	±0.009	±0.006	±0.011

* See TWG recommendation §4

2) COMPUTATIONS OF CAMPAIGNS ($ITRF_{YY}$ TO $ETRF_{YY}$)

- **ITRF2000 to ETRF2000 (epoch 2007.75)**

Table 5: Transformation parameters from $ITRF_{yy}$ to ETRF2000 **at epoch 2000.0** and their rates/year

ITRF Solution	T1 mm	T2 mm	T3 mm	D 10^{-9}	R1 mas	R2 mas	R3 mas
ITRF2008	52.1	49.3	-58.5	1.34	0.891	5.390	-8.712
Rates	0.1	0.1	-1.8	0.08	0.081	0.490	-0.792
ITRF2005	54.1	50.2	-53.8	0.40	0.891	5.390	-8.712
Rates	-0.2	0.1	-1.8	0.08	0.081	0.490	-0.792
ITRF2000	54.0	51.0	-48.0	0.00	0.891	5.390	-8.712
Rates	0.0	0.0	0.0	0.00	0.081	0.490	-0.792
ITRF97	47.3	46.7	-25.3	-1.58	0.891	5.390	-8.772
Rates	0.0	0.6	1.4	-0.01	0.081	0.490	-0.812
ITRF96	47.3	46.7	-25.3	-1.58	0.891	5.390	-8.772
Rates	0.0	0.6	1.4	-0.01	0.081	0.490	-0.812
ITRF94	47.3	46.7	-25.3	-1.58	0.891	5.390	-8.772
Rates	0.0	0.6	1.4	-0.01	0.081	0.490	-0.812
ITRF93	76.1	46.9	-19.9	-2.07	2.601	6.870	-8.412
Rates	2.9	0.2	0.6	-0.01	0.191	0.680	-0.862
ITRF92	39.3	44.7	-17.3	-0.87	0.891	5.390	-8.772
Rates	0.0	0.6	1.4	-0.01	0.081	0.490	-0.812
ITRF91	27.3	30.7	-11.3	-2.27	0.891	5.390	-8.772
Rates	0.0	0.6	1.4	-0.01	0.081	0.490	-0.812
ITRF90	29.3	34.7	4.7	-2.57	0.891	5.390	-8.772
Rates	0.0	0.6	1.4	-0.01	0.081	0.490	-0.812
ITRF89	24.3	10.7	42.7	-5.97	0.891	5.390	-8.772
Rates	0.0	0.6	1.4	-0.01	0.081	0.490	-0.812

"Memo: Specifications for…"

(Boucher and Altamimi, 2011)

2) COMPUTATIONS OF CAMPAIGNS ($ITRF_{YY}$ TO $ETRF_{YY}$)

- *ITRF2000 to ETRF2000 (epoch 2007.75)*

STEP 2

Kirkkonummi	X(ITRF2000) (m)		T (m)		dR_i (mas/y)
	2007.75				
X	2892570,751	T1	0.054	R1	0.081
Y	1311843,490	T2	0.051	R2	0.490
Z	5512634,152	T3	-0.048	R3	-0.792

STEP 1

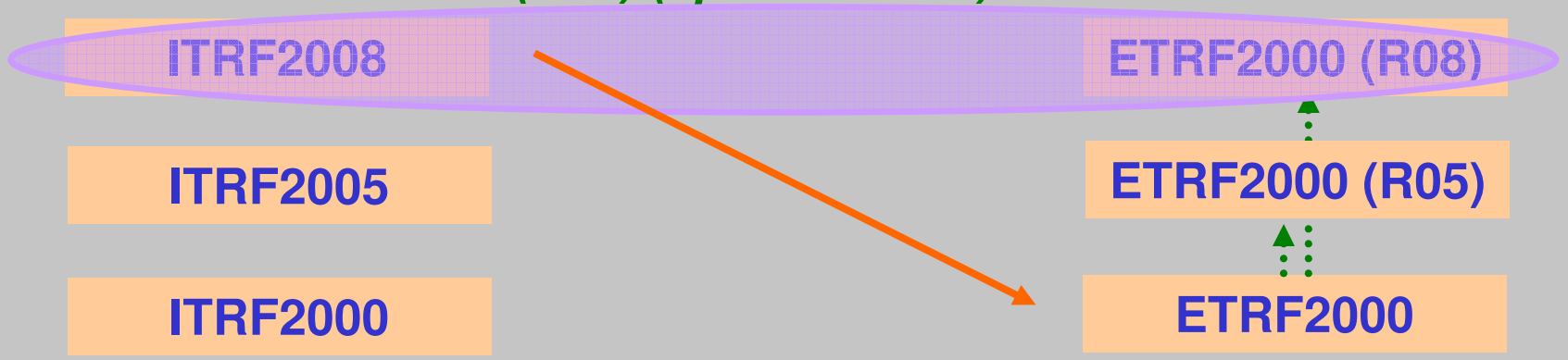
R_i (mas) (dR_i . (tc-1989.0))	R (rad)			R . X(ITRF2000) (tc) (m)	X(ETRF2000) (tc) (m)
2007.75	2007.75				2007.75
1.519	0	7.199E-08	4.454E-08	0.340	2892571,145
9.188	-7.199E-08	0	-7.363E-09	-0.249	1311843,292
-14.850	-4.454E-08	7.363E-09	0	-0.119	5512633,984

Kirkkonummi	X(ETRF2000) (m)	V (m/y)	X(ETRF2000) (m)
	1989.00	ETRF2000	2007.75
X	2892571,104	0.0021	2892571,143
Y	1311843,262	0.0016	1311843,292
Z	5512633,939	0.0024	5512633,984

CHECK

3) COMPUTATIONS OF CAMPAIGNS ($ITRF_{XX}$ TO $ETRF_{YY}$)

- *ITRF2008 to ETRF2000(R08) (epoch 2005.0)*



3) COMPUTATIONS OF CAMPAIGNS ($ITRF_{XX}$ TO $ETRF_{YY}$)

- *ITRF2008 to ETRF2000(R08) (epoch 2005.0)*

3. POSITIONS/VELOCITIES PUBLISHED BY THE IERS

Latest release

EUREF has classified METS (Kirkkonummi, Finland) as a class A station

ETRF2000(R08)	epoch t_0	Position (m)			Velocity (m/y)		
		X	Y	Z	V_X	V_Y	V_Z
start - 365/2008	001/2005	2892571.136 ± 0.001	1311843.285 ± 0.001	5512633.977 ± 0.001	0.0022 ± 0.0001	0.0014 ± 0.0000	0.0026 ± 0.0001

ITRF2008	epoch t_0	Position (m)			Velocity (m/y)		
		X	Y	Z	V_X	V_Y	V_Z
start - 365/2008	001/2005	2892570.788 ± 0.001	1311843.445 ± 0.001	5512634.137 ± 0.001	-0.0163 ± 0.0001	0.0145 ± 0.0000	0.0103 ± 0.0001

3) COMPUTATIONS OF CAMPAIGNS ($ITRF_{XX}$ TO $ETRF_{YY}$)

- **ITRF2008 to ETRF2000(R08) (epoch 2005.0)**

Table 5: Transformation parameters from $ITRF_{yy}$ to ETRF2000 **at epoch 2000.0** and their rates/year

ITRF Solution	T1 mm	T2 mm	T3 mm	D 10^{-9}	R1 mas	R2 mas	R3 mas
ITRF2008	52.1	49.3	-58.5	1.34	0.891	5.390	-8.712
Rates	0.1	0.1	-1.8	0.08	0.081	0.490	-0.792
ITRF2005	54.1	50.2	-53.8	0.40	0.891	5.390	-8.712
Rates	-0.2	0.1	-1.8	0.08	0.081	0.490	-0.792
ITRF2000	54.0	51.0	-48.0	0.00	0.891	5.390	-8.712
Rates	0.0	0.0	0.0	0.00	0.081	0.490	-0.792
ITRF97	47.3	46.7	-25.3	-1.58	0.891	5.390	-8.772
Rates	0.0	0.6	1.4	-0.01	0.081	0.490	-0.812
ITRF96	47.3	46.7	-25.3	-1.58	0.891	5.390	-8.772
Rates	0.0	0.6	1.4	-0.01	0.081	0.490	-0.812
ITRF94	47.3	46.7	-25.3	-1.58	0.891	5.390	-8.772
Rates	0.0	0.6	1.4	-0.01	0.081	0.490	-0.812
ITRF93	76.1	46.9	-19.9	-2.07	2.601	6.870	-8.412
Rates	2.9	0.2	0.6	-0.01	0.191	0.680	-0.862
ITRF92	39.3	44.7	-17.3	-0.87	0.891	5.390	-8.772
Rates	0.0	0.6	1.4	-0.01	0.081	0.490	-0.812
ITRF91	27.3	30.7	-11.3	-2.27	0.891	5.390	-8.772
Rates	0.0	0.6	1.4	-0.01	0.081	0.490	-0.812
ITRF90	29.3	34.7	4.7	-2.57	0.891	5.390	-8.772
Rates	0.0	0.6	1.4	-0.01	0.081	0.490	-0.812
ITRF89	24.3	10.7	42.7	-5.97	0.891	5.390	-8.772
Rates	0.0	0.6	1.4	-0.01	0.081	0.490	-0.812

"Memo: Specifications for…"

(Boucher and Altamimi, 2011)

3) COMPUTATIONS OF CAMPAIGNS ($ITRF_{XX}$ TO $ETRF_{YY}$)

- *ITRF2008 to ETRF2000(R08) (epoch 2005.0)*

STEP 1

Kirkkonummi	X(ITRF2008) (m)		D (10^{-9})		T (m)		R_i (mas/y)
	2005.0		2005.0		2005.0		2005.0
X	2892570.788	D	1.74	T1	0.0526	R1	1.296
Y	1311843.445			T2	0.0498	R2	7.840
Z	5512634.137			T3	-0.0675	R3	-12.672

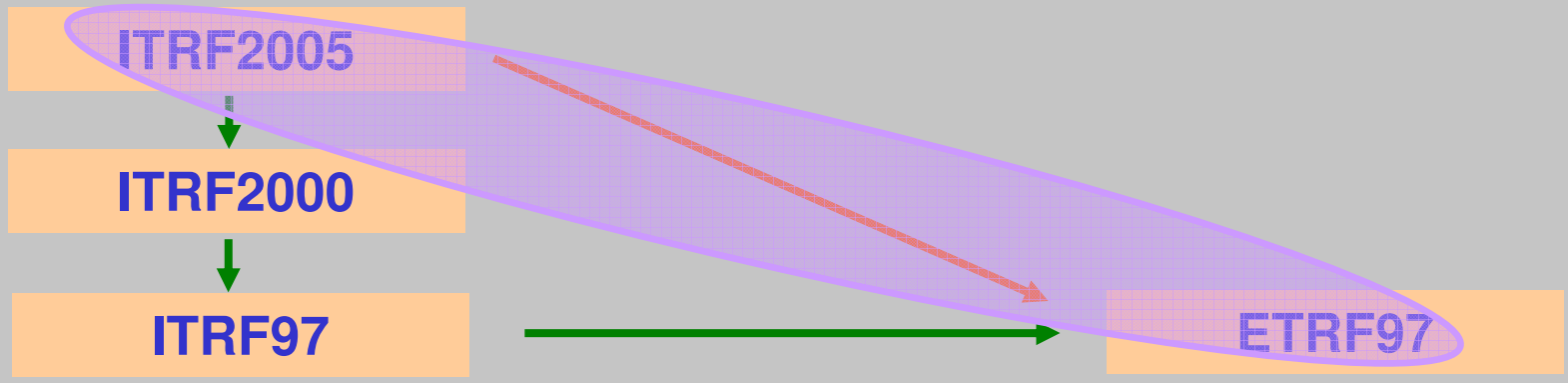
STEP 2

CHECK

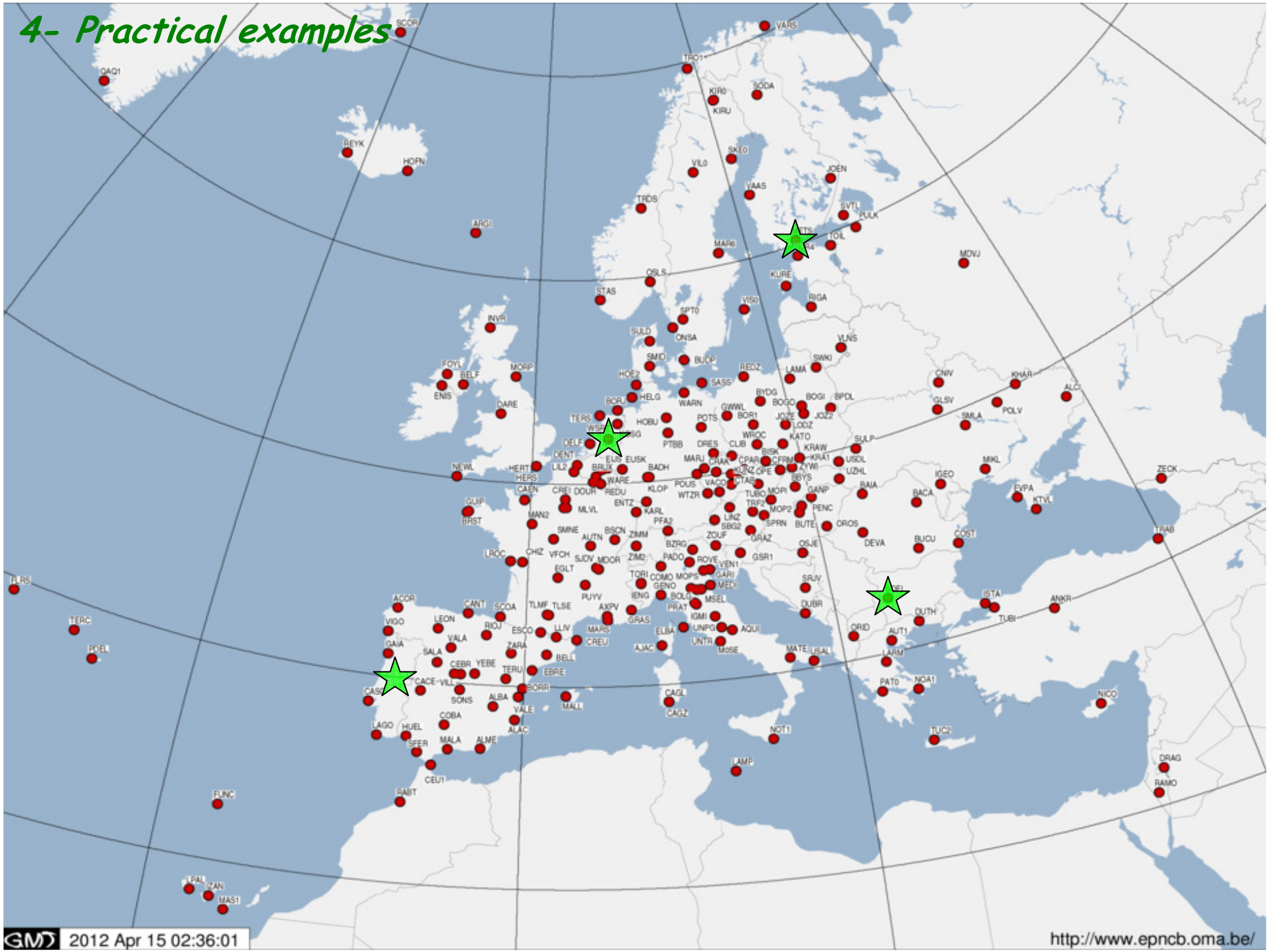
D . X(ITRF2008) (tc) (m)	R (rad)			R . X(ITRF2008) (tc) (m)	X(ETRF2000(R08)) (tc) (m)
	2005.0				2005.0
0.0050	0	6.1435E-08	3.8009E-08	0.2901	2892571,136
0.0023	-6.1435E-08	0	-6.2832E-09	-0.2123	1311843,285
0.0096	-3.8009E-08	6.2832E-09	0	-0.1017	5512633,977

3) COMPUTATIONS OF CAMPAIGNS ($ITRF_{XX}$ TO $ETRF_{YY}$)

- *ITRF2005 to ETRF97 (epoch 2008.53)*



4- Practical examples



3) COMPUTATIONS OF CAMPAIGNS ($ITRF_{XX}$ TO $ETRF_{YY}$)

Step 1: ITRF2005 to ITRF2000 (epoch 2008.53)

Transformation Parameters between ITRF2005 and ITRF2000

14 transformation parameters between ITRF2005 and ITRF2000 have been estimated and listed in Table 1, using 70 stations listed in Table 2 and located at sites shown on Figure 2.

	T1 mm	T2 mm	T3 mm	D 10-9	R1 mas	R2 mas	R3 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

Table 1: Transformation parameters at epoch 2000.0 and their rates from ITRF2005 to ITRF2000 (ITRF2000 *minus* ITRF2005)

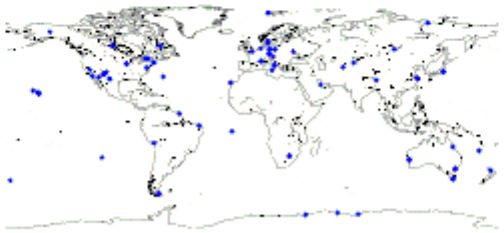


Figure 2: Sites used in the estimation of the transformation parameters between ITRF2005 and ITRF2000

http://itrf.ensg.ign.fr/

3) COMPUTATIONS OF CAMPAIGNS ($ITRF_{XX}$ TO $ETRF_{YY}$)

Step 2: ITRF2000 to ITRF97 (epoch 2008.53)

TRANSFORMATION PARAMETERS AND THEIR RATES FROM ITRF2000 TO PREVIOUS FRAMES
(See Note Below)

SOLUTION	T1	T2	T3	D	R1	R2	R3	EPOCH	Ref.
UNITS---------->	cm	cm	cm	ppb	.001"	.001"	.001"		IERS Tech. Note #
RATES	T1	T2	T3	D	R1	R2	R3		
UNITS---------->	cm/y	cm/y	cm/y	ppb/y	.001"/y	.001"/y	.001"/y		
ITRF97	0.67	0.61	-1.85	1.55	0.00	0.00	0.00	1997.0	27
rates	0.00	-0.06	-0.14	0.01	0.00	0.00	0.02		
ITRF96	0.67	0.61	-1.85	1.55	0.00	0.00	0.00	1997.0	24
rates	0.00	-0.06	-0.14	0.01	0.00	0.00	0.02		
ITRF94	0.67	0.61	-1.85	1.55	0.00	0.00	0.00	1997.0	20
rates	0.00	-0.06	-0.14	0.01	0.00	0.00	0.02		
ITRF93	1.27	0.65	-2.09	1.95	-0.39	0.80	-1.14	1988.0	18
rates	-0.29	-0.02	-0.06	0.01	-0.11	-0.19	0.07		
ITRF92	1.47	1.35	-1.39	0.75	0.00	0.00	-0.18	1988.0	15
rates	0.00	-0.06	-0.14	0.01	0.00	0.00	0.02		
ITRF91	2.67	2.75	-1.99	2.15	0.00	0.00	-0.18	1988.0	12
rates	0.00	-0.06	-0.14	0.01	0.00	0.00	0.02		
ITRF90	2.47	2.35	-3.59	2.45	0.00	0.00	-0.18	1988.0	9
rates	0.00	-0.06	-0.14	0.01	0.00	0.00	0.02		
ITRF89	2.97	4.75	-7.39	5.85	0.00	0.00	-0.18	1988.0	6
rates	0.00	-0.06	-0.14	0.01	0.00	0.00	0.02		
ITRF88	2.47	1.15	-9.79	8.95	0.10	0.00	-0.18	1988.0	IERS An. Rep.
rates	0.00	-0.06	-0.14	0.01	0.00	0.00			

http://itrf.ensg.ign.fr/

3) COMPUTATIONS OF CAMPAIGNS ($ITRF_{XX}$ TO $ETRF_{YY}$)

Steps 1 and 2: ITRF2005 to ITRF97 (epoch 2008.53)

	ITRF2005 to ITRF2000			ITRF2000 to ITRF97			ITRF2005 to ITRF97	
	t0: 2000.00	*tc: 2008.53*		*t0: 1997.00*	*tc: 2008.53*			
Parameter	***at t0***	**Rate/year**	***at tc***	***at t0***	**Rate/year**	***at tc***	***at tc***	***unit***
T1	0.1	-0.2	-1.6	6.7	0	6.7	5.1	*mm*
T2	-0.8	0.1	0.1	6.1	-0.6	-0.8	-0.7	*mm*
T3	-5.8	-1.8	-21.2	-18.5	-1.4	-34.6	-55.8	*mm*
D	0.4	0.08	1.08	1.55	0.01	1.67	2.75	10^{-9}
R1	0	0	0	0	0	0	0	*0.001"*
R2	0	0	0	0	0	0	0	*0.001"*
R3	0	0	0	0	0.020	0.231	0.231	*0.001"*

3) COMPUTATIONS OF CAMPAIGNS ($ITRF_{XX}$ TO $ETRF_{YY}$)

Step 3: ITRF97 to ETRF97 (epoch 2008.53)

"Memo: Specifications for…" (Boucher and Altamimi, 2011)

Table 3: Estimation of T_{YY}

YY		T1 cm	T2 cm	T3 cm
89		0	0	0
90	A	1.9	2.8	-2.3
	B	2.6	2.5	-2.6
	±	0.7	0.7	0.7
91	A	2.1	2.5	-3.7
	B	2.3	2.1	-3.1
	±	0.7	0.7	0.7
92	A	3.8	4.0	-3.7
	B	4.3	3.4	-3.2
	±	0.8	0.8	0.8
93	A	1.9	5.3	-2.1
	B	1.0	5.9	-1.4
	±	0.5	0.5	0.6
94	A	4.1	4.1	-4.9
	B	2.9	4.3	-3.6
	±	0.4	0.5	0.5
96	A	4.1	4.1	-4.9
	B	3.9	4.1	-3.9
	±	0.4	0.4	0.4
97	A	4.1	4.1	-4.9
	B	3.4	4.4	-4.3
	±	0.4	0.4	0.4
00	A	5.4	5.1	-4.8
	B	4.2	5.1	-4.6
	±	0.4	0.4	0.4
05*	A	5.6	4.8	-3.7
	B	3.6	4.2	-4.1
	±	0.4	0.4	0.4

Table 3 : (cont'd)

* See TWG recommendation §4

Table 4: Estimation of R_{YY}

YY	$\dot{R}1$ mas/y	$\dot{R}2$ mas/y	$\dot{R}3$ mas/y
89	0.11	0.57	-0.71
90	0.11	0.57	-0.71
91	0.21	0.52	-0.68
92	0.21	0.52	-0.68
93	0.32	0.78	-0.67
94	0.20	0.50	-0.65
96	0.20	0.50	-0.65
97	0.20	0.50	-0.65
00	0.081	0.490	-0.792
	±0.021	±0.008	±0.026
05*	0.054	0.518	-0.781
	±0.009	±0.006	±0.011

* See TWG recommendation §4

3) COMPUTATIONS OF CAMPAIGNS ($ITRF_{XX}$ TO $ETRF_{YY}$)

Step 3: ITRF97 to ETRF97 (epoch 2008.53) & final set of parameters: ITRF2005 to ETRF97 (epoch 2008.53)

	ITRF97 to ETRF97			ITRF2005 to ETRF97	
	t0: 1989.00	*tc: 2008.53*			
Parameter	***at t0***	**Rate/year**	***at tc***	***at tc***	***unit***
T1	**41.0**	**0**	**41.0**	**46**	***mm***
T2	**41.0**	**0**	**41.0**	**40**	***mm***
T3	**-49.0**	**0**	**-49.0**	**-105**	***mm***
D	**0**	**0**	**0**	**2.75**	***10^{-9}***
R1	**0**	**0.200**	**3.906**	**3.906**	***0.001"***
R2	**0**	**0.500**	**9.765**	**9.765**	***0.001"***
R3	**0**	**-0.650**	**-12.695**	**-12.465**	***0.001"***

Difference wrt coordinates computed directly with the IBERIA95 solution (ETRF97, epoch 1995.4) is 2-3cm

4) ETRS89 REALIZATIONS CONSISTENCY

4-a) Time series of EPN sites: ITRS and ETRS89

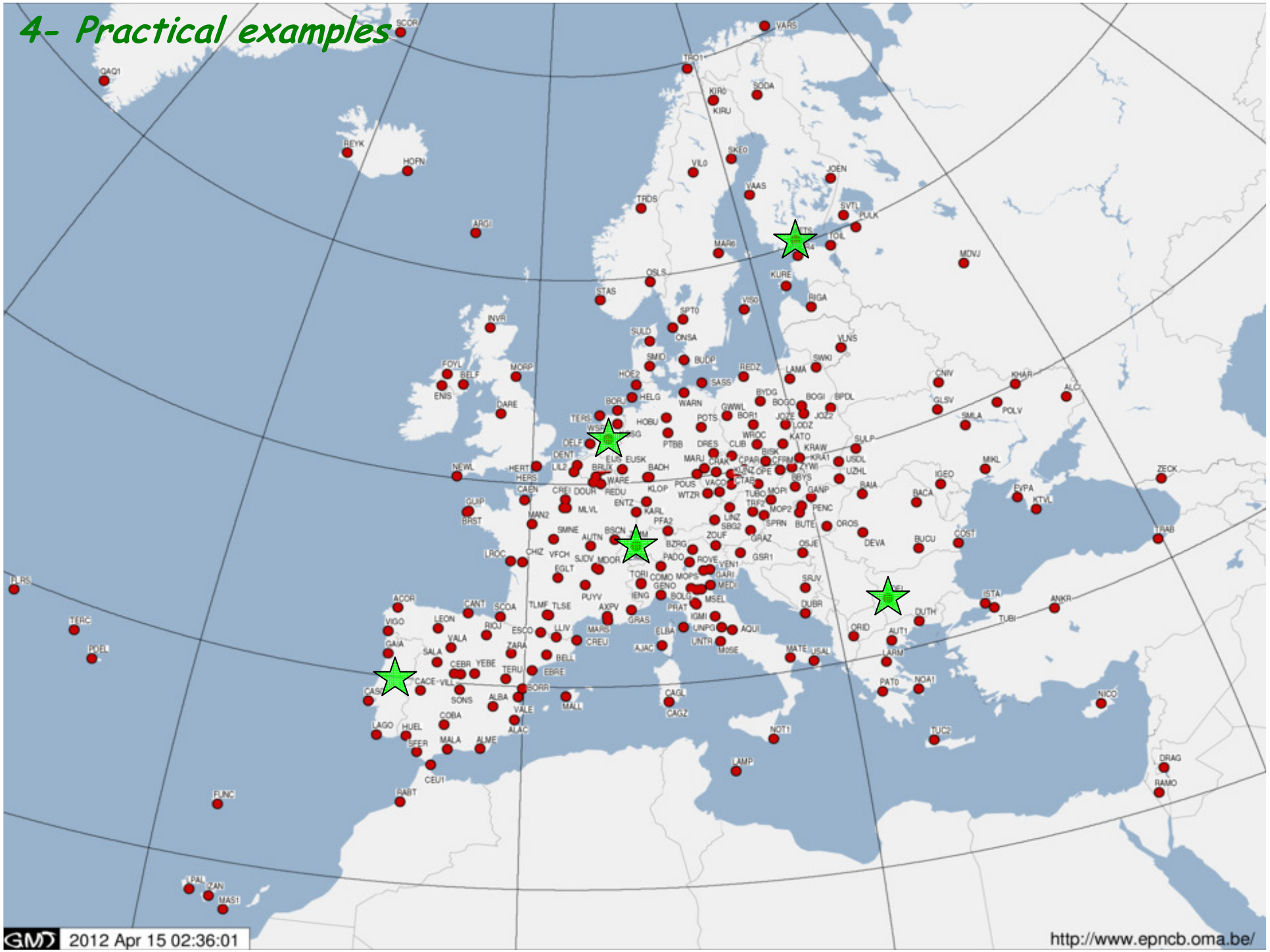
DATA & PRODUCTS > **TIME SERIES**

Coordinate time series displaying the time evolution of the coordinates included in the weekly combined EPN solutions:

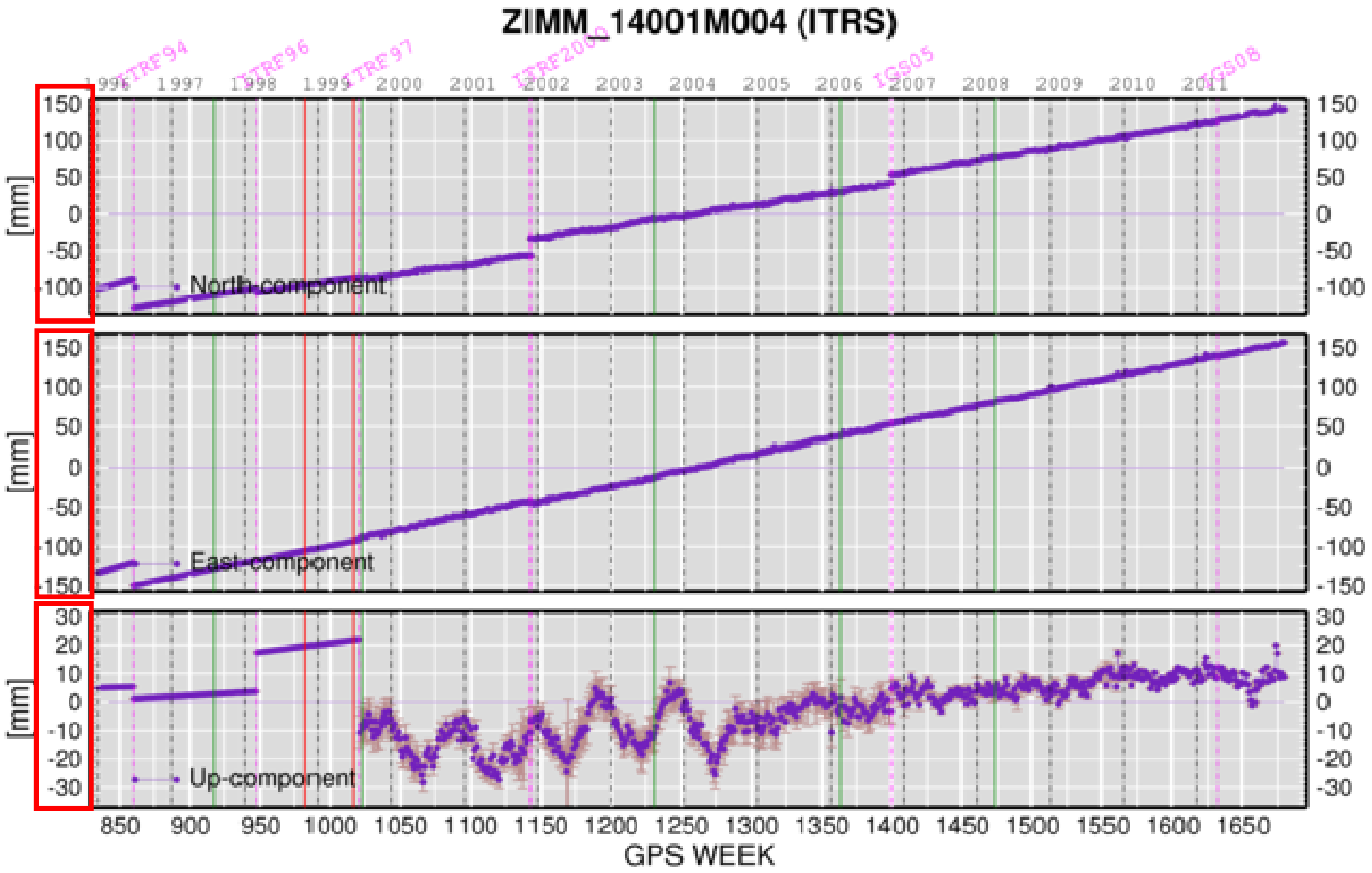
- ITRS time series: coordinates in ITRS extracted from weekly solution as is
- ETRS time series: coordinates in ITRS extracted from weekly solution and transformed to ETRS89

ITRS time series	ETRS89 time series
Coordinate Time Series in ITRS extracted from weekly EPN combined solution.	Coordinate Time Series in ETRS89 extracted from weekly EPN combined solution.
Updated weekly (select a station) Purpose : • Evaluate influence of the different ITRS realisations on the station coordinates • Visualise large periodic signals in EPN combined solution • Easily distinguish between constrained and non-contrained stations in EPN combined solution Procedure : • Extract for each station the weekly estimated (X,Y,Z) coordinates, as is, from the weekly EPN combined solutions. These solutions are linked to the successive realisations of the ITRS at the epoch of observation. • Then, these weekly station coordinates are then converted to a local reference system (N,E,U) with respect to the mean coordinates of that station. • The resulting coordinate time series display for each EPN station the so-called 'ITRS' time series.	Updated weekly (select a station) Purpose : • Evaluate influence of the different ETRS89 realisations on the station coordinates • Visualise common signatures in EPN combined solution • Easily distinguish between constrained and non-contrained stations in EPN combined solution Procedure : • Extract for each station the weekly estimated (X,Y,Z) coordinates, as is, from the weekly EPN combined solution. This solution is linked to the successive realisations of the ITRS at the epoch of observation. • Then, the extracted weekly coordinate solutions are converted into the European Terrestrial Reference System (ETRS89) by applying the transformation formula published by Boucher and Altamimi. • In a last step the weekly ETRS89 (X,Y,Z) coordinates are then converted to a local reference system (N,E,U) with respect to the mean coordinates of that station.

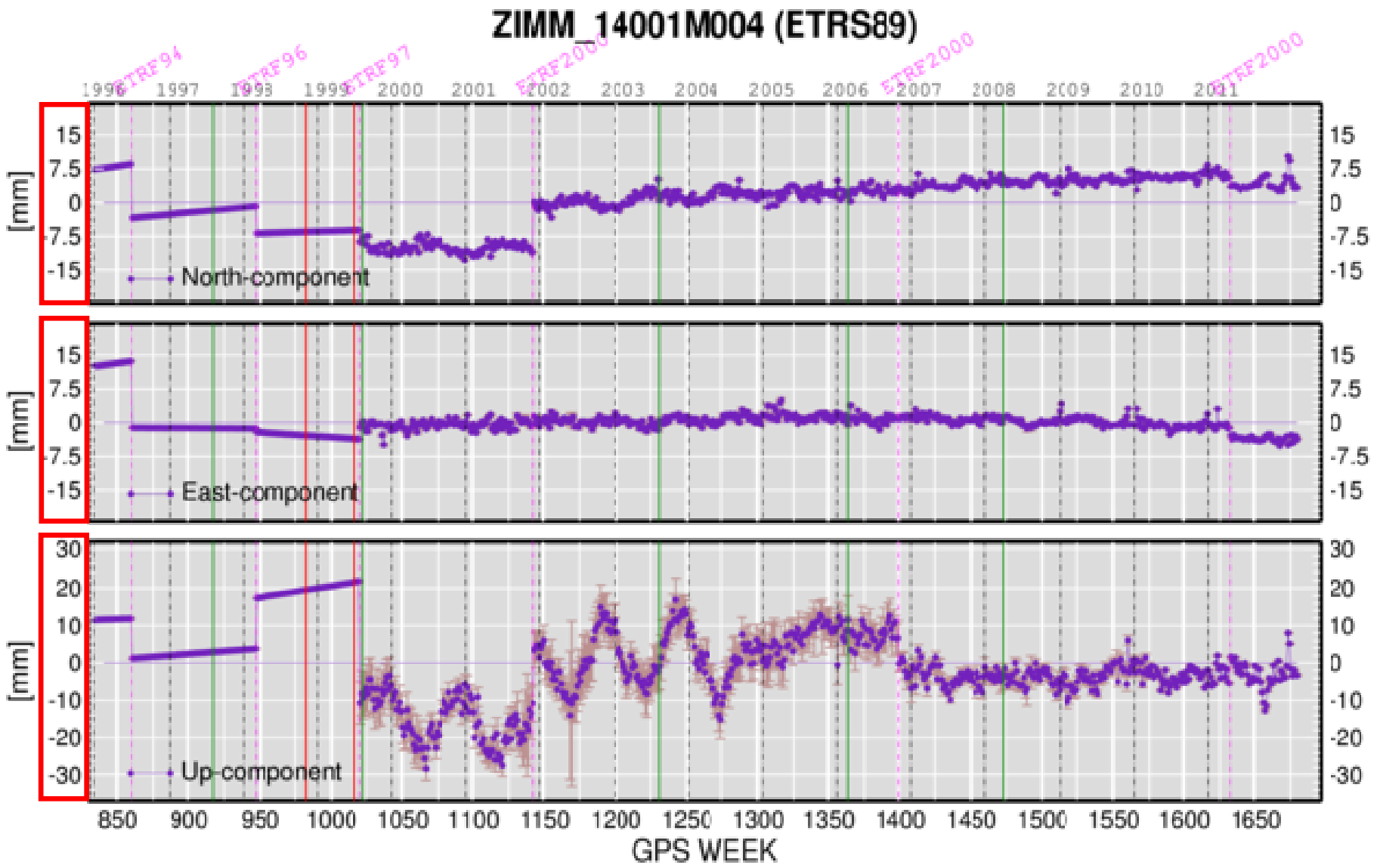
4- Practical examples



4- Practical examples



4- Practical examples



4) ETRS89 REALIZATIONS CONSISTENCY

4-b) Monitoring of EUREF coordinates

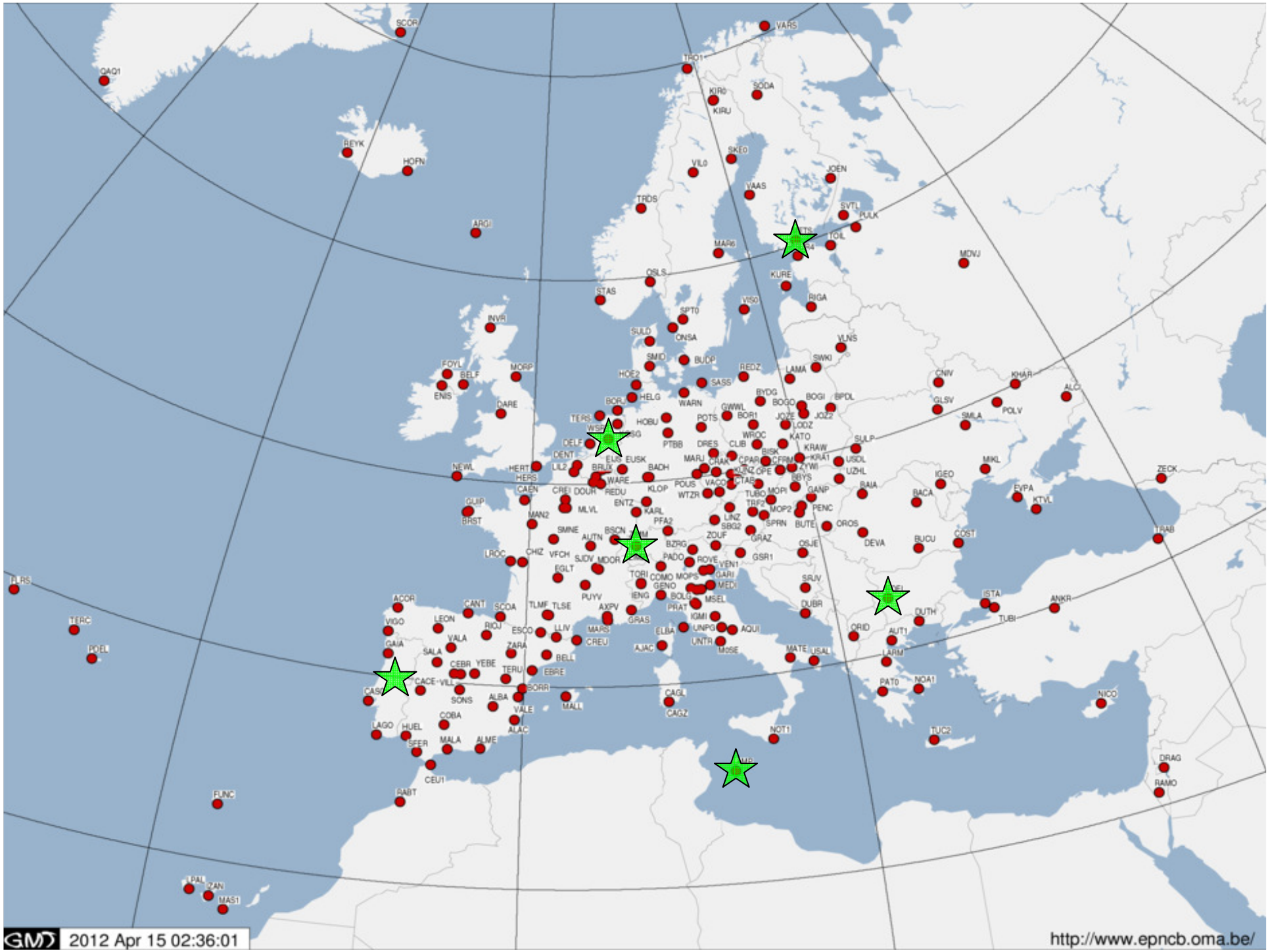
"Monitoring of official national ETRF coordinates on EPN web" (Brockmann, 2010)

comparisons between

- *"scientific" coordinates in ETRF2000*
  - *latest release*
  - *based on a combination of weekly combined EPN SINEX files*
  - *tied to ITRF2005 using minimal constraints on a highest quality set of stations*
  - *compliant with relative antenna PCV models (= many national reference frames)*

and

- *official coordinates provided by the countries*


GMT 2012 Apr 15 02:36:01
http://www.epncb.oma.be/

4) ETRS89 REALIZATIONS CONSISTENCY

4-b) Monitoring of EUREF coordinates

EUREF has classified LAMP (Lampedusa, Italy) as a class A station

1. POSITIONS/VELOCITIES PUBLISHED BY EUREF

Latest release

EPN_A_ETRF2000_C1600.SSC - EPN_A_ITRF2005_C1600.SSC (October 23, 2010)

ETRF2000	epoch t_0	Position (m)			Velocity (m/y)		
		X	Y	Z	V_X	V_Y	V_Z
193/2009 - 254/2010	001/2005	5073165.031 ± 0.001	1134512.287 ± 0.000	3683180.900 ± 0.001	-0.0024 ± 0.0001	-0.0040 ± 0.0000	0.0017 ± 0.0001
309/2006 - 192/2009	001/2005	5073165.028 ± 0.000	1134512.285 ± 0.000	3683180.905 ± 0.000	-0.0024 ± 0.0001	-0.0040 ± 0.0000	0.0017 ± 0.0001
171/1999 - 308/2006	001/2005	5073165.026 ± 0.000	1134512.282 ± 0.000	3683180.902 ± 0.000	-0.0024 ± 0.0001	-0.0040 ± 0.0000	0.0017 ± 0.0001

5. POSITIONS PUBLISHED BY THE COUNTRY

The official ETRS89 coordinates used in Italy are maintained by *IGM*. This agency is fully responsible for the information kindly provided to the EPN:

Valid (from - to)	epoch t_0	Position (m)			Velocity (m/y)		
		X	Y	Z	V_X	V_Y	V_Z
000/0000 - now	001/2008	5073165.026	1134512.273	3683180.910	NA	NA	NA

4) ETRS89 REALIZATIONS CONSISTENCY

4-b) Monitoring of EUREF coordinates

(Brockmann, 2010)

File name	Country	Reference frame
AUT_20090211.ETRF	Austria	ETRF00
BEL_20090127.ETRF	Belgium	ETRF2000
CHE_20081021.ETRF	Switzerland	ETRF93
DEU_20081104.ETRF	Germany	ETRS89
ESP_20090201.ETRF	Spain	ETRF05
FIN_20090119.ETRF	Finland	ETRF96
FRA_20090428.ETRF	France	ETRF93
HUN_20090120.ETRF	Hungary	ETRF00
ITA_20090101.ETRF	Italy	ETRF2000
NLD_20090325.ETRF	Netherlands	ETRF2000(R05)
POL_20090129.ETRF	Poland	ETRF05(R05)
PRT_20090402.ETRF	Portugal	ETRF89
SVK_20090421.ETRF	Slovakia	ETRF2000
SWE_20081024.ETRF	Sweden	ETRF97
Czech Republic	no EPN station with official national ETRF coordinates	

Tab 1: File contribution of the 15 countries of the pilot project containing national ETRF coordinates for EPN stations.

4) ETRS89 REALIZATIONS CONSISTENCY

4-b) Monitoring of EUREF coordinates (Brockmann, 2010)

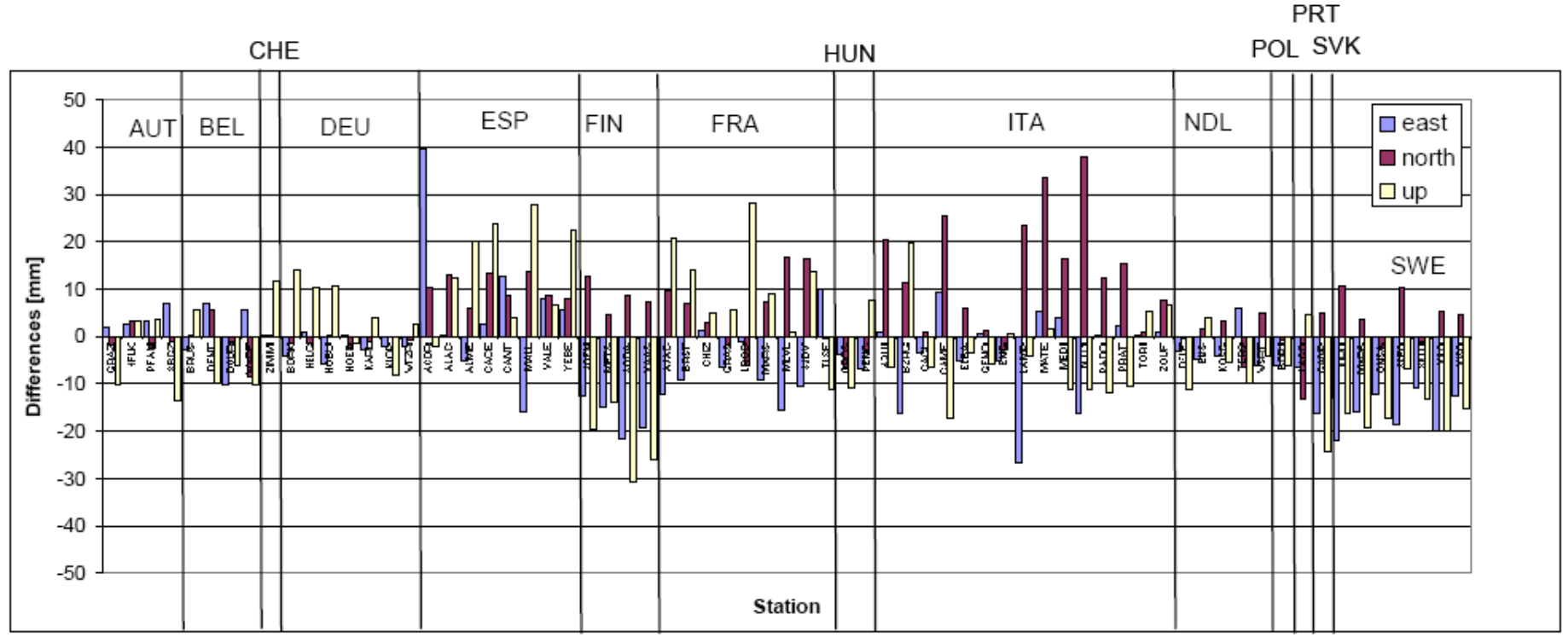
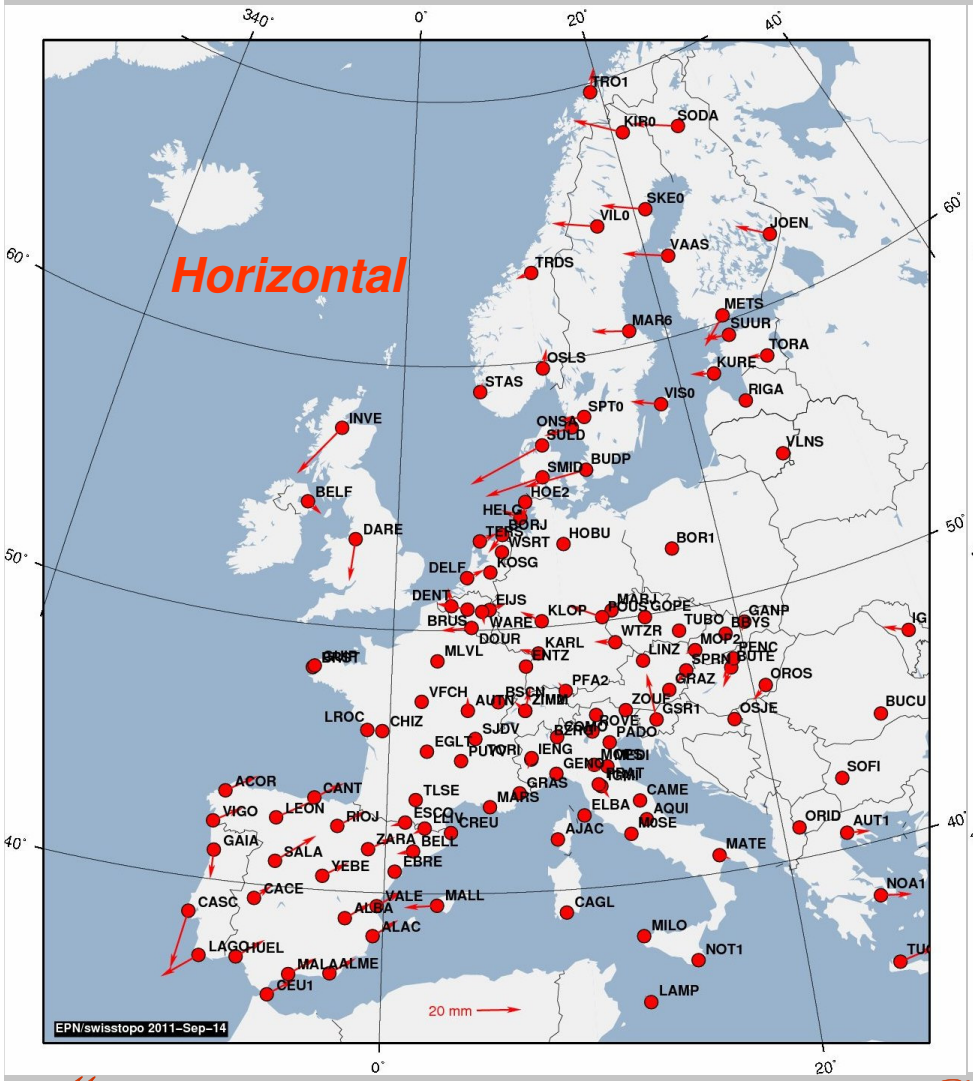


Fig 4: Differences in East, North and Up for 70 EPN stations between official national ETRF coordinates and the EPN densification solution.

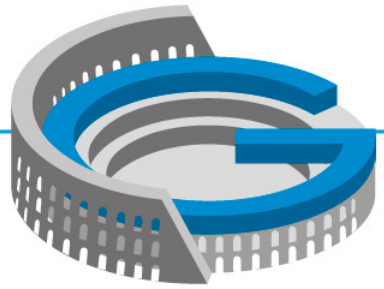
4) ETRS89 REALIZATIONS CONSISTENCY

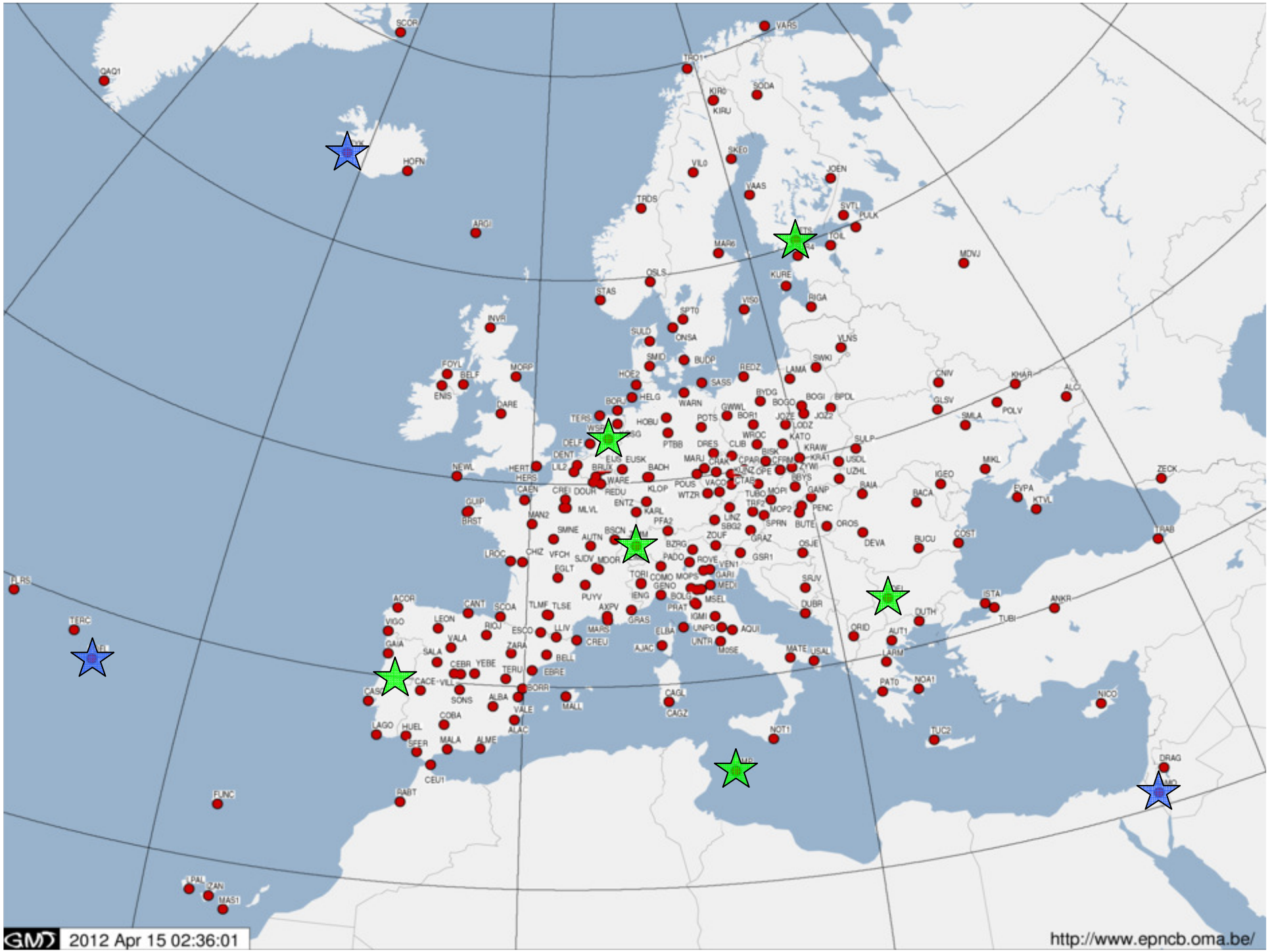
4-b) Monitoring of EUREF coordinates (Brockmann, 2010)

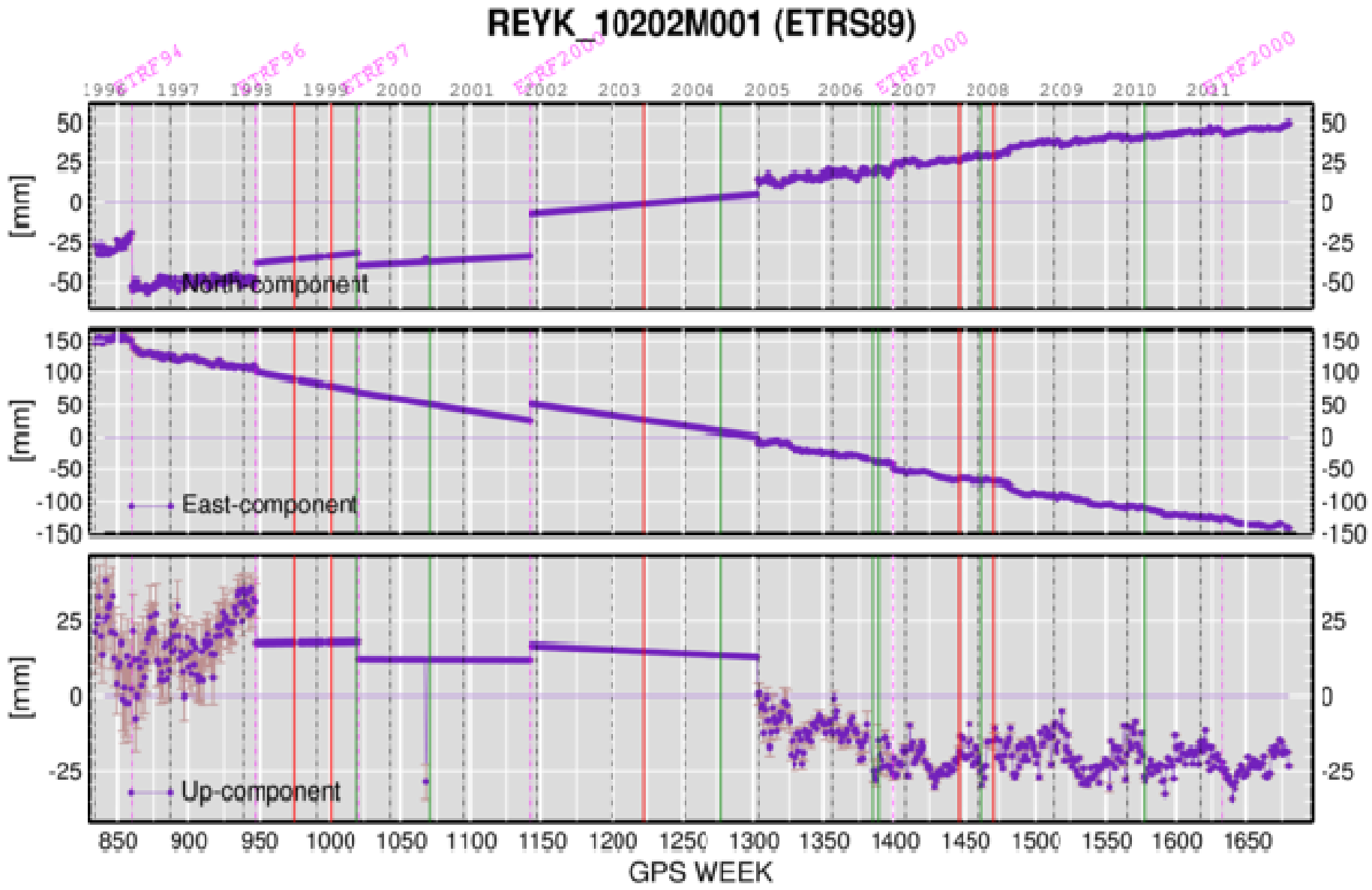


SUMMARY

- ***About Sub-commission 1.3***
  "Regional Reference Frames"
- ***Similarity transformations in space:***
  a short review
- ***The case of ETRS89:***
  definition and realization (ETRF)
- ***Practical examples:***
  computation and comparison of realizations
- ***Discussion***

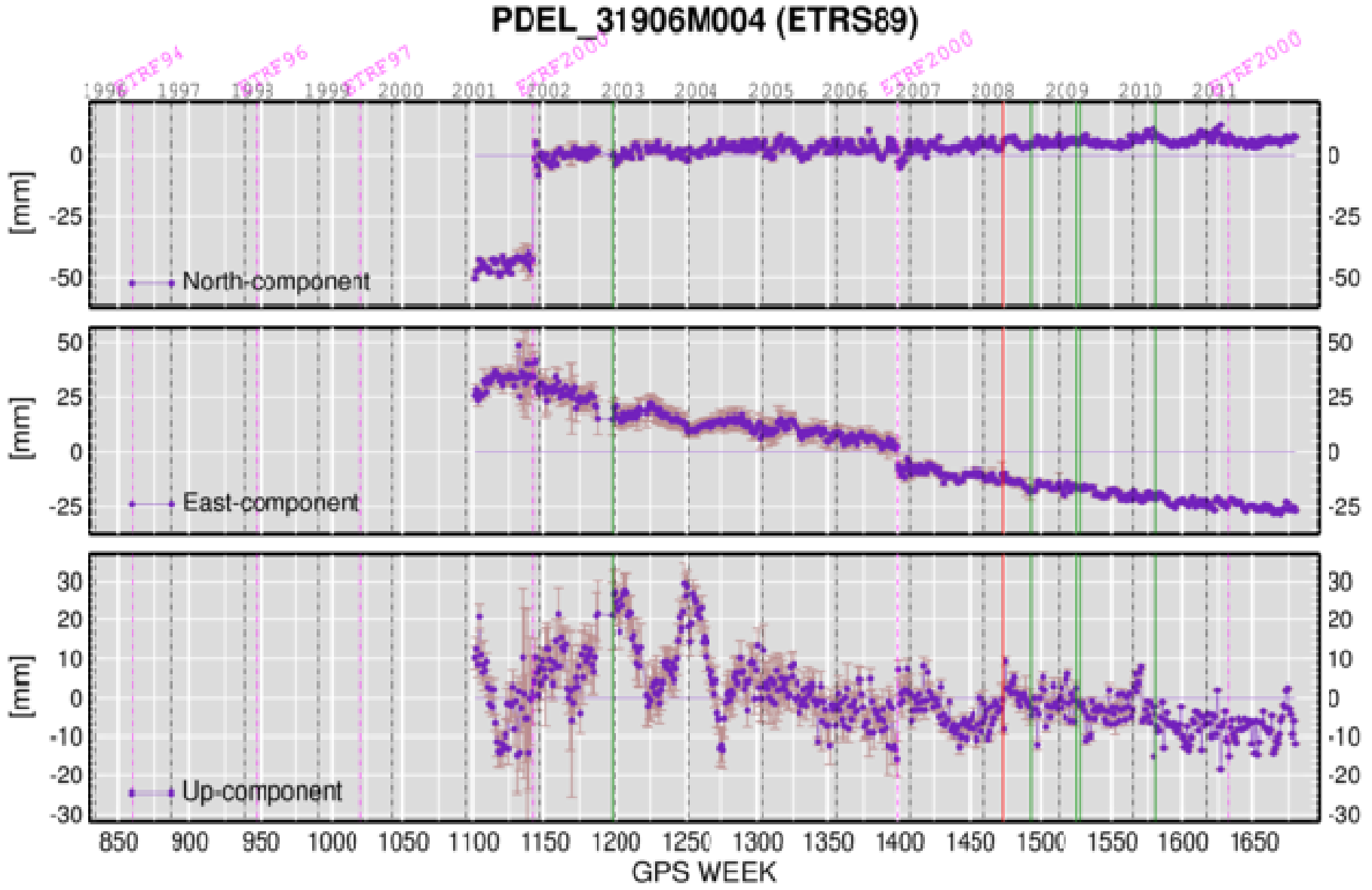



GMT 2012 Apr 15 02:36:01
http://www.epncb.oma.be/



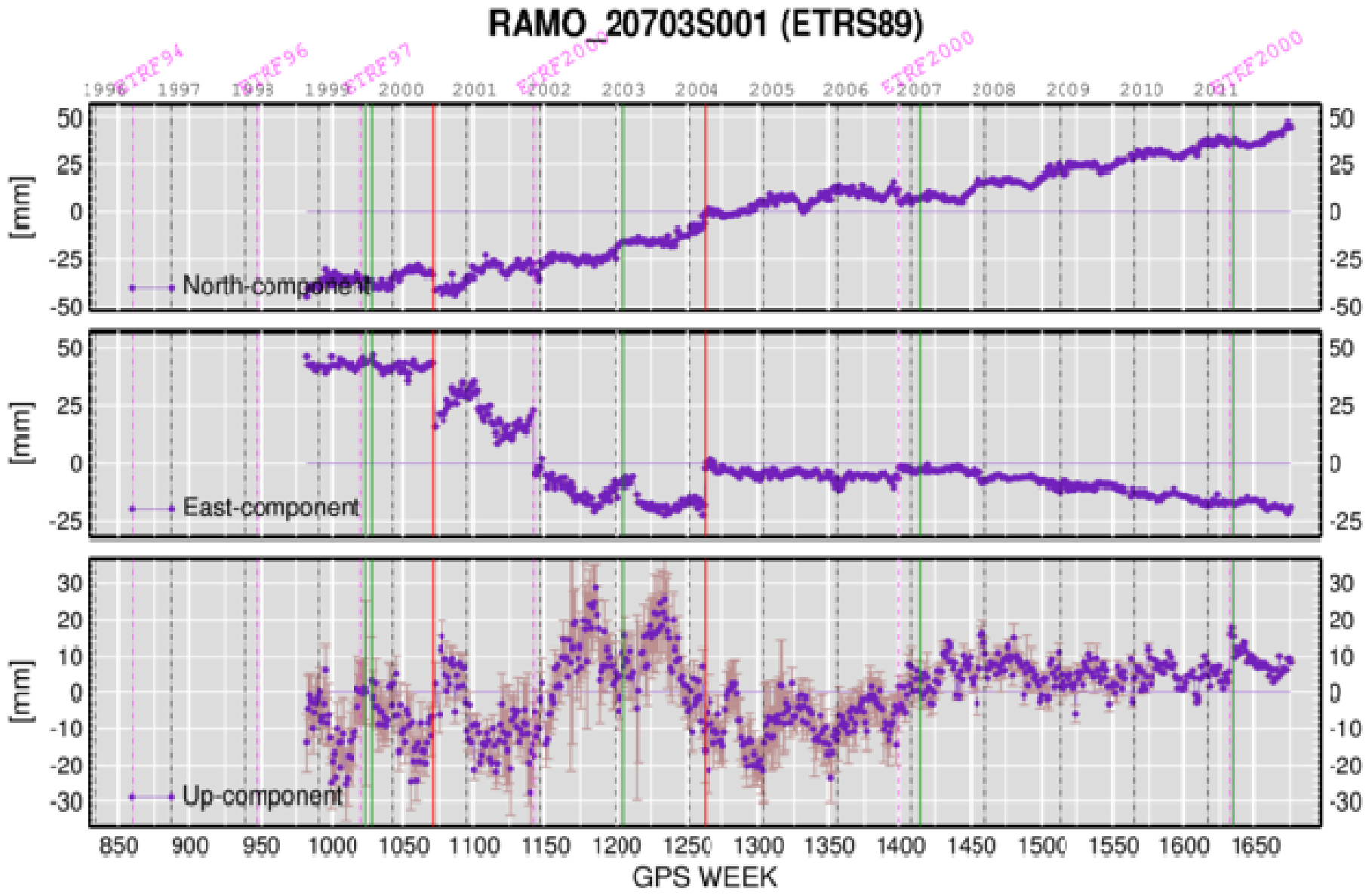
EPN CB

Sun Apr 29 04:40:23 2012



EPN CB

Sat Apr 28 04:45:53 2012

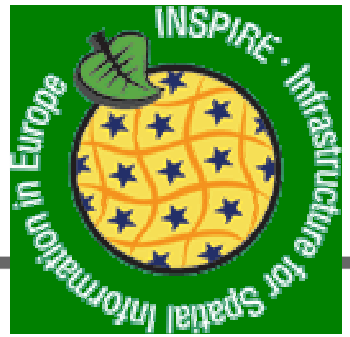


EPN CB

Sat Apr 28 04:46:35 2012

INSPIRE Specification on Coordinate Reference Systems

Requirement 1	For the three-dimensional and two-dimensional (horizontal component) coordinate reference systems, the European Terrestrial Reference System 1989 (ETRS89) shall be used for the areas within the geographical scope of ETRS89.



INSPIRE			Reference: INSPIRE_Specification_CRS_v3.1.pdf
TWG-RS	INSPIRE Specification on *Coordinate reference systems*	2010-04-26	Page 7

Requirement 2	The International Terrestrial Reference System (ITRS) or other geodetic coordinate reference systems compliant with ITRS shall be used in areas that are outside the geographical scope of ETRS89.

Requirement 3	For the computation of latitude, longitude and ellipsoidal height, and for the computation of plane coordinates using a suitable mapping projection, the parameters of the GRS80 ellipsoid shall be used.