Earth Orientation Parameters from a combination of geodetic techniques

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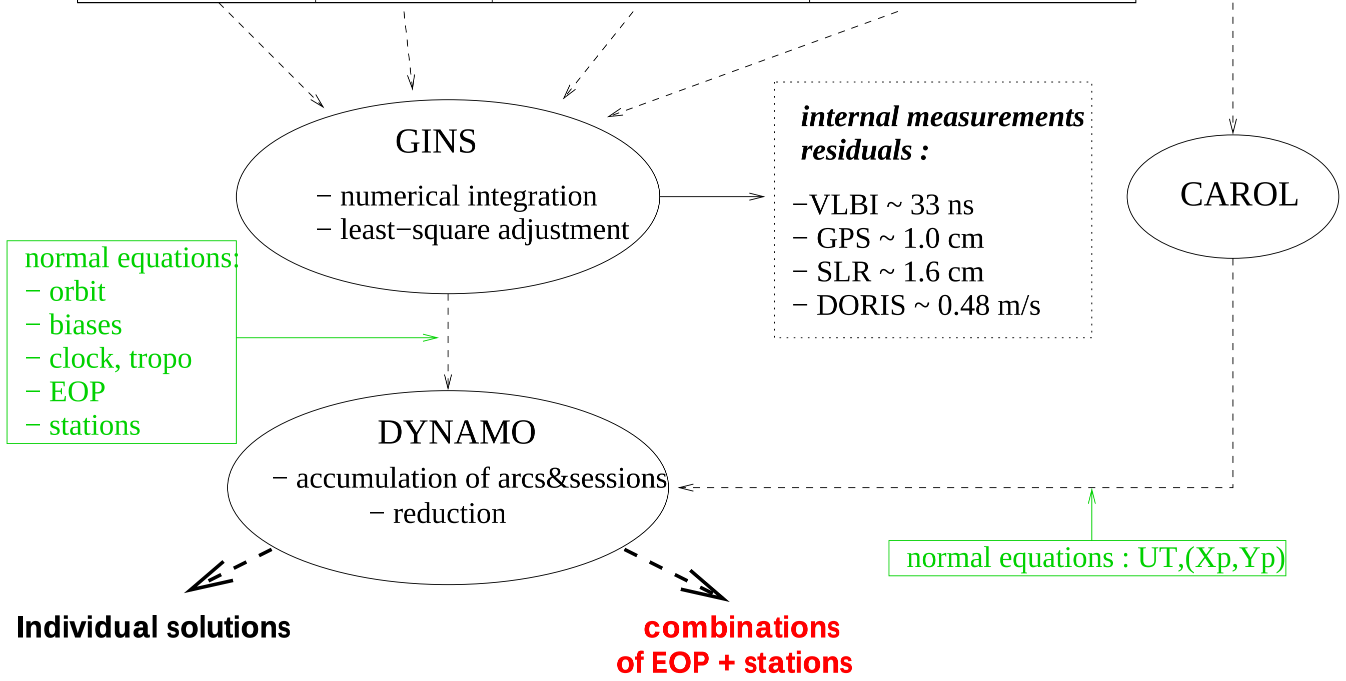
INTRODUCTION

- Goal : obtain a precise and stable **EOP series** (Xp,Yp,UT1-UTC, dψ,dε) and **stations coordinates** from a **combination** of VLBI, GPS, SLR, DORIS and LLR measurements
- Strategy : combine the parameters at the **observation level** (normal equation matrices) with a **6h-resolution** processing, using **GINS-DYNAMO** software from CNES/GRGS, and **Helmert** weighting
- Test period : **3 months** from 1 July 2000 to 30 September 2000
- Comparison with our previous solution (no optimal weight, no "high" resolution)
- Constraint study on (Xp,Yp) solution

PROCESSING DIAGRAM

Data over 3 months

	VLBI		GPS	SLR		DORIS				LLR
	intensive	weekly		lageos1	lageos2	topex		spot2	spot4	
Nobs	754	12288	8 800 000	15000	14000	54 000	540 000	330 000	380 000	
observable	time delay		pseudo−range phase	range		doppler frequencies				



HELMERT WEIGHTING METHOD (I)

- Idea : compare **a-priori weight matrix** elements w_{ij} and **a-posteriori variance-covariance matrix** elements v_{ij}
- If we assume : A = partial derivative matrix, W = a priori weight matrix, X = unknown elements, Y = observation elements, N = normal matrix, the **normal equation** and its solution are :

$$(A^t \underbrace{W}_{w_{ij}}{}^{-1} A)X = A^t W^{-1} Y \qquad \longrightarrow \qquad X = \underbrace{N^{-1}}_{v_{ij}} A^t W^{-1} Y$$

- Helmert method estimates a **coefficient** w_H in order to obtain a new a-priori weight matrix W' : $w'_{ij} = w_H w_{ij} \simeq v_{ij}$
- **Iterative** method : convergence of w_H

HELMERT WEIGHTING METHOD (II)

With the following simplified assumptions :

- 2 groups of observations A and B
- no observation correlations, *i.e.* $w_{ij} = 0$ if $i \neq j$,

the **global weight** P_A of the observation group A (a distinct satellite or a distinct technique) is :

$$P_A = \frac{\sum_i w'_{i,A}}{\sum_i w'_{i,A} + \sum_i w'_{i,B}}$$

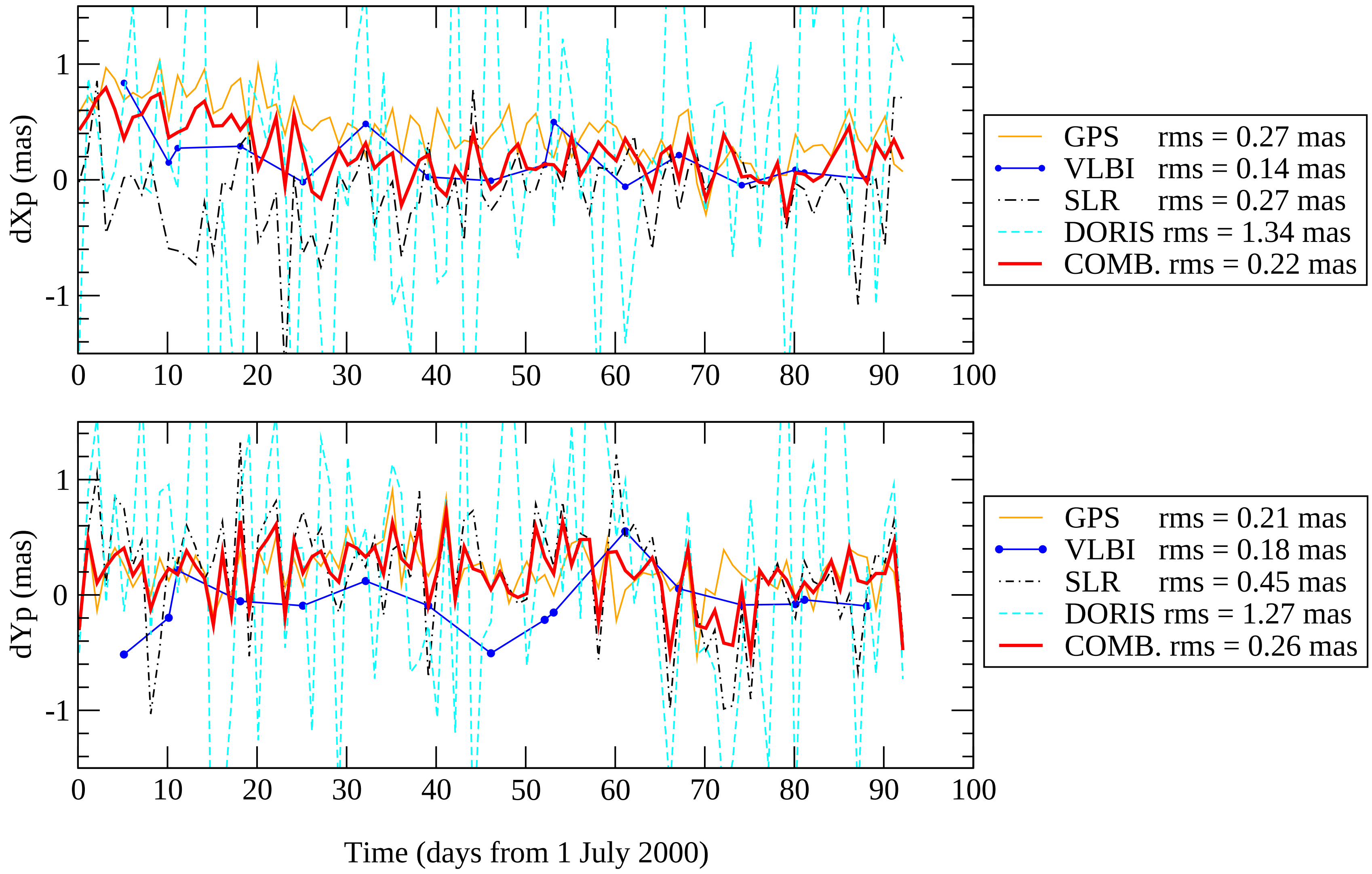
$$P_A = \frac{w_{H,A} \sum_i (\frac{\sigma_{0,A}}{\sigma_{i,A}})^2}{w_{H,A} \sum_i (\frac{\sigma_{0,A}}{\sigma_{i,A}})^2 + w_{H,B} \sum_i (\frac{\sigma_{0,B}}{\sigma_{i,B}})^2}$$

with $\sigma_{i,A}$ = a-priori error on measurement i of group A

and $\sigma_{0,A}$ = error of an observation with the **unicity weight** ($w_{0,A} = 1$)

RESULT OF THE COMBINATION

(24h concatenation from 6h resolution)



COMPARISON OF SOLUTIONS

The values are the *r.m.s* with respect to **EOP97C04** and **ITRF 2000**.
- Normal font → Helmert weighting and a priori 6h solution
- *Italic* → no optimal weighting and a priori 24h solution.

technique	weight(%)					X_p mas	Y_p mas	UT ms	$d\psi$ mas	$d\varepsilon$ mas	station (cm) X / Y / Z	3D
VLBI	int	wee										
	18	82				0.14	0.18	0.010	0.36	0.21	0.4/0.6/0.8	1.4
						0.31	*0.31*	*0.020*	*0.78*	*0.30*		
GPS						0.27	0.21				2.3/3.2/4.5	3.9
						0.47	*0.32*					
SLR	la1	la2	tpx									
	35	19	46			0.27	0.45				0.8/0.8/0.6	1.0
						0.38	*0.45*					
DORIS	sp2	sp4	tpx									
	27	30	43			1.34	1.27				4.8/5.9/4.0	5.0
						1.71	*1.32*					
LLR								0.226				
COMB.	vlb	gps	slr	dor	llr							
	15	65	15	5	0*	0.22	0.26	0.016	0.36	0.21	2.3/2.9/4.7	3.4
						0.29	*0.26*	*0.020*	*0.78*	*0.30*		

* <0.5%

CONSTRAINTS (I)

- Goal : **noise reduction** in high resolution solution
- Chosen constraint :

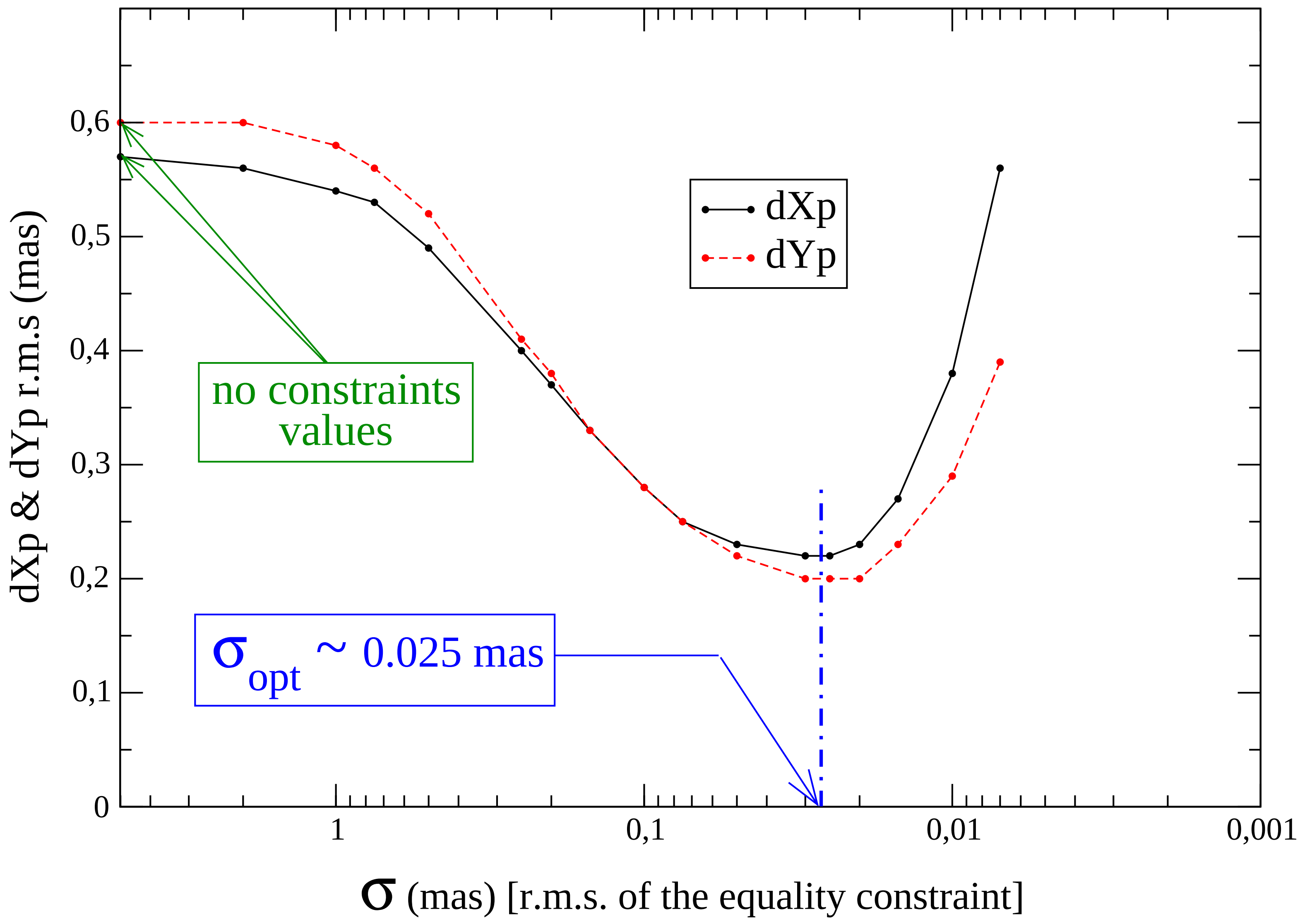
$$\begin{cases} X_p(t_{i+1}) = X_p(t_i) \pm \sigma_{X_p} \\ Y_p(t_{i+1}) = Y_p(t_i) \pm \sigma_{Y_p} \end{cases}$$

  with

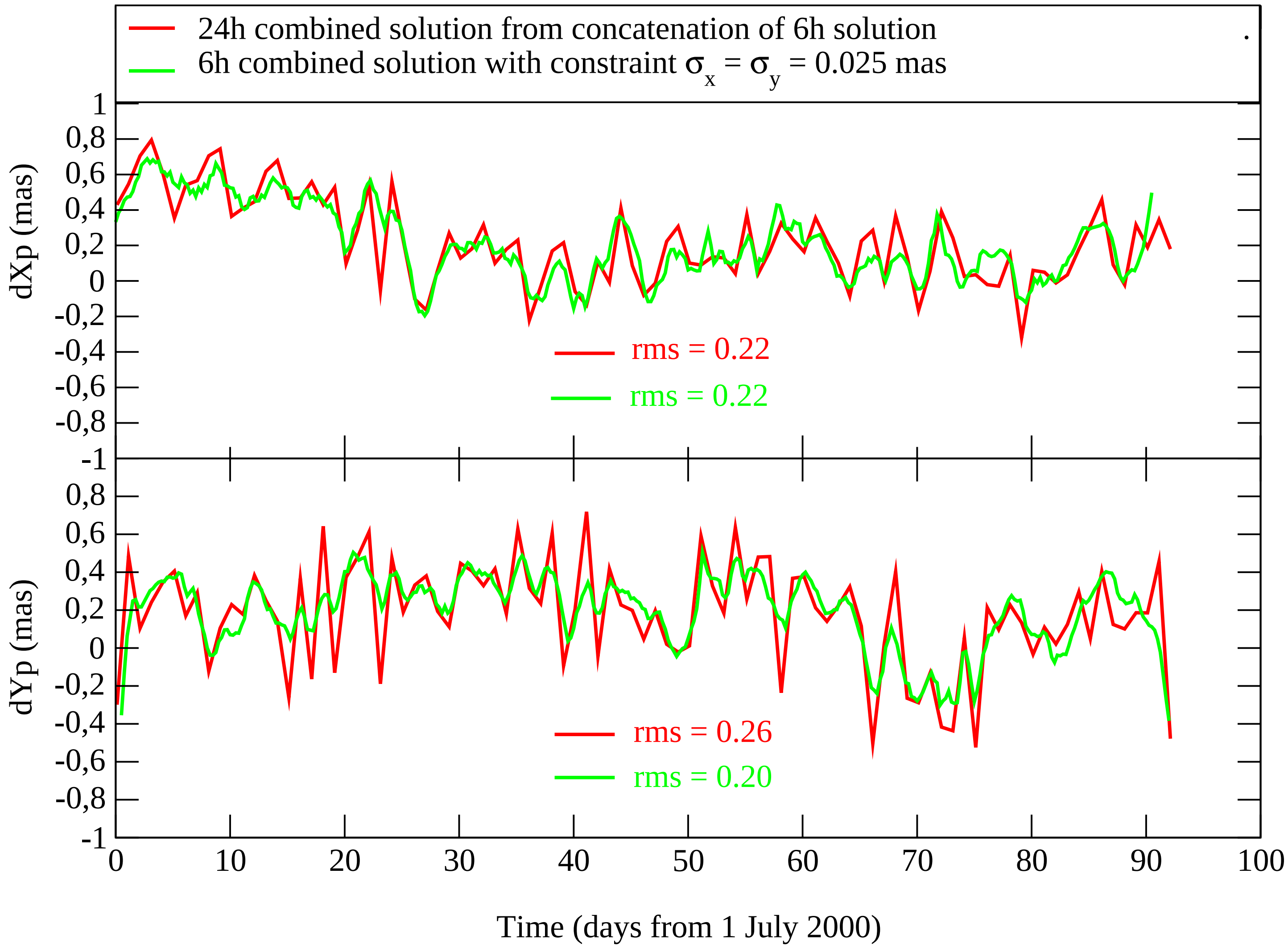
$$t_{i+1} = t_i + 6h$$

- Results : X_p and Y_p *r.m.s.* decrease **from** 0.6 **mas** (no constraint) **to** 0.2 **mas** ($\sigma_{X_p} = \sigma_{Y_p} = 0.025$ mas, see figure)

CONSTRAINTS (II)



CONSTRAINTS (III)



CONCLUSIONS & PERSPECTIVES

- GINS-DYNAMO = a powerful **multi-technique** software
- **Helmert** weighting increases the combination
- A priori "high" resolution seems to be a good strategy to determine the EOPs
- Now we almost reach VLBI precision with satellite density
- To go further : eliminate the visible biases, and apply an **optimal constraint** on all EOP estimates