Earth rotation parameters determined over CONT08 from the combination of space geodetic techniques

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Theory and realization of global terrestrial reference systems

J.-Y. Richard[1], D. Gambis[1], C. Bizouard[1], R. Biancale[2]

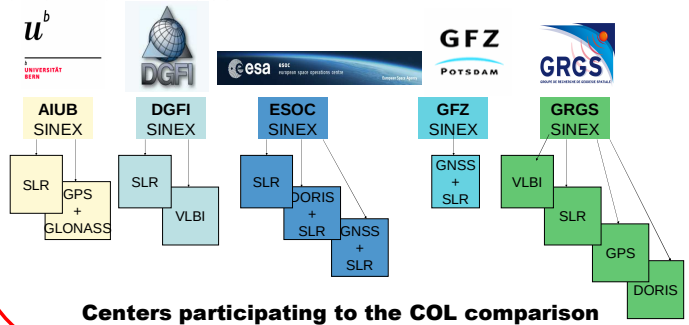
(1) Observatoire de Paris SYRTE, 75, Paris, France
jean-yves.richard@obspm.fr, +33 (0)1 40 51 23 67
(2) CNES/OMP/DTP/UMR 5562-CNRS, Toulouse, France

Project

Working Group on Combination at the Observation Level (**COL**) was created in the frame of the IERS. Its main objective is to review the interest in combining techniques at the observation level for EOP and reference frames and to bring together groups capable to such combinations. This project consist to compare combined EOP and stations solutions issued from heterogeneous softwares and explain the possible differences. The benchmark is established from August 10 to August 30, 2008 and includes the CONT08 VLBI period from August 12 to August 26 that constitute a good opportunity to densify the observations for VLBI and to combine with other geodetic satellite technique observations.

GRGS analyses of multi-technique combinations produce EOP solutions with time resolution of 6h for Pole coordinates and Universal Time and 12h for nutation offset parameters.

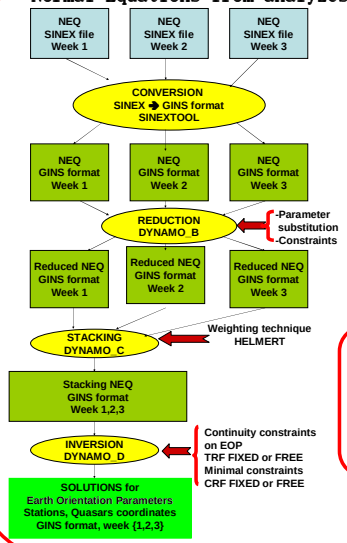
The file exchange format is SINEX format delivering normal equations (NEQs) per week. These files contain the unconstrained normal equation system. All SINEX files delivered by the participants are available at ftp://hpiers.obspm.fr/iers/eop/grgs with documentations



Centers participating to the COL comparison campaign and techniques analyzed per center

Strategy

Normal Equations from analyzes centers



Parameters	VLBI	SLR	GPS	DORIS
Pole coordinates (Xp,Yp) 1/6h	*	*	*	*
Universal Time (UT1-TAI) 1/6h	*	*		*
Obliquity & Eccentricity Nutation angle ($\psi\sin(\varepsilon_0)$,ε) 1/12h	*		*	*
Stations coordinates relative to ITRF2005 1/week	11	14	121	49
Troposphere Zenith Bias (MZB) 1/1h	*			*
Quasars coordinates relative to ICRF2 1/week	*			

Table 1: Parameters contained in the GRGS NEQ for individual techniques

Perspectives:

This strategy to combine the GRGS observations to estimate EOP and stations coordinates have to apply to a set of normal equations produced by other groups and compare results.

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Results

Pole Coordinates & Universal Time UT1

X-Pole & Y-Pole differences with (C04 + Ocean tidal model)

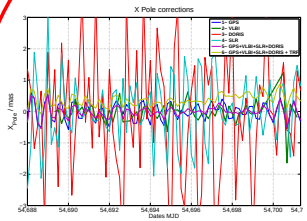

Figure 1 – X-Pole corrections at 6h intervals

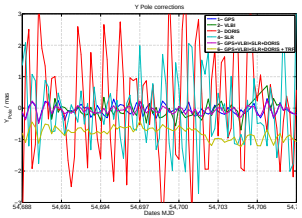

Figure 2 – Y-Pole corrections at 6h intervals

UT1-TAI differences with (C04 + Ocean tidal model)

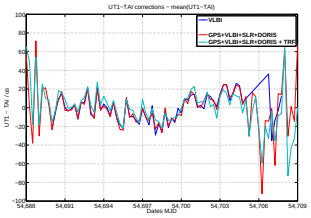

Figure 3 – UT1-TAI corrections at 6h intervals

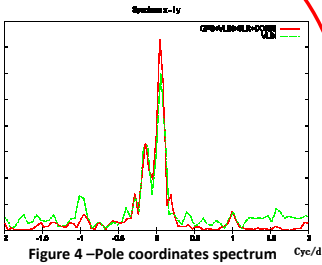

Figure 4 –Pole coordinates spectrum

Pole & UT are estimated at 6h intervals by different combination techniques (Nutation fixed) with **a-priori C04 interpolated at 6h intervals + Ocean tidal model**

1-GPS TRF fixed, UT eliminated, No continuity constraints

2-VLBI TRF fixed No continuity constraints, quasars eliminated, Reduction of tropospheric zenithal bias

3-DORIS TRF fixed, No continuity constraints

4-SLR TRF fixed (No nutation parameters), No continuity constraints

5-Weighted Combination **GPS+VLBI+SLR+DORIS** TRF fixed, No continuity constraints

6-Weighted Combination **GPS+VLBI+SLR+DORIS + TRF** estimated, continuity constraint 3cm for polar motion, 100us for UT, minimal constraints and co-located ties for stations

	Technique	Weighted Mean	Weighted RMS
X_pole / µas	1- GPS	-10.3	266
	2- VLBI	-17.2	234
	3- DORIS	31.5	1927
	4- SLR	-25.7	1028
	5- Combined	-10.0	153
	6- Combined +TRF	380	428
Y_pole / µas	1- GPS	-60.3	175
	2- VLBI	-91.7	230
	3- DORIS	262	1722
	4- SLR	-193	1002
	5- Combined	-66.8	136
	6- Combined +TRF	-794	817
UT / µs	VLBI	0	13
	Combined	0	14
	Combined +TRF	0	21

Table 2: Weighted mean & WRMS (Xp,Yp,UT)

Conclusions

- When TRF and CRF are held fixed, EOP solutions are unbiased and combined solution exhibit the smallest WRMS value

-TRF estimated: the combined solution is biased by a few hundred µas for pole coordinates and no bias for UT1

-Spectrum of pole exhibits diurnal and sub-diurnal terms (error on ocean tidal effect modeling / atmospheric tides)

Celestial Pole Offset

with respect IAU 1980 precession nutation model

	$\sigma^2_{apriori}/N_{obs}$	Weight
GPS	6.95	0.144
VLBI	35.73	0.029
SLR	0.71	1.444
DORIS	1.08	0.922

Table 4: Variance factor & Weights applied on the combination Calculated by Helmert algorithm

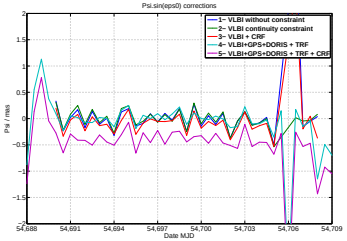

Figure 5: ψ.sin(ε) Nutation longitude corrections at 12h intervals with IAU 1980 model

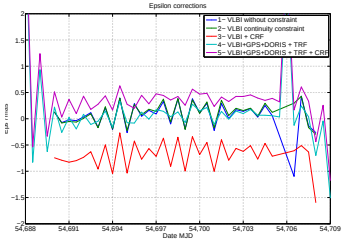

Figure 6: ε Nutation obliquity corrections at 12h intervals with IAU 1980 model

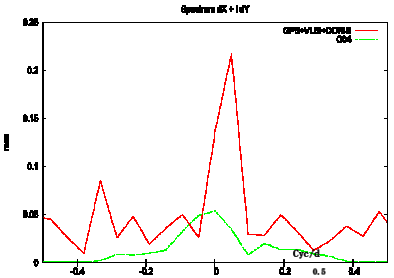

Figure 7: Celestial pole offset Spectrum Combined and C04 solution

Celestial pole offset ψ are estimated at 12h interval by different combination techniques (UT1 free) with **a-priori** EOP **C04 interpolated at 12h interval , terrestrial and celestial a-priori ITRF2005 & ICFR2.**

1-VLBI TRF fixed, No continuity constraints on nutation

2-VLBI TRF fixed with continuity constraints (3cm on nutation & 100µs on UT)

3-VLBI + CRF Quasars estimated, No constraint on nutation, No constraint on quasars

4-Weighted Combination **VLBI+GPS+DORIS + TRF** estimated, nutation parameters with continuity constraints

5-Weighted Combination **VLBI+GPS+DORIS + TRF + CRF** estimated continuity constraints on nutation; minimal constraints, local ties, stability constraints on stations coordinates; stability constraints on quasars coordinates

	Technique	Weighted Mean	Weighted RMS
dX or $\psi\sin(\varepsilon_0)$	VLBI	-26.2	181
	VLBI with constraint	-6.5	186
	VLBI + CRF	-81.7	315
	Combined + TRF	-1.2	137
	Combined + TRF + CRF	-389	445
dY or ε	VLBI	77.9	197
	VLBI with constraint	91.0	204
	VLBI + CRF	-688	736
	Combined + TRF	41.4	167
	Combined + TRF + CRF	322	392

Table 3: Differences with respect C04 Weighted mean & WRMS

Conclusions

-Continuity constraints have weak effect on nutation determination

-Nutation offsets have the smallest WRMS by combination of VLBI+GPS+DORIS and no bias are introduced when TRF is estimated.

-Nutation with TRF and CRF estimated exhibit a bias

-Spectrum exhibits prograde and retrograde terms with weekly periods, not present in C04