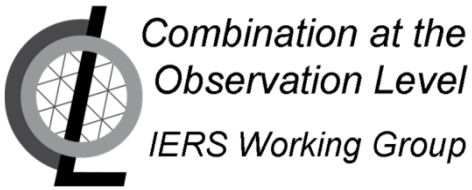


IERS COL-WG project
GRGS COMBINATION CENTRE

R. Biancale[(1)], J-Y. Richard[(2)], D. Gambis[(2)], C. Bizouard[(2)],T. Carlucci[(2)]
(1) GRGS, CNES Toulouse
(2) GRGS, Paris Observatory, SYRTE

Outlook

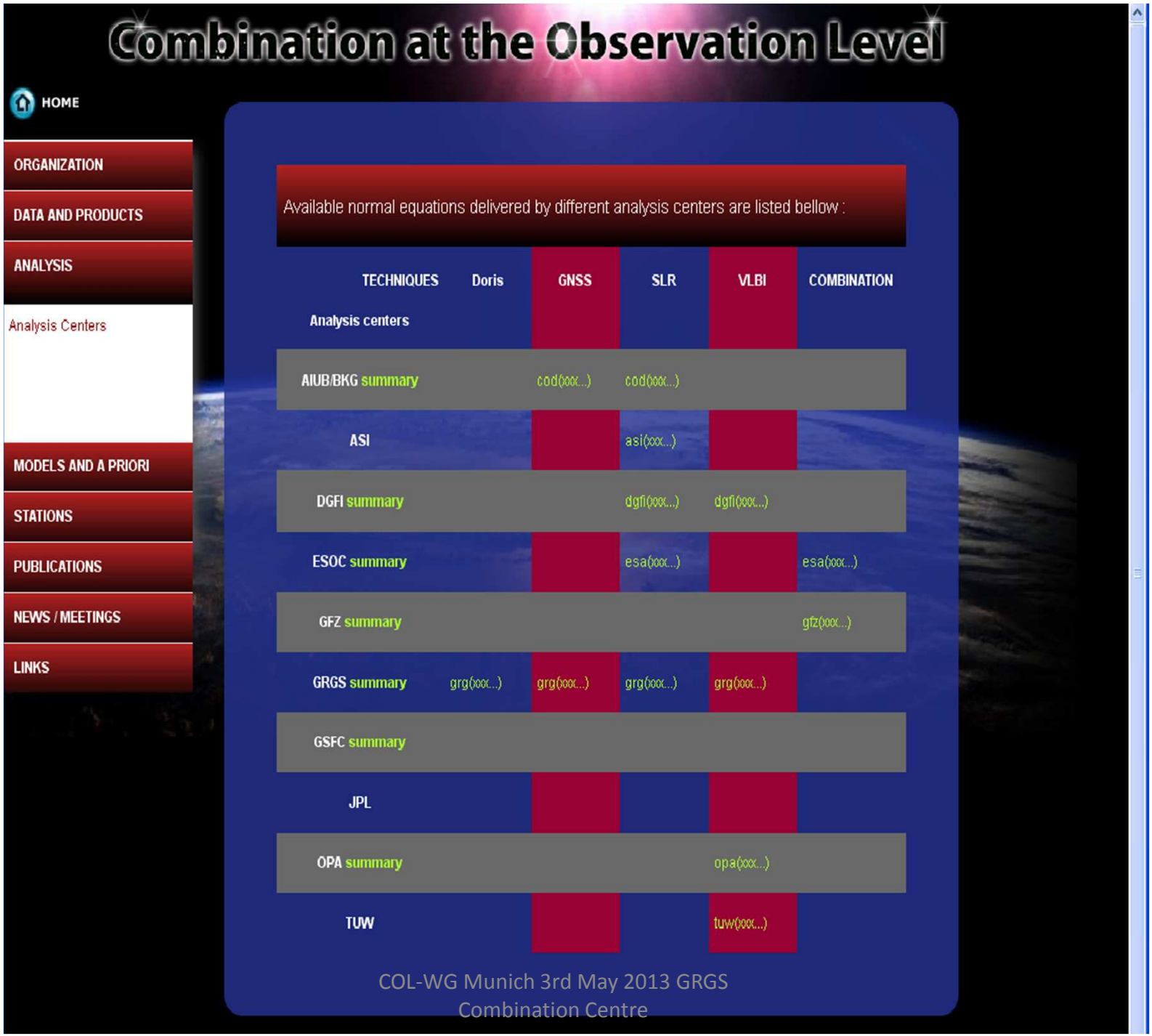
- Delivered normal equations
- Combination strategy at GRGS
- Results
- Conclusion

Delivered SINEX on ftp site: ftp://hpiers.obspm.fr/iers/eop/grgs/

Analysis Center	DORIS	GNSS	SLR	VLBI	Pre combined
AIUB/BKG		Delivered 14-Nov-2011 SINEX **version n3** CONT08	Delivered 22-May-2012 SINEX version **n3** CONT08 & CONT11		
ASI			Delivered 29-April-2013 **SINEX version 2** CONT08 & CONT11		
DGFI			Delivered 09-Nov-2012 **SINEX version 3** CONT08 & CONT11	Delivered 07-Jun-2011 version n2, CONT08	
ESOC			Delivered 18-Mar-2010 version n1, CONT08		**SLR-GPS** CONT08 18-Mar-2010 **SLR-DORIS** CONT08 18-Mar-2010 **GNSS-DORIS-SLR** CONT08 26-Apr-2013
GFZ		**GPS** CONT08-CONT11, 22-Jan-2013, **version n1**			
GRGS	Delivered CONT08-CONT11 22-Nov-2013 **SINEX version n7**	Delivered CONT08-CONT11 20-Nov-2012 **SINEX version n9**	Delivered CONT08-CONT11 10-May-2012 **SINEX version n4**	Delivered CONT08-CONT11 08-Jan-2013 GINS version v4 **SINEX version n6**	
GSFC	Expected	Expected	Expected	Excepted	
OPA				Delivered 05-Oct-2011 SINEX version n1	
TUW				Delivered CONT08-CONT11 31-Oct-2012 **version n3** 29-Apr-2013 **version n4**	

New NEQs with conventional models proposed in May 2012 for the COL project

Combination at the Observation Level



Normal Equation Parameters in the last delivered SINEX

Parameters	DORIS GRGS version n7	GPS GRGS version n9	GPS GFZ version n1	SLR ASI version 1	SLR DGFI version 3	VLBI TUW version n3	VLBI GRGS version n6	GNSS DORIS SLR ESOC Version n1
Informations	Weekly bases 1-day arcs Spot2 (CONT08), Spot4,, Spot5, Envisat, Jason2, Cryosat2 (CONT11)	Weekly bases	Daily bases	Weekly bases 7 Days Arcs Lageos1/2, Etalon1/2,	Weekly bases 7 Days Arcs Lageos1/2, Etalon1/2, Stella, Starlette, Ajisaï, Larets, Blits, weighted by the variance component estimation	Daily bases	Weekly bases	Weekly bases CONT08
Pole x,y UT1	**XPPO, YPO** @0h,3h,6h…21h **UT1-TAI**	**XPPO, YPO** **UT1-TAI** @0h,3h,6h…21h		**XPPO, YPO UT1-UTC** @0h,3h,6h…21h	**XPPO, YPO UT1-UTC** 1/d, PWL @12h	**XPPO, YPO UT1-UTC** @0h,3h,6h…21h	**XPPO, YPO** **UT1-TAI** @0h,3h,6h…21h	**XPPO, YPO, UT1-TAI, LOD, XPOR, YPOR** @12h
Nutation	**NUT_X, NUT_Y /** IAU2000 @0h,12h apriori≠0 & ≠C04	**NUT_X, NUT_Y /** IAU2000 @12h apriori ≠0 & ≠C04 **NUTR_X, NUTR_Y** 1/d@12h				**NUT_X, NUT_Y /** IAU2006/2000A @0h apriori set to 0	**NUT_X, NUT_Y /** IAU2006/2000A @0h,12h apriori≠0 & ≠C04	
Stations coordinates	**STAX, STAY,STAZ** **1**/w	**STAX, STAY,STAZ** 1 /w	**STAX, STAY,STAZ** 1 /w	**STAX, STAY,STAZ** 1 /w	**STAX, STAY,STAZ** 1 /w	**STAX, STAY,STAZ** 1 /d	**STAX, STAY,STAZ** 1 /w	**STAX, STAY,STAZ** 1 /w
Tropospheric Zenithal Bias	**ZBIAS** : Zenith Wet delay @0h,1h,2h,3h…,23h 1 bias/pass, passes of all satellites in the same hour are stacked	**ZBIAS** co-located stations @1h,3h,5h,…,23h				**TROWET :** Zenith wet delay @0h,2h,4h,6h,…, 22h	**ZBIAS :** Zenith offset delay of co-located stations @0h,1h,2h,3h…,23 h	
Troposphere Horizontal Gradients		**TGNTOT, TGETOT** @3h,21h				**TGNTOT, TGETOT** @0h,24h apriori=0		
Quasars coordinates						**RS_RA, RS_DE** 1 /d	**RS_RA, RS_DE** 1 /w	

Parameterizations for the COL campaign

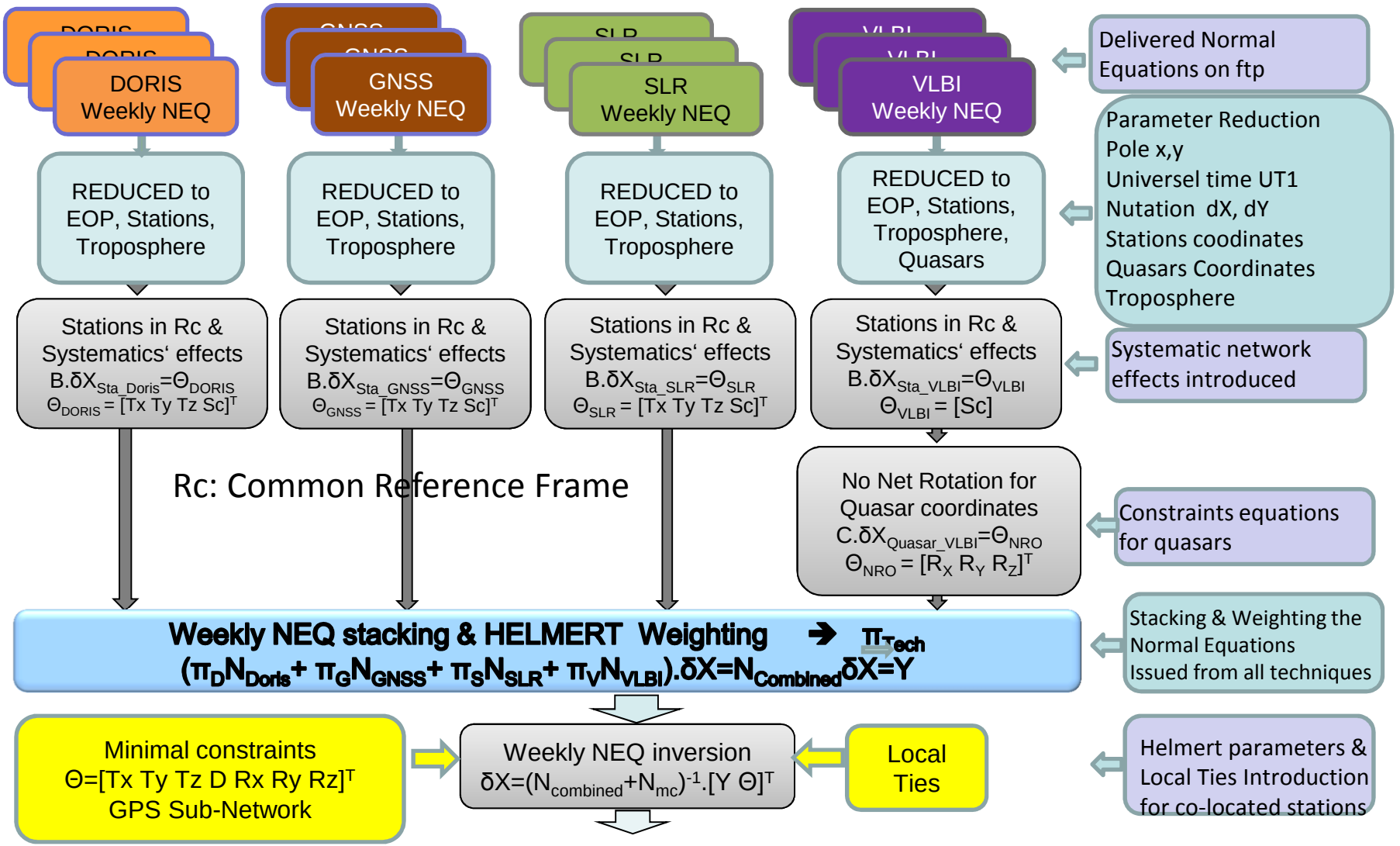
Parameters	*Parameters to be estimated*	*Initial values*
Pole, UT1-UTC or UT1-TAI	XPO, YPO, UT : PWL @ {00, 03, 06, 09, 12, 15, 18, 21, 24} hr	IERS EOP 08-C04 (tables available on the Forum Multi-technic Combination http://grgs.obspm.fr/forum/)
Pole Rate	XPOR, YPOR 1pt/day @ 12hr	Set to 0
LOD	LOD 1pt/day @ 12hr	Set to 0
Nutation angles	NUT_X, NUT_Y : PWL @ 0hr corrections to the model IAU2000	Set to 0
Station coordinates	SX, SY, SZ at mid epoch	ITRF2008
Radio sources coordinates	RS_RA, RS_DE 1pt/week	ICRF2
Zenithal Tropospheric Delay Wet component & Horizontal gradients	TROWET @ {00, 02, 04, … 24} hr: Adjustment of the wet component to the model TGETOT, TGNTOT daily 00h	GPT/GMF model for radio waves & Mendes/Pavlis for optical waves

Recommended MODELS for the COL campaign
Available on the Forum Multi-Technic Combination http://grgs.obspm.fr/forum/

Gravity Field	EIGEN model computed from GRACE-GOCE completed by the mean gravity variations of the atmosphere and the non-IB oceanic response
Ocean Tides Loading	FES2004 check at the triple co-location sites
Troposphere Delay	GPT+GMF for radio-electrical waves, Mendes-Pavlis for optical waves
Atmospheric Tide Model	Modified Ray-Ponte (2003)
Atmospheric Loading	Not applied

Strategy

GRGS Multi-Techniques Combination Strategy at the weekly bases



Global Solutions: EOP, Stations coordinates in the combined frame, Troposphere, Systematic effects, Quasars coordinates, Transformation parameters, rotations parameters of celestial frame

Solutions are available on
ftp://hpiers.obspm.fr/iers/eop/grgs/

Systematic effects associated to the geodetic techniques *

In order to take into account inconsistencies between techniques, we introduce Helmert parameters, translations and scale for satellites and scale factor for VLBI. Station coordinates are transformed into a common reference R_c for each technique by adding the Helmert parameters in the transformation equation:

$$\mathbf{X_{Tech} = X_{Tech\_ITRF} + A.\Theta_{Tech}}$$

$$A = \begin{bmatrix} A_{1_{Tech}} \\ \cdot \\ \cdot \\ A_{n_{Tech}} \end{bmatrix}, A_{i_{Tech}} = \begin{bmatrix} 1 & 0 & 0 & x_i^0 \\ 0 & 1 & 0 & y_i^0 \\ 0 & 0 & 1 & z_i^0 \end{bmatrix}, \Theta_{Tech} = \begin{bmatrix} T_{x_{Tech}} \\ T_{y_{Tech}} \\ T_{Z_{Tech}} \\ S_{c_{Tech}} \end{bmatrix} \quad A_i = \begin{bmatrix} x_i^0 \\ y_i^0 \\ z_i^0 \end{bmatrix}, \Theta_{Tech} = \begin{bmatrix} S_c \end{bmatrix}_{Tech}$$

Considering all n_{Tech} stations with *Tech: DORIS,GNSS,SLR,VLBI*

$\begin{bmatrix} x_i^0 & y_i^0 & z_i^0 \end{bmatrix}^T_{Tech}$ represents a priori station coordinates in the ITRF reference frame.

Processing of systematic effects estimation

The station parameters X_{Tech} with systematic effects cancelled are expressed in a common reference frame Rc and form the constraints equations added to the unconstraint normal equation for each technique:

$$\mathbf{(A^TA)^{-1}\, A^T\, (X_{Tech} - X_{Tech\_ITRF}) - \Theta_{Tech} = 0 \pm \sigma \text{ with } \sigma = 10\mu m}$$

The station parameters expressed in the referential ITRF are reduced from the normal equation of each technique and the station parameters X_{Tech} and systematic effect Θ_{Tech} are kept.

*Reference: Arnaud Pollet IGN/LAREG thesis « COMBINAISON DE TECHNIQUES DE GÉODÉSIE SPATIALE », Jan. 2011

Systematic Effects

CONT08

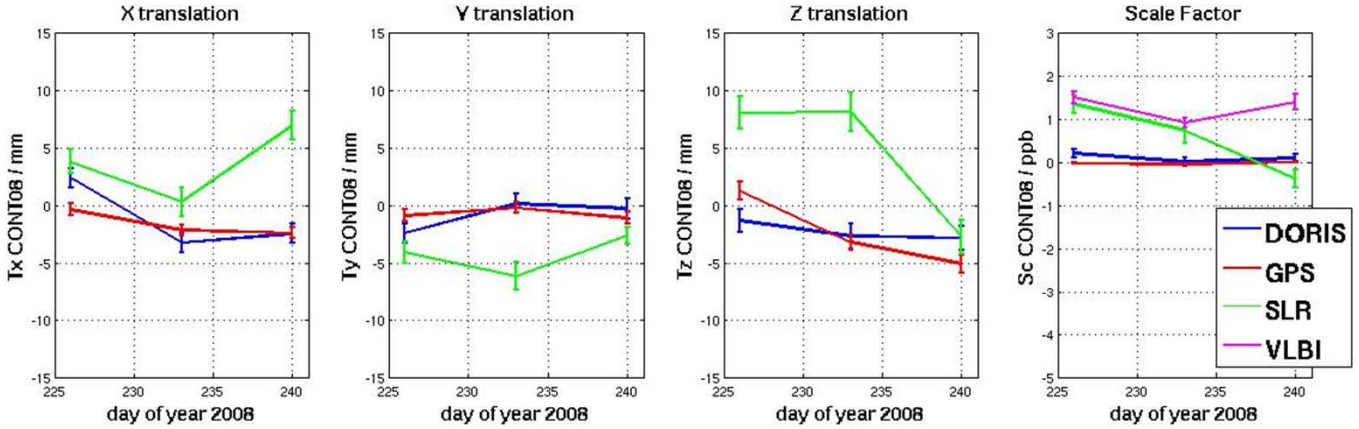
	DORIS	GPS	SLR	VLBI
Tx mm	-1,1 ± 2,7	-1,7 ± 1,9	3,7 ± 4,4	
Ty mm	-0,9 ± 1,4	-0,7 ± 0,8	-4,3 ± 4	
Tz mm	-2,3 ± 2,3	-2,3 ± 3,5	4,5 ± 6,7	
Sc ppb	0,1 ± 0,13	-0,030 ± 0,035	0,56 ± 0,93	1,26 ± 1,22

CONT11

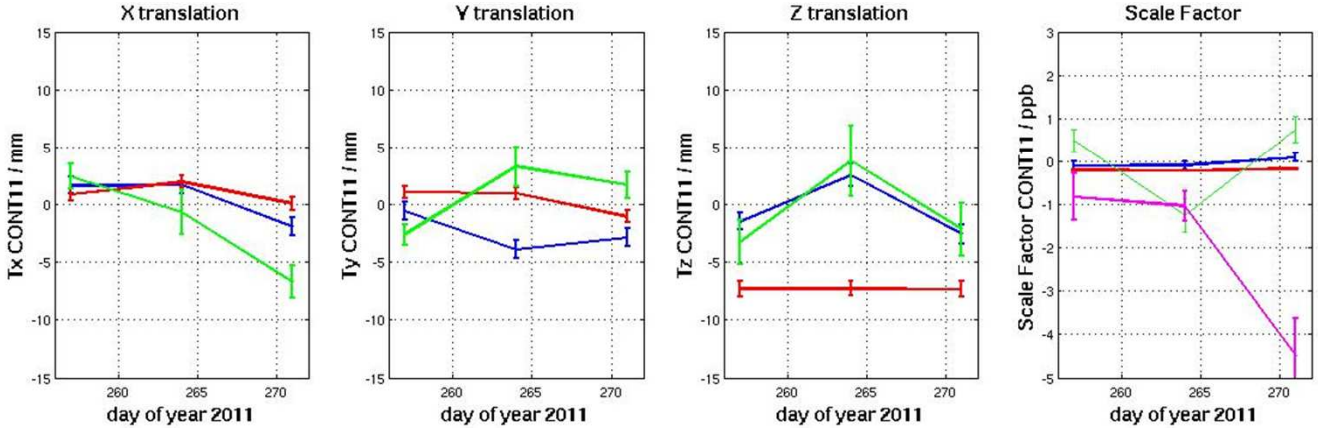
	DORIS	GPS	SLR	VLBI
Tx mm	0,5 ± 1,8	0,9 ± 1,2	-1,7 ± 4,1	
Ty mm	-2,5 ± 2,8	0,3 ± 1,0	0,8 ± 2,5	
Tz mm	-0,5 ± 2,2	-7,3 ± 7,3	-0,5 ± 3,1	
Sc ppb	-0,04 ± 0,09	-0,2 ± 0,2	-0,005 ± 0,78	-2,12 ± 1,7

Mean & WRMS over CONT period in mm for translation parameters & in ppb in scale factor

CONT08



CONT11



NO NET ROTATION FOR CELESTIAL FRAME TIE in VLBI analysis

In order to orientate the radio sources onto the a-priori catalog (ICRF2) we add transformed parameters between the a-priori and the estimated catalog, imposed to be zero. The 3-parameter transformation is represented by 3 rotations R_1, R_2, R_3 constraining the small angles for the i-th source:

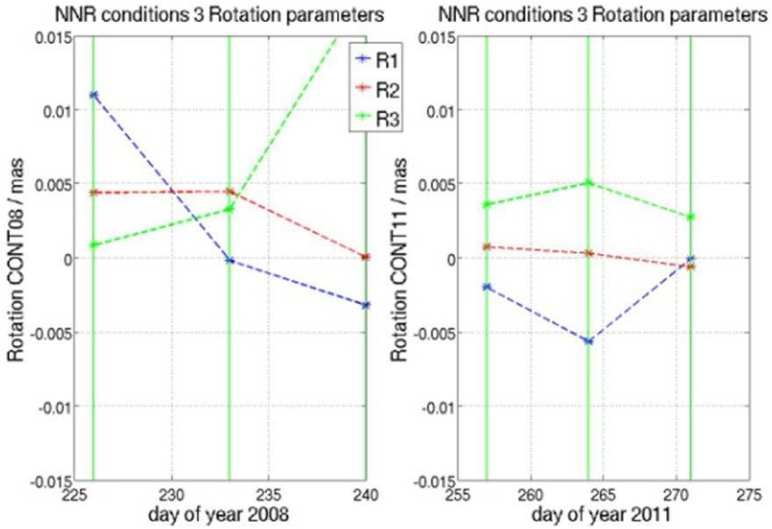
$$\mathbf{\Delta RS\_DA_i = R_1 cos(RS\_DA_i)\, tan(RS\_DE_i) + R_2 sin(RS\_DA_i)\, tan(QDE_i) - R_3}$$

$$\mathbf{\Delta RS\_DE_i = -R_1 sin(RS\_DA_i) + R_2 cos(RS\_DA_i)}$$

With **RS_DA** = Right Ascencion & **RS_DE** = Declination

Writing $Q=(\Delta RS\_DA_i\ ,\ \Delta RS\_DE_i\ )^T$ & $\mathbf{\Theta = (R_1\ R_2\ R_3)^T}$ The normal equation constraint applied is :

$$\mathbf{(B^T B)^{-1}\, B^T\, (\Delta Q) - \Theta = 0 \pm \sigma} \text{ with } \mathbf{\sigma = 1nrd}$$



NNR	CONT08	CONT11
R_1 µas	2,4 ± 6,4	-2,6 ± 3,5
R_2 µas	2,6 ± 3,6	0,1 ± 1,4
R_3 µas	7,6 ± 10,8	1,0 ± 1,0

Mean values over 3 weeks

The 3 Rotation parameters are at the level of 10^{-9} radian that show the good consistency between celestial and terrestrial frame simultaneously estimated

Weighting by variance analysis component (Helmert)

$$(w_D N_{Doris} + w_G N_{GNSS} + w_S N_{SLR} + w_V N_{VLBI}).\delta X = N_{Combined}\delta X = Y$$

Variance factor

$$s0 = \frac{(O-C)^T P(O-C)}{N_{obs} - N_{param} - N_{red}}$$

	GPS	DORIS	SLR	VLBI
CONT08				
Variance factor **s0**	5,736	1,062	0,2337	35,458
Weight **w**	0,1804	0,9957	7,486	0,0306
s0*w	**1,0347744**	**1,0574334**	**1,7494782**	**1,0850148**
Variance factor **s0**	5,478	1,069	0,2809	31,8319
Weight **w**	0,1889	0,9884	5,492	0,03417
s0*w	**1,0347942**	**1,0565996**	**1,5427028**	**1,08769602**
Variance factor **s0**	5,3362	1,062	0,2187	43,1838
Weight **w**	0,1942	0,9956	7,154	0,0264
s0*w	**1,03629004**	**1,0573272**	**1,5645798**	**1,14005232**
CONT11				
	GPS	**DORIS**	**SLR**	**VLBI**
Variance factor **s0**	6,8851	1,061	0,5721	157,292
Weight **w**	0,1501	0,9967	2,353	0,00731
s0*w	**1,03345351**	**1,0574987**	**1,3461513**	**1,14980452**
Variance factor **s0**	6,5659	0,992	0,6723	100,508
Weight **w**	0,1574	1,067	1,669	0,0115
s0*w	**1,03347266**	**1,058464**	**1,1220687**	**1,155842**
Variance factor **s0**	6,6873	1,044	0,4202	147,6499
Weight **w**	0,1546	1,013	2,969	0,0081
s0*w	**1,03385658**	**1,057572**	**1,2475738**	**1,19596419**

Estimation of station coordinates relative to a combined reference frame

Local ties

The technique's link consisting of local ties between stations are considered and form constraints at the epoch between collocated stations 1 and 2: $\mathbf{X_2(t) - X_1(t) = \Delta_{21}(t)}$

Minimal contraints

The weekly normal equations of each technique are stacked and weighted by the Helmert algorithm [Ref. 2] that forms the combined normal equation. Estimation of the station coordinates of each technique relatively to the combined referential frame is realized by adding minimal constraints to the combined normal equation consisting to add 7 transformation parameters for each technique:

$$\mathbf{X_{Tech} = X_{apriori\_ITRF} + B.\Theta}$$

$$B = \begin{bmatrix} B_1 \\ \cdot \\ \cdot \\ B_n \end{bmatrix}, B_i = \begin{bmatrix} 1 & 0 & 0 & x_i^0 & 0 & z_i^0 & -y_i^0 \\ 0 & 1 & 0 & y_i^0 & -z_i^0 & 0 & x_i^0 \\ 0 & 0 & 1 & z_i^0 & y_i^0 & -x_i^0 & 0 \end{bmatrix}, \Theta = \begin{bmatrix} T_x \\ T_y \\ T_Z \\ S_c \\ R_x \\ R_y \\ R_z \end{bmatrix}$$

These minimal constraints form the constraint equation added to the combined normal equation for each technique:

$$\mathbf{(B^TB)^{-1} B^T (X_{Tech} - X_{Tech\_ITRF}) - \Theta = 0} \pm\sigma \text{ with } \sigma=0{,}1\text{mm}$$

Some Results

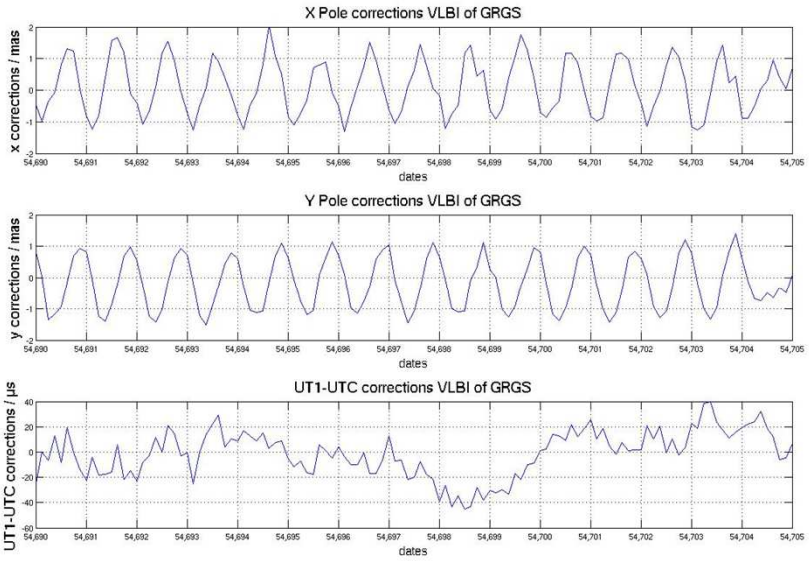
VLBI GRGS

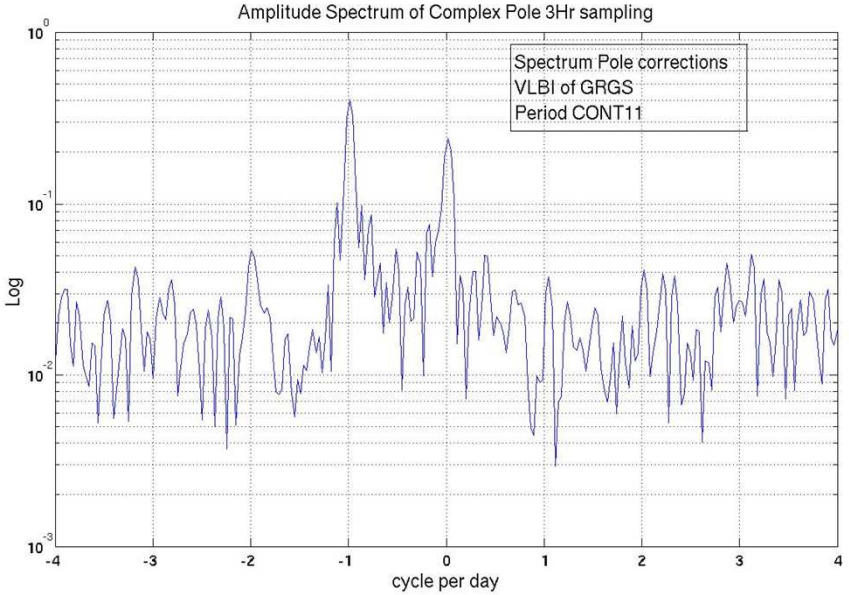
Normal equations version n6, changes include:
* Model force related to atmospheric pressure is added (model Ray / Ponte level 10)
* Pole model a priori to 3 hours provided by Daniel Gambis from Paris Observatory. Two files were used (one for CONT08 campaign and one for CONT11 campaign).
* Taking into account the motion of the displacements due to atmospheric pressure loading s1s2 and geocenter motion associated with tidal surges
* NRO with Lagrangian interpolation.
* Display of total zenith tropospheric bias (model + topping) by a priori in the normal equations.

Parameters:
- The Pole coordinates and UT1 every 3 hours
- Nutation NX / NY daily @12H
- Troposphere for collocated stations every 1 hour
-X, Y, Z station coordinates

Conditions:
- Systematic effects for station coordinates applied with σ=1µm
- Minimal constraints for station coordinates 7 parameters applied with σ=10µm

CONT08



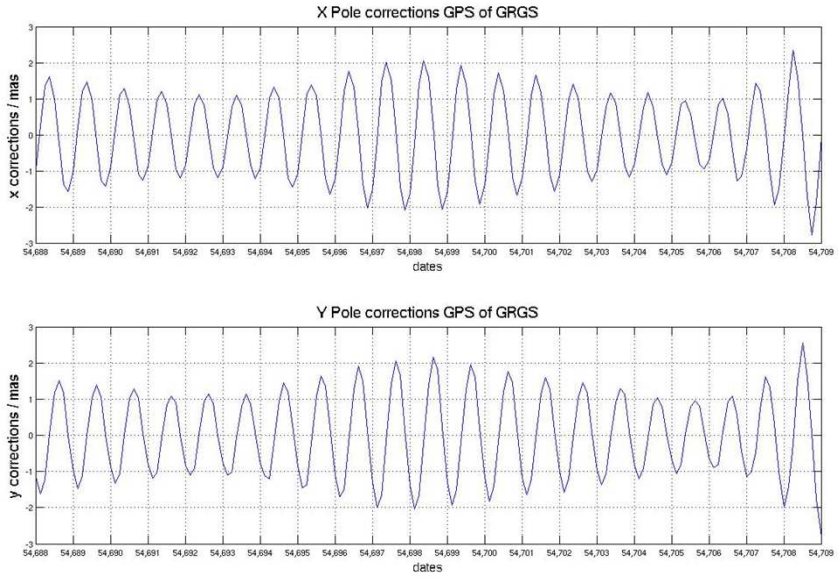


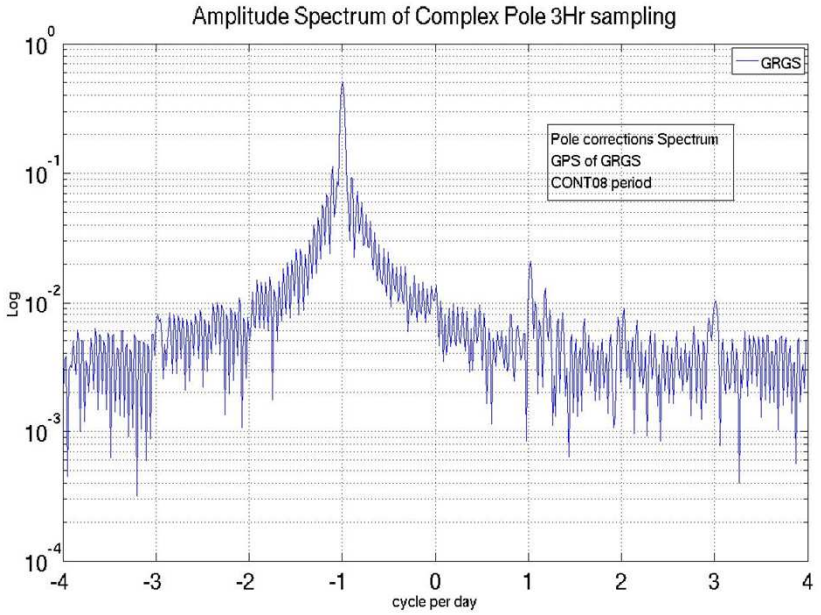
GPS GRGS

Normal equations version n9
Parameters:
- The Pole coordinates and UT1 every 3 hours
- Nutation NX / NY daily @12H
- Troposphere for collocated stations every 2 hour
- X, Y, Z station coordinates

Conditions: - Systematic effects for station coordinates applied with σ=1µm
- Minimal constraints for station coordinates 7 parameters applied with σ=10µm

CONT08





Dispersion of Quasar coordinates with respect to ICRF2 by combination simultaneously estimated with EOP & terrestrial frame

CONT08

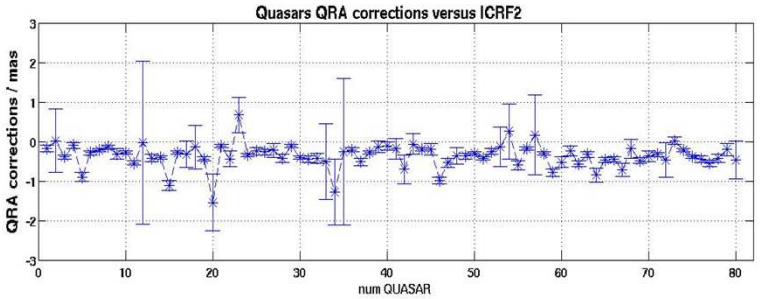
corrections	σ_weighted
QRA / mas	0.167
QDE / mas	0.207

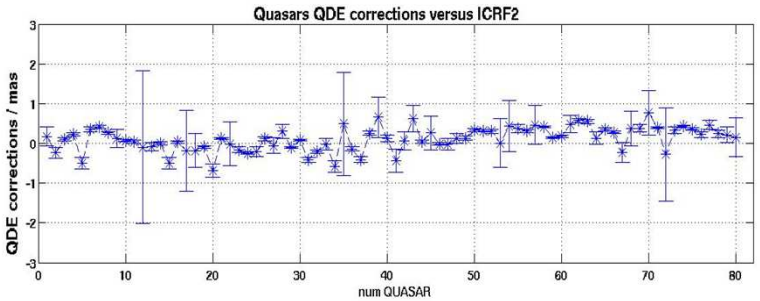
Rotations	estimation
R1 / µas	2.4
R2 / µas	2.6
R3 / µas	7.6

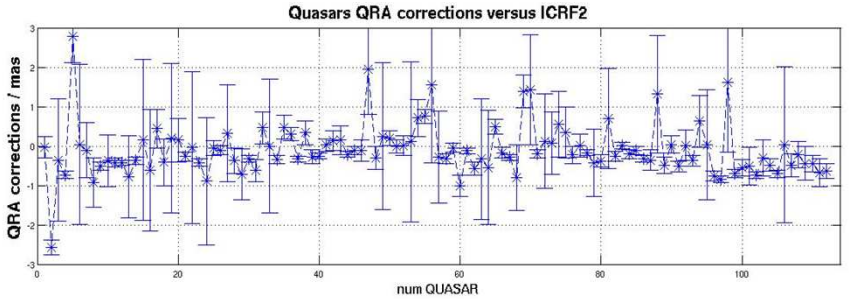
CONT11

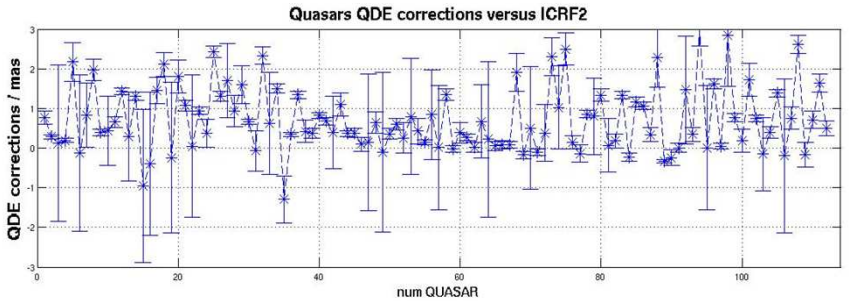
corrections	σ_weighted
QRA / mas	0.403
QDE / mas	0.623

Rotations	estimation
R1 / mas	-2.6
R2 / mas	0.1
R3 / mas	1.0









VLBI GRGS, Nutation estimation versus IAU2000 model

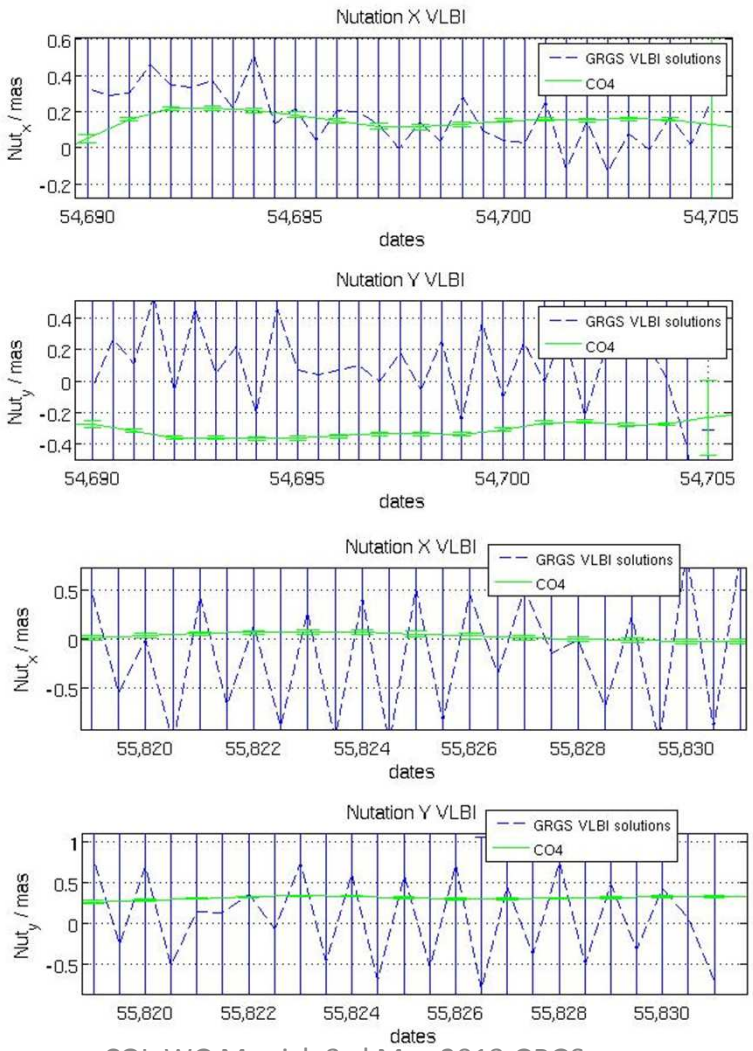
- Systematics' VLBI network effect cancelled ➔ scale factor estimated
- Minimal constraints Tx, Ty, Tz, Sc, Rx, Ry, Rz
- Quasar coordinates with No Net Rotation applied ➔ rotation parameters R1, R2, R3
- Nutation parameters estimated,
- Pole coordinates fixed
- Stations coordinates estimated

CONT08

corrections	σ_weighted
Nut_X / mas	0.155
Nut_Y / mas	0.370

CONT11

corrections	σ_weighted
Nut_X / mas	0.649
Nut_Y / mas	0.530

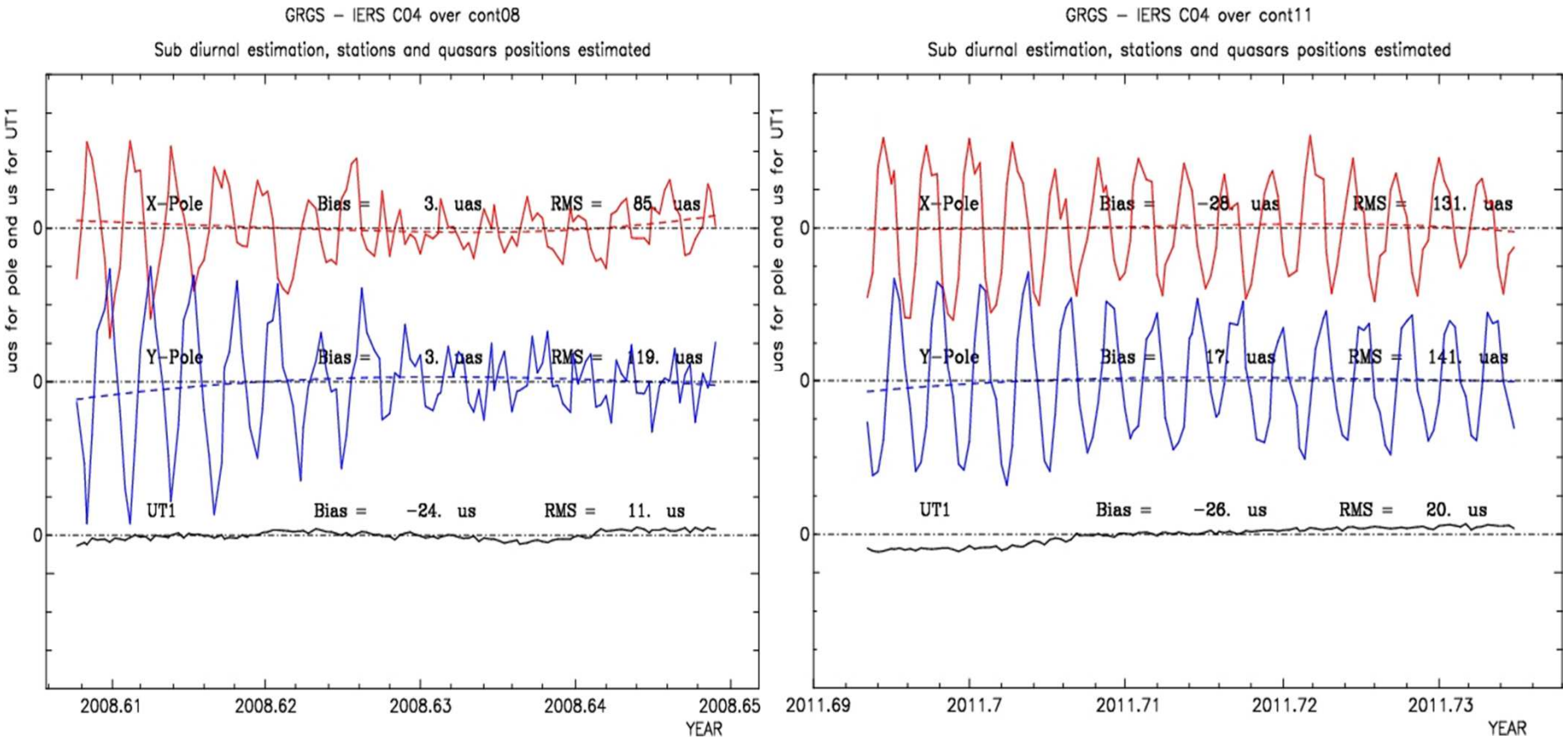


Parameters	CONT08	CONT11
Scale factor ppb	1,18	-0,775
R1 / mas	0,006	0,00001
R2 / mas	0,004	0,0035
R3 / mas	0,012	-0,0024
Tx / mm	-0,17	-0,28
Ty / mm	-0,07	0,41
Tz / mm	0,31	0,07
Sc / ppb	0,0077	0,0151
Rx / mas	0,0013	-0,0063
Ry / mas	0,0049	-0,0044
Rz / mas	0,0100	0,0076

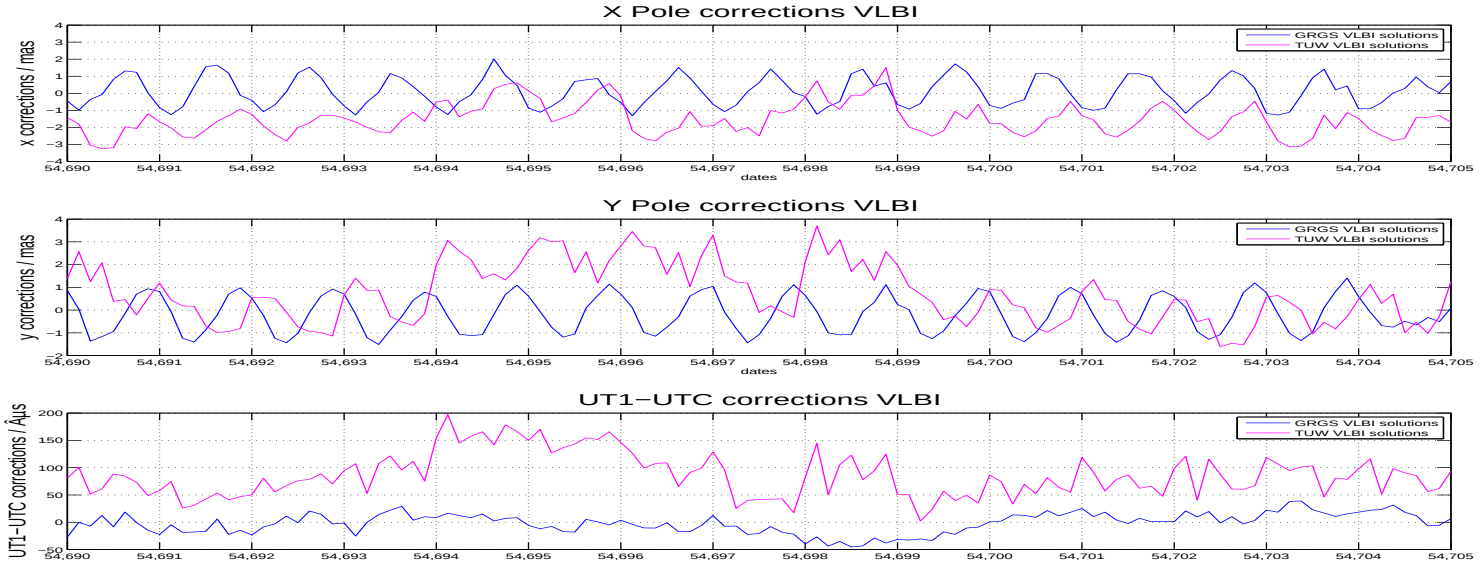
Systematics parameters
Rotation parameters
Helmert parameters
over middle week

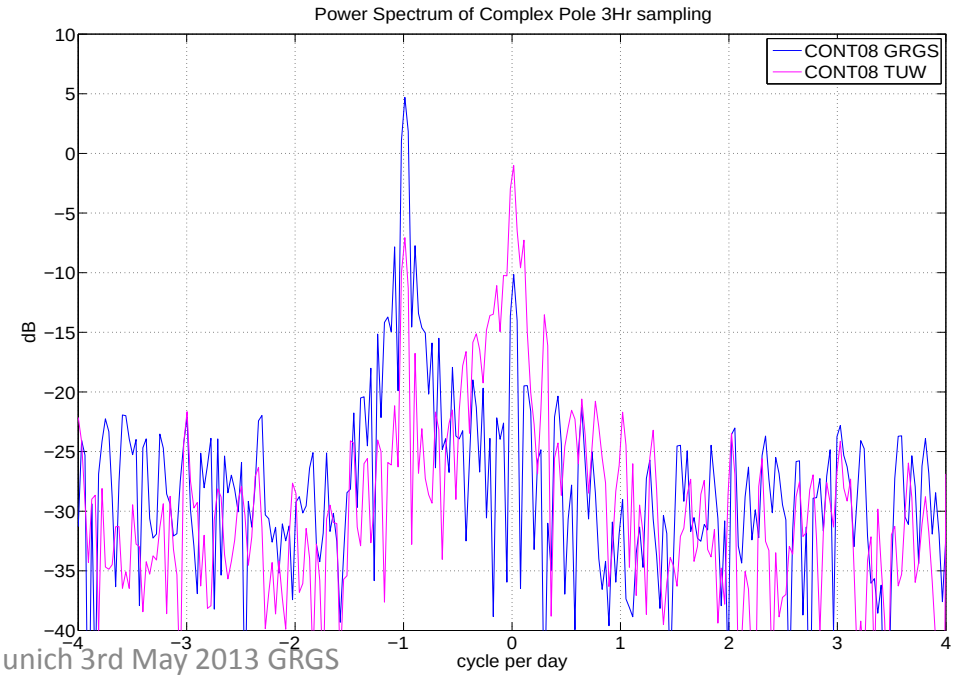
Pole & UT by combination with DORIS-GPS-SLR_VLBI from GRGS normal equations

- Systematic effects applied for the 4 techniques
- Local ties applied on sub network DORIS, GPS, SLR, VLBI
- Minimal constraints Tx, Ty, Tz, Sc, Rx, Ry, Rz
- Pole, UT, Station and Quasar coordinates, Troposphere estimated, nutation fixed
- Solutions available on ftp: http://hpiers.obspm.fr/iers/eop/grgs/GRGS/combination/



Pole & UT1-UTC from VLBI TUW & GRGS comparison – CONT08 period





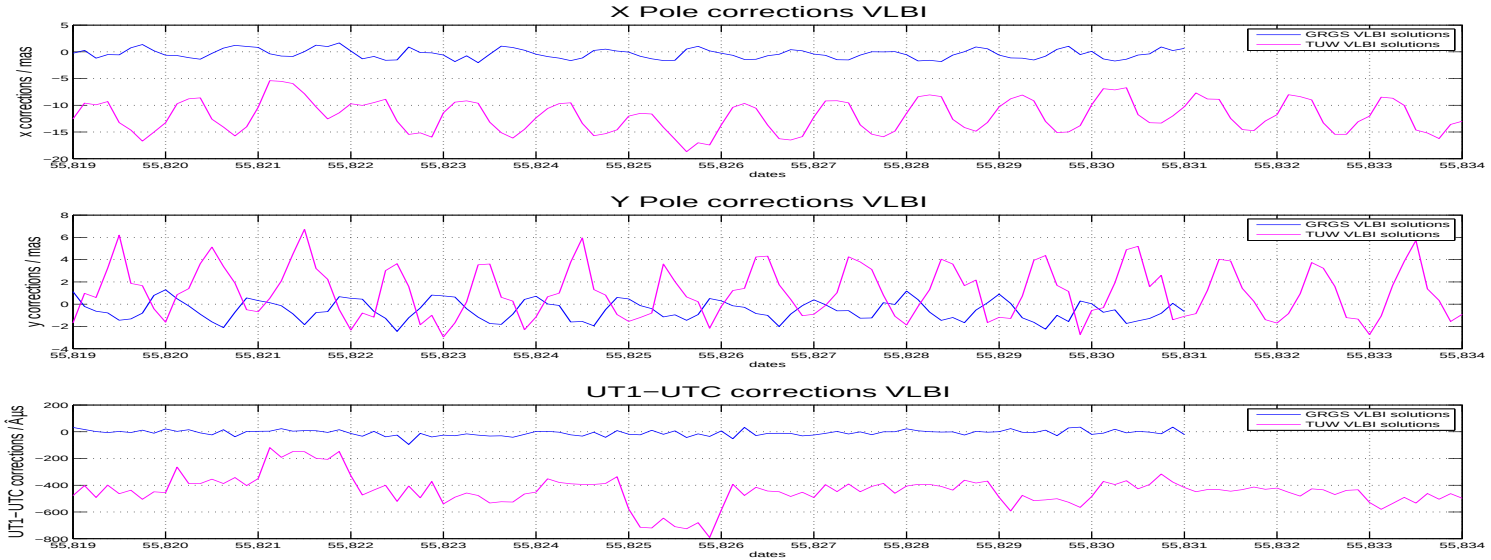
Mean X pole correction VLBI GRGS / (mas) = 0.1044
Mean Y pole correction VLBI GRGS / (mas) = -0.1752
Mean UT pole correction VLBI GRGS / (µs) = -1.436

Mean X pole correction VLBI TUW / (mas) = -1.5195
Mean Y pole correction VLBI TUW / (mas) = 0.6994
Mean UT pole correction VLBI TUW / (µs) = 86.419

WRMS X pole correction VLBI GRGS / (mas) = 0.8726
WRMS Y pole correction VLBI GRGS / (mas) = 0.8237
WRMS UT correction VLBI GRGS / (µs) = 18.201

WRMS X pole correction VLBI TUW / (mas) = 0.9119
WRMS Y pole correction VLBI TUW / (mas) = 1.2900
WRMS UT correction VLBI TUW / (µs) = 39.189

Pole & UT1-UTC from VLBI TUW & GRGS comparison – CONT11 period

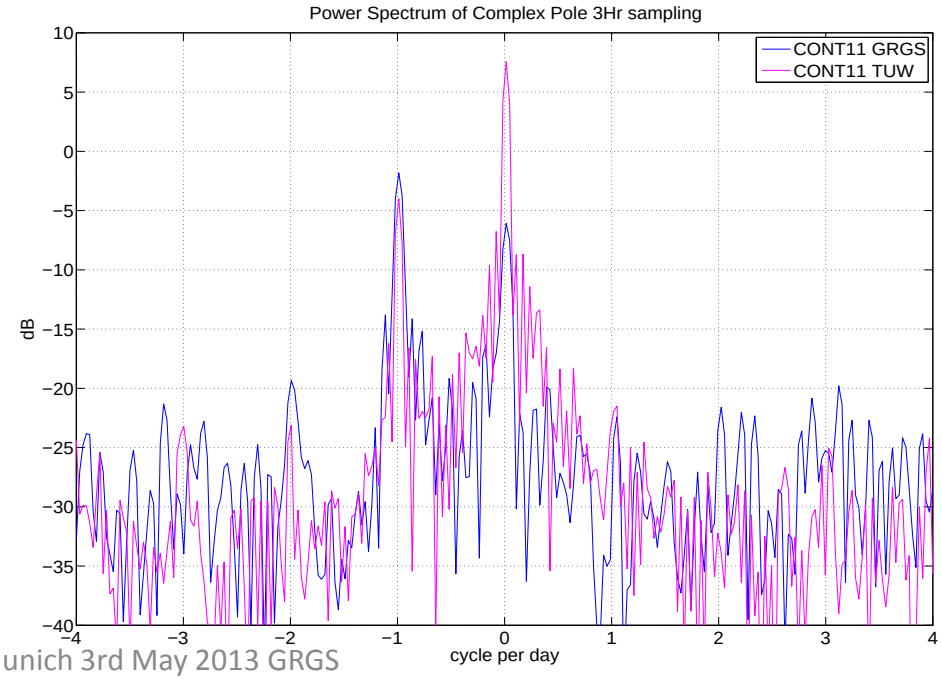


Mean X pole correction VLBI GRGS / (mas) = -0.3733
Mean Y pole correction VLBI GRGS / (mas) = -0.5342
Mean UT pole correction VLBI GRGS / (µs) = -7.8101

Mean X pole correction VLBI TUW / (mas) = -11.995
Mean Y pole correction VLBI TUW / (mas) = 1.0805
Mean UT pole correction VLBI TUW / (µs) = -441.298

WRMS X pole correction VLBI GRGS / (mas) = 0.8812
WRMS Y pole correction VLBI GRGS / (mas) = 0.8573
WRMS UT correction VLBI GRGS / (µs) = 21.1963

WRMS X pole correction VLBI TUW / (mas) = 2.9523
WRMS Y pole correction VLBI TUW / (mas) = 2.249
WRMS UT correction VLBI TUW / (µs) = 110.171

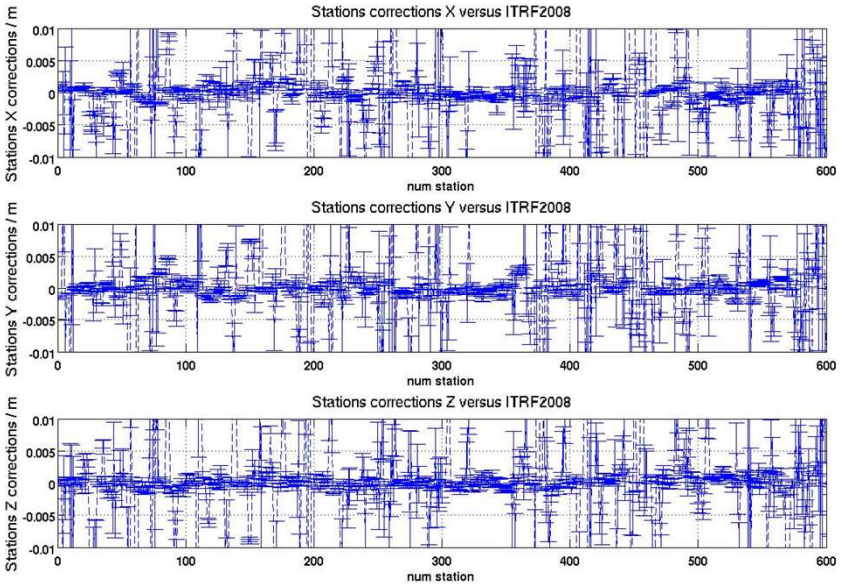


Dispersion of Station coordinates corrections with respect to ITRF2008 by DORIS, GPS, SLR, VLBI

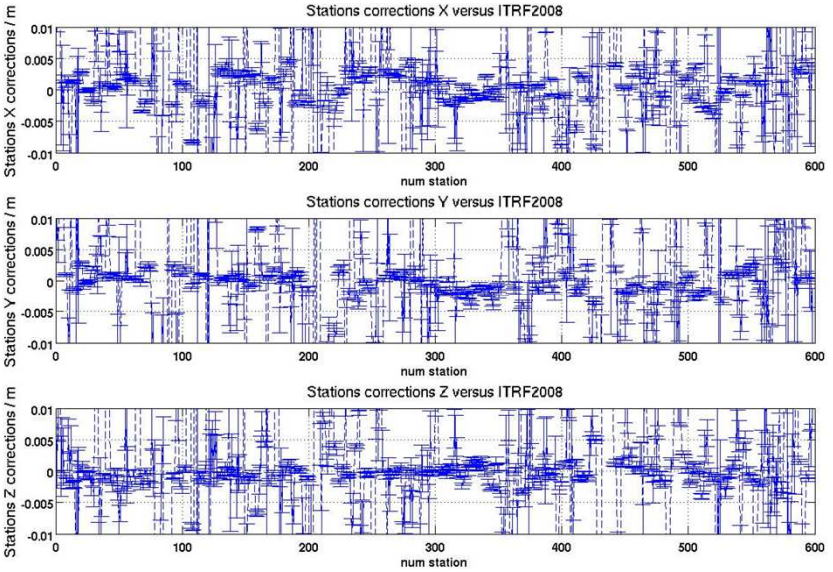
	CONT08 WRMS (mm)	CONT11 WRMS (mm)
X	1.7	19.8
Y	1.7	3.7
Z	0.2	17.5

Coordinate corrections for the ensemb of stations

CONT08



CONT11



Station corrections versus ITRF2008 show a good homogeneous dispersion at the level of millimeter for CONT08 and cm for X and Z component for CONT11.

Transformation parameters for CONT08 (minimal contraints)

- CONT08 #1

	Moyenne quadratique des ecarts de COORDONNEES (X, Y et Z)	Moyenne simple des NORMES des vecteurs Ecart	Moyenne quadratique des NORMES des vecteurs Ecart
AVANT transformation	3.3717E-02 (brut : 4.7545E-02)	1.3265E-02	5.7903E-02
APRES transformation	3.3664E-02 (brut : 4.7568E-02)	1.4218E-02	5.7806E-02

0.125945E-02 +/- 0.304E-05	1 : translation en x (metres)
-.216409E-03 +/- 0.306E-05	2 : translation en y (metres)
0.210694E-02 +/- 0.306E-05	3 : translation en z (metres)
0.124024E-10 +/- 0.489E-12	4 : facteur d'echelle de position geocentrique (0.1e-07 facteur d'echelle = env. 6.4 cm)
0.426411E-04 +/- 0.114E-06	5 : rotation par rapport a x (sec. de degre) (0.1e-02 seconde de degre = env. 3.1 cm)
-.103605E-04 +/- 0.118E-06	6 : rotation par rapport a y (sec. de degre) (0.1e-02 seconde de degre = env. 3.1 cm)
-.749419E-04 +/- 0.123E-06	7 : rotation par rapport a z (sec. de degre) (0.1e-02 seconde de degre = env. 3.1 cm)

- CONT08 #2

	Moyenne quadratique des ecarts de COORDONNEES (X, Y et Z)	Moyenne simple des NORMES des vecteurs Ecart	Moyenne quadratique des NORMES des vecteurs Ecart
AVANT transformation	3.4118E-02 (brut : 4.7463E-02)	1.3336E-02	5.9104E-02
APRES transformation	3.4059E-02 (brut : 4.7493E-02)	1.4380E-02	5.8989E-02

0.159094E-02 +/- 0.304E-05	1 : translation en x (metres)
-.262520E-03 +/- 0.306E-05	2 : translation en y (metres)
0.221867E-02 +/- 0.306E-05	3 : translation en z (metres)
0.205577E-10 +/- 0.487E-12	4 : facteur d'echelle de position geocentrique (0.1e-07 facteur d'echelle = env. 6.4 cm)
0.337962E-04 +/- 0.114E-06	5 : rotation par rapport a x (sec. de degre) (0.1e-02 seconde de degre = env. 3.1 cm)
-.138540E-05 +/- 0.117E-06	6 : rotation par rapport a y (sec. de degre) (0.1e-02 seconde de degre = env. 3.1 cm)
-.840157E-04 +/- 0.124E-06	7 : rotation par rapport a z (sec. de degre) (0.1e-02 seconde de degre = env. 3.1 cm)

- CONT08 #3

	Moyenne quadratique des ecarts de COORDONNEES (X, Y et Z)	Moyenne simple des NORMES des vecteurs Ecart	Moyenne quadratique des NORMES des vecteurs Ecart
AVANT transformation	3.4282E-02 (brut : 4.7726E-02)	1.3392E-02	5.9459E-02
APRES transformation	3.4224E-02 (brut : 4.7755E-02)	1.4457E-02	5.9349E-02

0.138938E-02 +/- 0.307E-05	1 : translation en x (metres)
-.202724E-03 +/- 0.306E-05	2 : translation en y (metres)
0.224480E-02 +/- 0.310E-05	3 : translation en z (metres)
0.246470E-10 +/- 0.492E-12	4 : facteur d'echelle de position geocentrique (0.1e-07 facteur d'echelle = env. 6.4 cm)
0.325116E-04 +/- 0.115E-06	5 : rotation par rapport a x (sec. de degre) (0.1e-02 seconde de degre = env. 3.1 cm)
-.490515E-05 +/- 0.119E-06	6 : rotation par rapport a y (sec. de degre) (0.1e-02 seconde de degre = env. 3.1 cm)
-.871186E-04 +/- 0.124E-06	7 : rotation par rapport a z (sec. de degre) (0.1e-02 seconde de degre = env. 3.1 cm)

Transformation parameters for CONT11 (minimal contraints)

CONT11 #2 Regression lineaire de 1155 equations suivant 7 parametres

	Moyenne quadratique des ecarts de COORDONNEES (X, Y et Z)	Moyenne simple des NORMES des vecteurs Ecart	Moyenne quadratique des NORMES des vecteurs Ecart
AVANT transformation	2.0519E-02 (brut : 4.1554E-02)	1.3837E-02	3.5695E-02
APRES transformation	2.0349E-02 (brut : 4.1486E-02)	1.5108E-02	3.5369E-02

0.351676E-02	+/- 0.284E-05	1 : translation en x (metres)
0.483440E-03	+/- 0.289E-05	2 : translation en y (metres)
0.210291E-02	+/- 0.286E-05	3 : translation en z (metres)
0.135782E-10	+/- 0.465E-12	4 : facteur d'echelle de position geocentrique (0.1e-07 facteur d'echelle = env. 6.4 cm)
0.148581E-04	+/- 0.105E-06	5 : rotation par rapport a x (sec. de degre) (0.1e-02 seconde de degre = env. 3.1 cm)
0.985739E-04	+/- 0.110E-06	6 : rotation par rapport a y (sec. de degre) (0.1e-02 seconde de degre = env. 3.1 cm)
-.771176E-04	+/- 0.115E-06	7 : rotation par rapport a z (sec. de degre) (0.1e-02 seconde de degre = env. 3.1 cm)

CONT11 #2 Regression lineaire de 1161 equations suivant 7 parametres

	Moyenne quadratique des ecarts de COORDONNEES (X, Y et Z)	Moyenne simple des NORMES des vecteurs Ecart	Moyenne quadratique des NORMES des vecteurs Ecart
AVANT transformation	2.0694E-02 (brut : 3.6167E-02)	1.3990E-02	3.5863E-02
APRES transformation	2.0528E-02 (brut : 3.6168E-02)	1.5254E-02	3.5547E-02

0.372633E-02	+/- 0.247E-05	1 : translation en x (metres)
0.597918E-03	+/- 0.252E-05	2 : translation en y (metres)
0.205211E-02	+/- 0.249E-05	3 : translation en z (metres)
-.104078E-11	+/- 0.406E-12	4 : facteur d'echelle de position geocentrique (0.1e-07 facteur d'echelle = env. 6.4 cm)
0.115965E-04	+/- 0.914E-07	5 : rotation par rapport a x (sec. de degre) (0.1e-02 seconde de degre = env. 3.1 cm)
0.924004E-04	+/- 0.963E-07	6 : rotation par rapport a y (sec. de degre) (0.1e-02 seconde de degre = env. 3.1 cm)
-.700766E-04	+/- 0.995E-07	7 : rotation par rapport a z (sec. de degre) (0.1e-02 seconde de degre = env. 3.1 cm)

CONT11 #3 Regression lineaire de 1161 equations suivant 7 parametres

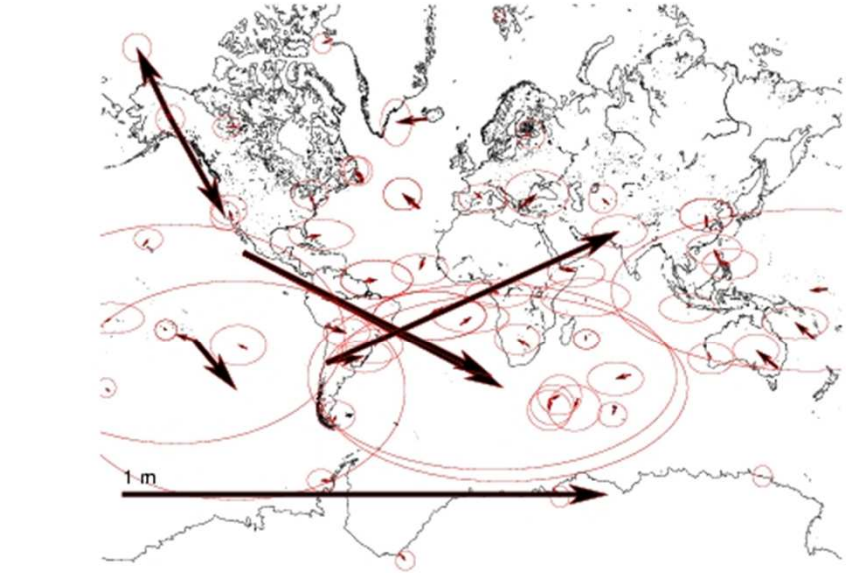
	Moyenne quadratique des ecarts de COORDONNEES (X, Y et Z)	Moyenne simple des NORMES des vecteurs Ecart	Moyenne quadratique des NORMES des vecteurs Ecart
AVANT transformation	2.2340E-02 (brut : 4.0239E-02)	1.4410E-02	3.8329E-02
APRES transformation	2.2195E-02 (brut : 4.0310E-02)	1.5584E-02	3.8055E-02

0.357838E-02	+/- 0.275E-05	1 : translation en x (metres)
0.553318E-03	+/- 0.280E-05	2 : translation en y (metres)
0.194053E-02	+/- 0.278E-05	3 : translation en z (metres)
0.653155E-10	+/- 0.452E-12	4 : facteur d'echelle de position geocentrique (0.1e-07 facteur d'echelle = env. 6.4 cm)
0.210484E-04	+/- 0.102E-06	5 : rotation par rapport a x (sec. de degre) (0.1e-02 seconde de degre = env. 3.1 cm)
0.889911E-04	+/- 0.107E-06	6 : rotation par rapport a y (sec. de degre) (0.1e-02 seconde de degre = env. 3.1 cm)
-.488918E-04	+/- 0.111E-06	7 : rotation par rapport a z (sec. de degre) (0.1e-02 seconde de degre = env. 3.1 cm)

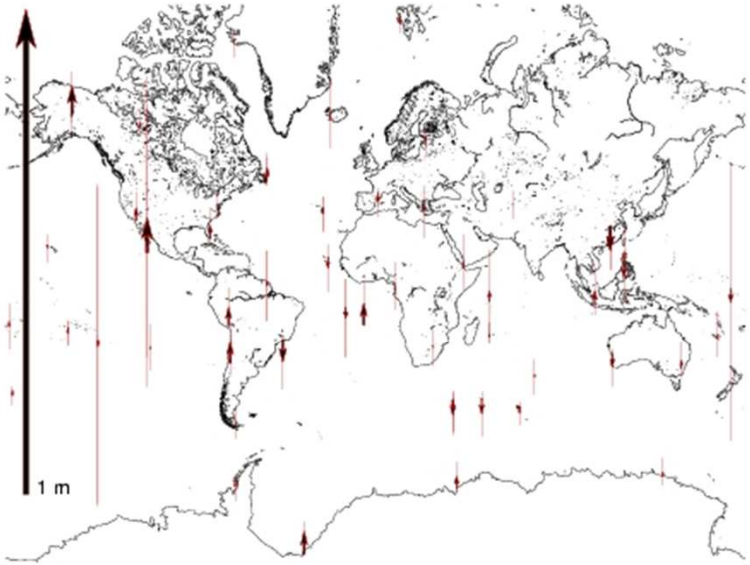
DORIS stations corrections with respect to ITRF2008
CONT08 Week #1, 60 stations ,4 eliminated (offset>10cm)

RMS 3D = 1,52cm

Transformation to apply for approaching ITRF
Tx : 0.221896E-02 +/- 0.734E-05
Ty : 0.395707E-03 +/- 0.687E-05
Tz : -.753207E-03 +/- 0.606E-05
Sc: 0.510338E-10 +/- 0.111E-11
Rx: -.319100E-04 +/- 0.232E-06
Ry: 0.263532E-04 +/- 0.233E-06
Rz: -.161825E-04 +/- 0.358E-06



2013 May 22 15:17:11 horizontal

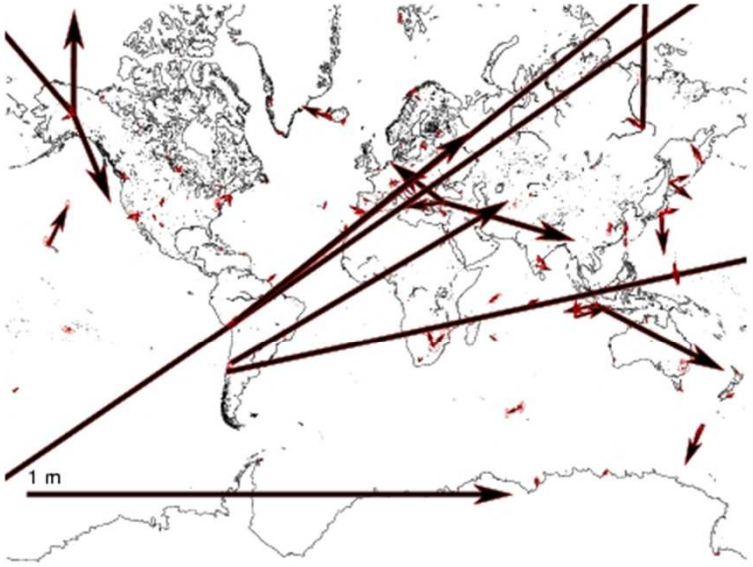


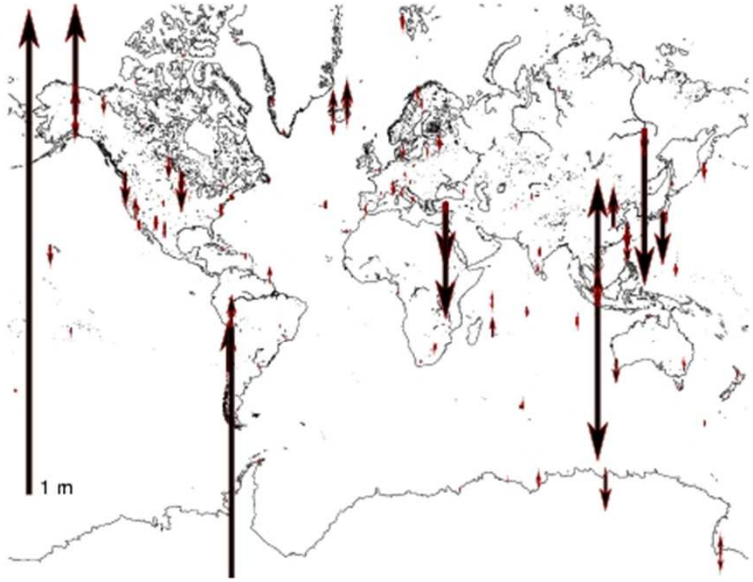
2013 May 22 15:17:11 vertical

GPS stations corrections with respect to ITRF2008
CONT08 Week #1, 291 stations , 13 eliminated (offset>10cm)

RMS 3D = 1,24cm

Transformation to apply for approaching ITRF
Tx (m): -.902423E-03 +/- 0.557E-06
Ty (m): 0.253655E-03 +/- 0.561E-06
Tz (m): 0.563130E-03 +/- 0.564E-06
Sc (10^{-9}=6,4mm) 0.205893E-09 +/- 0.897E-13
Rx (‘’): 0.231597E-05 +/- 0.210E-07
Ry (‘’): -.670282E-04 +/- 0.217E-07
Rz (‘’): 0.327873E-04 +/- 0.225E-07





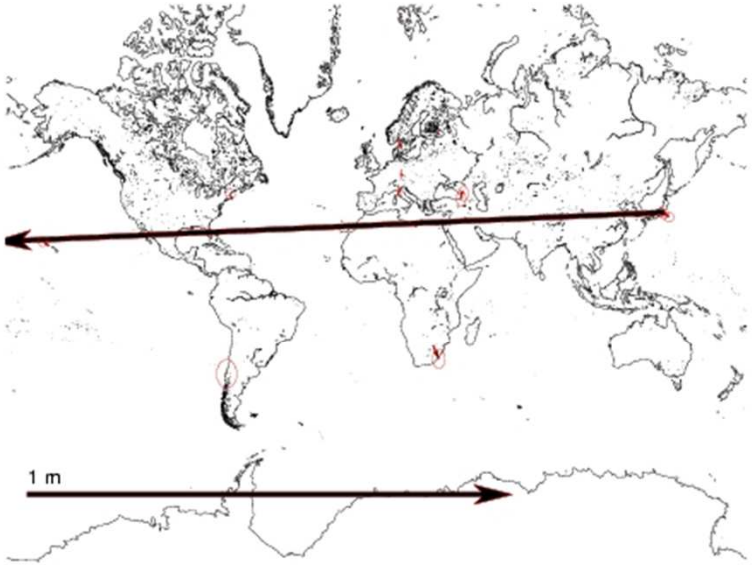
2013 May 22 15:17:12 horizontal

3 May 22 15:17:12 vertical

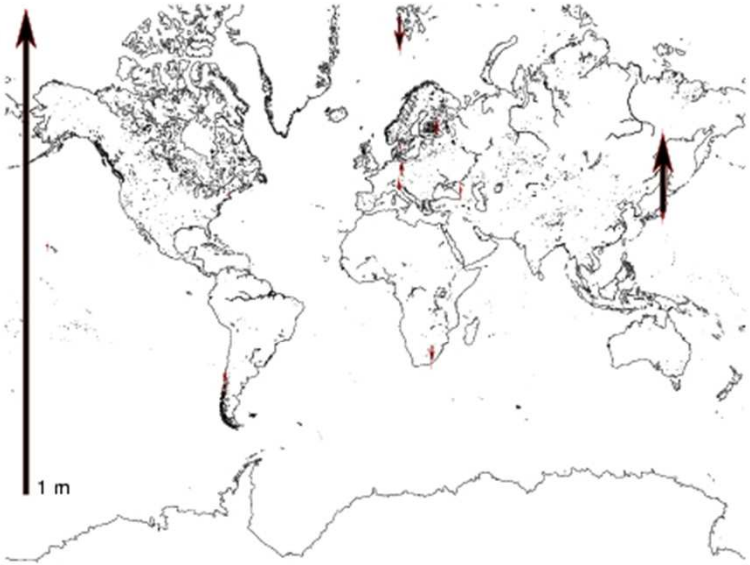
VLBI stations corrections with respect to ITRF2008
CONT08 Week #1, 14 stations , 1 eliminated (offset>10cm)

RMS 3D = 1,49cm

Transformation to apply for approaching ITRF
Tx (m): -.190791E-02 +/- 0.450E-05
Ty (m): 0.565836E-03 +/- 0.493E-05
Tz (m): 0.439081E-03 +/- 0.446E-05
Sc : 0.655768E-10 +/- 0.690E-12
Rx (‘’): -.369556E-04 +/- 0.192E-06
Ry (‘’): -.583983E-04 +/- 0.158E-06
Rz (‘’): -.342119E-04 +/- 0.145E-06



GIPSY 2013 May 22 15:17:12 horizontal



GIPSY 2013 May 22 15:17:12 vertical

Tropospheric Zenithal Delay

Technique	Conditioning	Stations Selected for CONT08 and CONT11
DORIS GRGS	**ZBIAS** : Zenith Wet delay @0h,1h,2h,3h…,23h 1 bias/pass, passes of all satellites in the same hour are stacked	SPJB 10317S005 D Ny-Alesund HBMB 30302S008 D Hartebeesthoek KOLB 40424S009 D KAUAI antenna greb 40451S176 D GREENBELT MSPB 50119S004 D Mt Stromlo
GPS GRGS	**ZBIAS** : Zenith Wet delay @0h,1h,2h,3h…,23h 1 bias/pass, passes of all satellites in the same hour are stacked	nyal 10317M001 P Ny-Alesund, Norway nya1 10317M003 P Ny-Alesund, Norway hrao 30302M004 P Krugersdorp, South Afr kodk 40419S003 P Kodiak, USA gode 40451M123 P Greenbelt, USA usn3 40451S007 P Washington, U.S.A. conz 41719M002 P Concepcion, Chil str1 50119M002 P Canberra, Australia thti 92201M009 P Papeete, Tahiti
VLBI TUW	**TROWET :** Zenith wet delay @0h,2h,4h,6h,…,22h	7331 10317S003 V Ny Alesund 7213 10402S002 V Onsala, Sweden 7382 12338S003 V Badary antenna 7380 12350S001 C SVETLOE Svetloe, Russ 7381 12351S001 V Zelenchukskaya, Russia 7386 13420S002 V Yebes, Spain 7230 12711S001 V Bologna, Italy 7224 14201S004 V Wettzell, FRG 7345 21730S007 V Tsukuba, Japan (32 m) 7232 30302S001 V Hartebeesthoek S Afr. 7298 40424S007 V Kokee Park Kauai, HI 7209 40440S003 V Westford, MA 7297 41602S001 V Fortaleza, Brazil 7640 41719S001 V TIGO at Concepcion, Ch 7640 41719S001 V TIGO at Concepcion, Ch 7374 50116S007 V Hobart
VLBI GRGS	**ZBIAS :** Zenith offset delay of co-located stations @0h,1h,2h,3h…,23h	nyal 10317M001 P Ny-Alesund, Norway => 7331 10317S003 onsa 10402M004 P Onsala, Sweden => 7213 10402S002 BADA 12338S001 D BADARY antenna => 7382 12338S003 svtl 12350M001 P Svetloe, Russia => 7380 12350S001 zeck 12351M001 P Zelenchukskaya, Russia => 7381 12351S001 7546 12711M002 L MEDICINA => 7230 12711S001 Bologna 7596 14201M004 L WETTZELL => 7224 14201S004 7311 21730S001 V Tsukuba, Japan => 7345 21730S007 7501 30302M003 L HARTEBEESTHOE => 7232 30302S001 kokb 40424M004 P Kokee Park, Waimea => 7298 40424S007 Kauai 7091 40440M001 L WESTFORD => 7209 40440S003 7405 41719M001 L CONCEPCION => 7640 41719S001

Station code error
GINS➔ Sinex conversion

Conclusion

Web site : http://hpiers.obspm.fr/combinaison/

- The Models proposed for the COL experiment are collected on the web
- A priori to be used for EOP, Stations, Quasars are available for users and can be uploaded
- Selection list of stations for DORIS, GPS, SLR and VLBI for the COL experiment are specified
- Data available from analysis centres can be uploaded on ftp

Strategy of combination

- Systematic network effects of each technique are introduced as parameters in the NEQ for cancelling their effects to the station coordinates
- NNR conditions are applied to the quasars coordinates
- Ties constraints for collocated stations are implemented

GRGS combination centre advancement

- Normal equation GINS to SINEX format upgraded for the GRGS purposes (introduction of the transformation parameters for DORIS, GPS, SLR, VLBI techniques)
- Solutions from GRGS combination are delivered in SINEX for CONT08 & CONT11 periods on the ftp site ftp://hpiers.obspm.fr/iers/eop/grgs/GRGS/combination/

Prospects

- Station code associated to the Tropospheric parameter ZBIAS for GRGS-VLBI SINEX don't correspond to the VLBI Station observed (conversion format from GINS to Sinex) & Analysis of tropospheric parameters combination is to be performed

parameter	code	domes	code VLBI		domes VLBI	site
ZBIAS	nyal	10317M001	7331		10317S003	NY-ALESUND
ZBIAS	BADA	12338S001	7382		12338S003	Badary
ZBIAS	zeck	12351M001	7381		12351S001	ZELENCHUKSKAYA
ZBIAS	7596	14201M004	**7224**		14201S004	WETTZELL
ZBIAS	7501	30302M003	**7232**		30302S001	Hartebeesthoek
ZBIAS	7405	41719S002	**7640**		41719S001	Conception
ZBIAS	onsa	10402M004	7213		10402S002	ONSALA
ZBIAS	7311	21730M001	**7345**		21730S007	Tsukub32
ZBIAS	kokb	40424M004	7298		40424S007	Kauai
ZBIAS	7091	40440M001	**7209**		40440S003	Westford
ZBIAS	hob2	50116M004	7374		50116S007	Hobart
ZBIAS	7546	12711M002	**7230**		12711S001	Bologna

- Statistical analysis on the station corrections for each techniques
- More analysis of COL solutions and comparison with conventional solutions
- Meaning of the diurnal oscillation observed in the pole coordinates
- Strategy of combination to adopt using the normal equations from ACs