

Combination at the
Observation Level
IERS Working Group



GRGS Combinations

Earth Orientation Parameters Strategy

Analyses Performed at GRGS

J-Y. Richard⁽¹⁾, D. Gambis⁽¹⁾, C. Bizouard⁽¹⁾,
G. Bourda⁽²⁾, F. Deleflie⁽³⁾, S. Loyer⁽⁴⁾, L. Soudarin⁽⁴⁾

1 - Observatoire de Paris SYRTE, 75, PARIS, France (jean-yves.richard@obspm.fr, +33 (0)1 40 51 23 67)

2 - Laboratoire d'Astrophysique de Bordeaux – Université de Bordeaux – CNRS/UMR5804, Bordeaux, France

3 - Observatoire de la Côte d'Azur / Geoazur - GRGS, Grasse, France

4 - Collecte Localisation Satellite, Ramonville Saint Agne, France



Systèmes de Référence Temps-Espace



Outline of Presentation

EOP Determination: Pole, UT at 6h, Nutation at 12h using
Combination at the Observation Level

- Processing
- Pole Coordinates solution
- Nutation solution

Station Space Coordinates Determination & daily EOP using
Combination at the Observation Level
Contribution to the realization of ITRF2008

- Processing
- Transformation Parameters
- Station Space Coordinates Solution
- Pole Coordinates solution
- Nutation solution

FORUM on multi technique Combinations

•Conclusion & Outlook

GRGS Program

Global Combination of Terrestrial Frame & Earth Orientation parameters at Observation Level



Techniques

SLR F. Deleflie
GPS S. Loyer
DORIS L. Soudarin
VLBI G. Bourda

OCA Géo-Azur
 CNES/CLS
 CNES/CLS
 Obs Bordeaux

Combinations

J.Y Richard
 C. Bizouard
 D. Gambis
 T. Carlucci

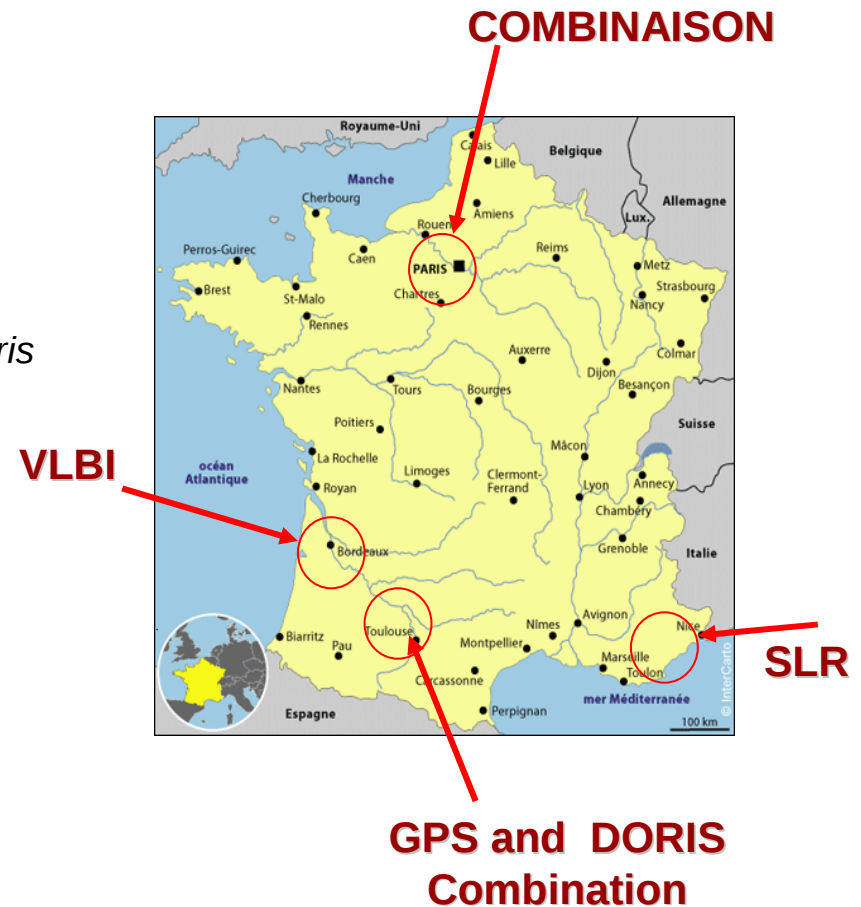
Observatoire de Paris

Software

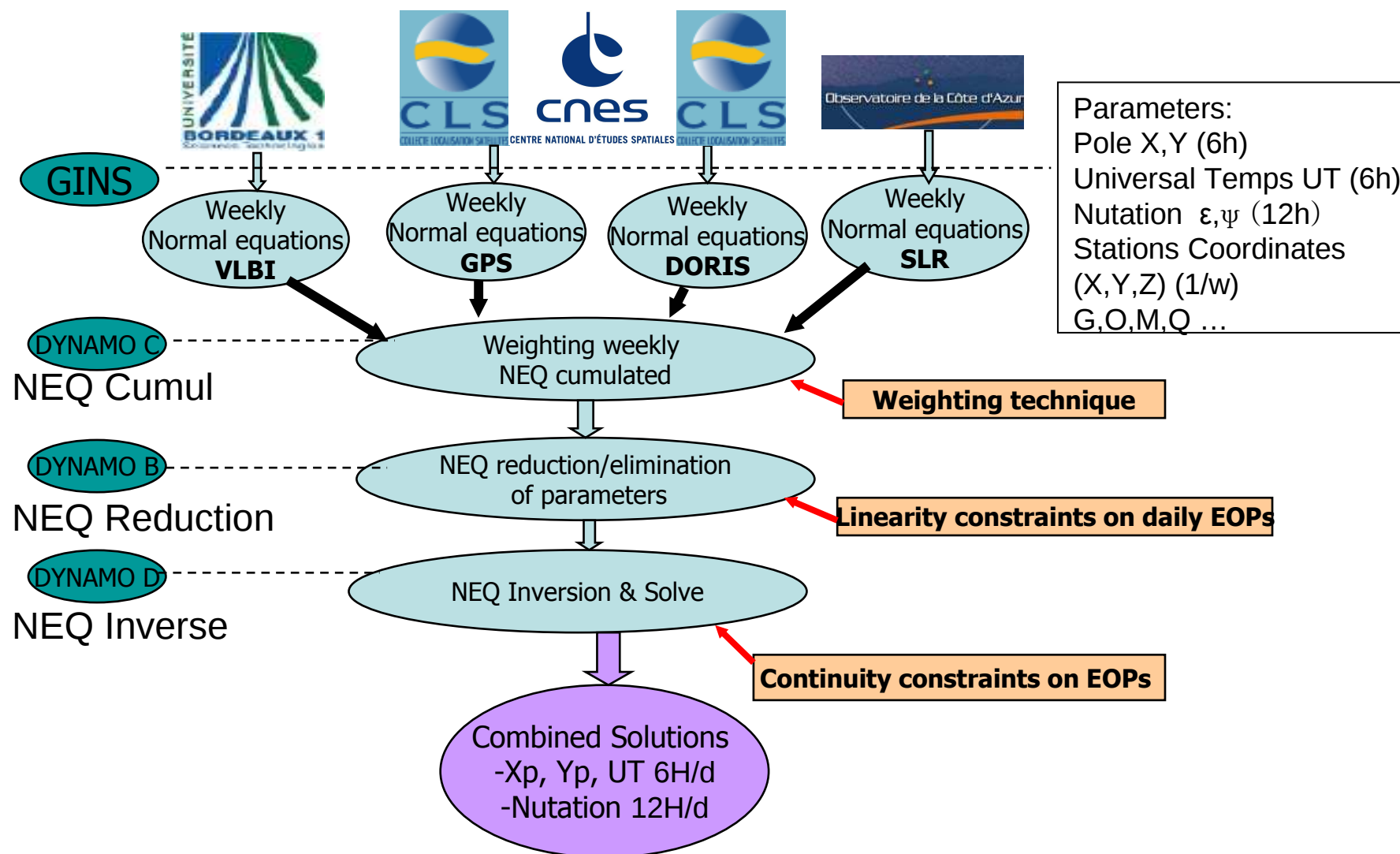
GINs J.C. Marty
DYNAMO J.M. Lemoine
Compsta
Compcont
CATREF Z. Altamimi
SINEXTOOL S. Loyer

CNES, Toulouse
 CNES

IGN LAREG
 CNES/CLS



EOP Determination : Pole (X,Y), UT1, Nutation obtained by combination of weekly Normal Equation



POLE Coordinates by Combination of VLBI+GPS (6h) week by week 2007-2008

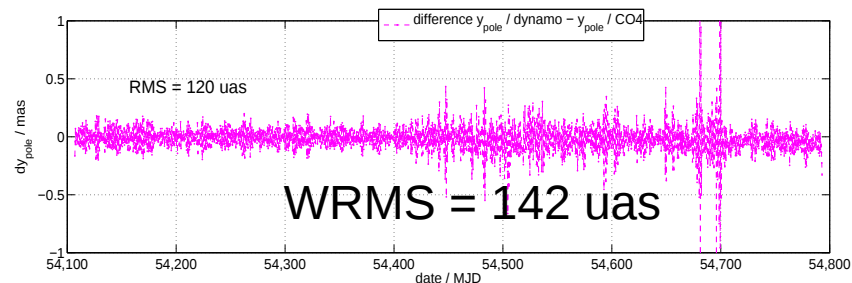
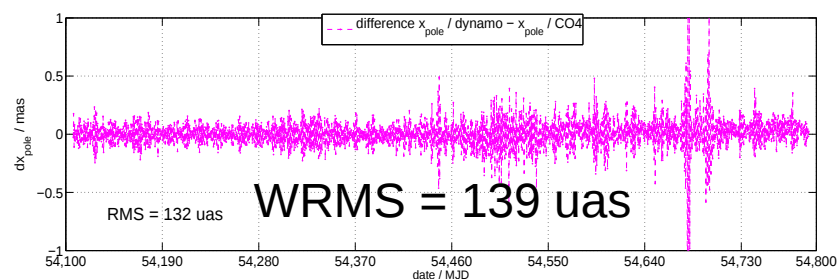
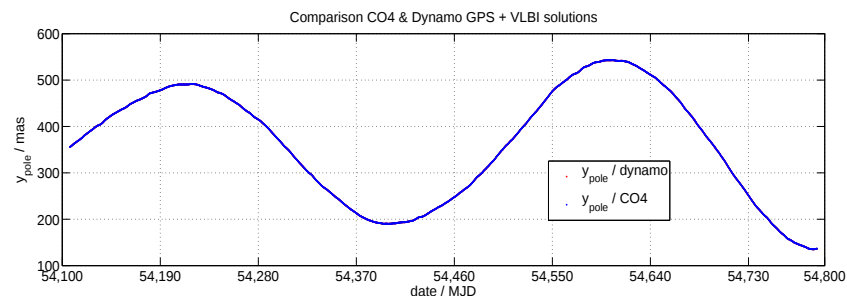
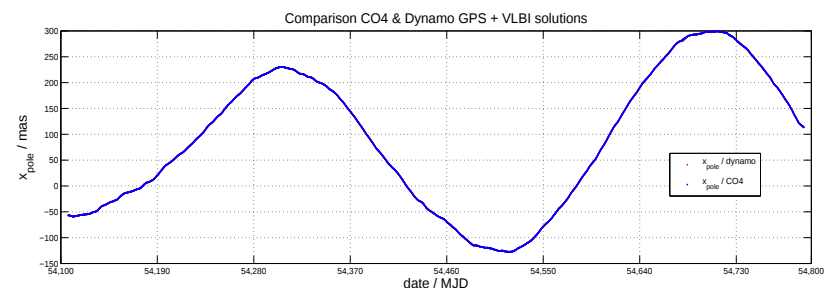
Weekly Normal Equations GPS + VLBI from Analysis Centers **CLS** (GPS) et **OB** (VLBI)
Pole Parameters (XP, YP) determination every 6h

A priori EOP C04 05

Continuity Constraints on pole coordinates : **1.3 cm**

UT& Nutation & Stations **FIXED**

Weighting : 5,212 **GPS** & 1.102 **VLBI**



2007 - 2008

2829 points for X pole solutions with mean of 4.4 uas
2829 points for Y pole solutions with mean of -18 uas

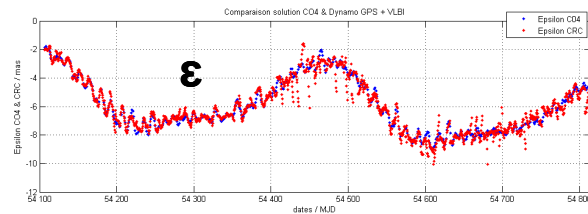
2007 - 2008

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October 2009

NUTATION parameters by Combination of GPS + VLBI week by week 2007 – 2008

Weekly Normal Equations **GPS** et **VLBI** from analyses services CLS (**GPS**) et OB (**VLBI**)
Nutation Parameters (ϵ , ψ) determination every 12h

VLBI + GPS : 1515 points



EOP C04 series
Interpolated at 12h
&
Nutation solutions
By combination

A priori EOP C04 05

Daily linearity Constraints : 10cm

apply to corrections nutation

Continuity Constraints nutation

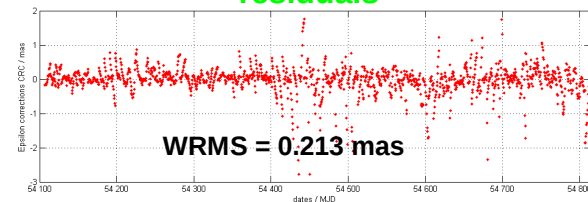
NE, NP : $0,3135 \times 10^{-9} \rightarrow 2\text{cm}$

UT & Pole & Stations FIXED

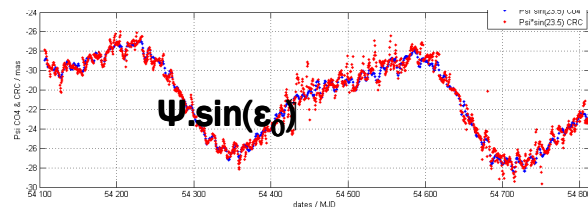
Weighting : 0.5 GPS

1.0 VLBI

residuals

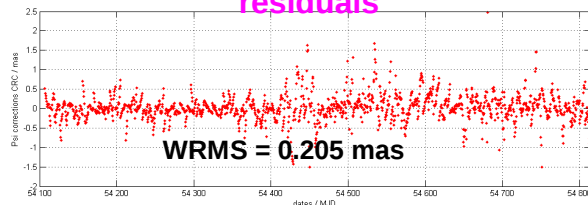


Solutions differences in the joint of the weeks

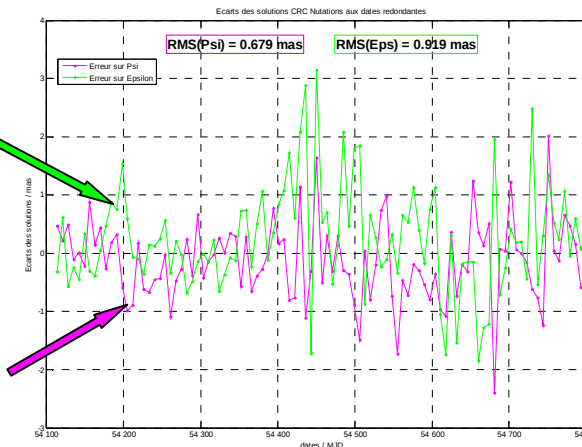


RMS(ϵ) = 0.679 mas

residuals



RMS(ψ) = 0.919 mas



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NUTATION by Combination of GPS + VLBI

Cumulated weeks 2007 2008

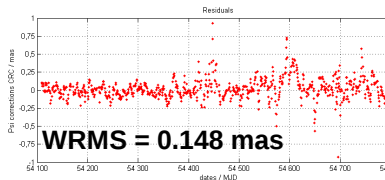
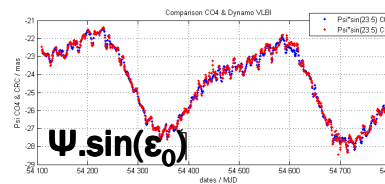
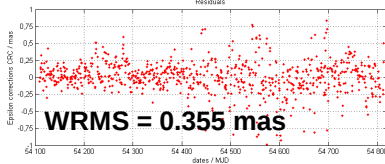
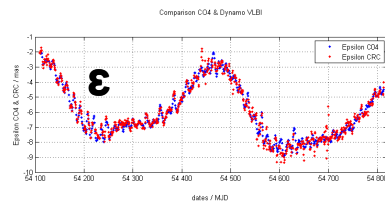
Stacked weekly Normal Equations over the period 2007-2008 are cumulated (100 NEQ **GPS** and 100 NEQ **VLBI**),
Combination of the 2 resultant NEQ cumulated

Weighting : 0.5 **GPS**, 1.0 **VLBI**

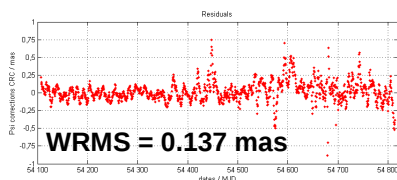
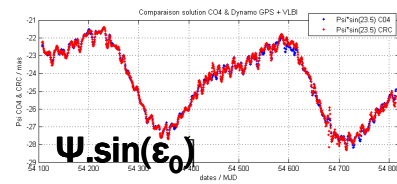
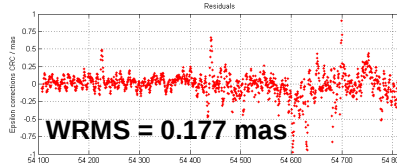
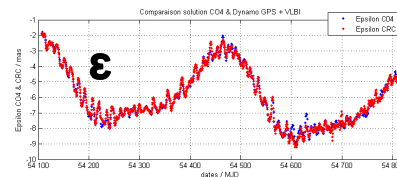
Nutation Parameters (ϵ , ψ) determination every 12h →

Continuity Constraints for Nutation: 2cm
Daily linearity Constraints de : 10cm
 UT& Pole & Stations are **FIXED** to their a priori

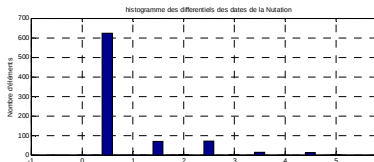
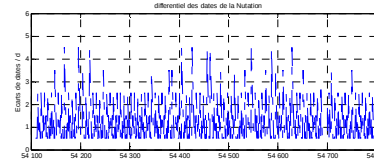
VLBI



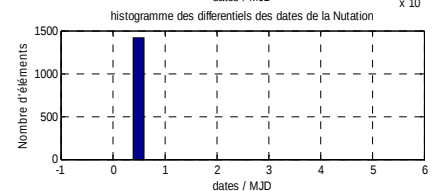
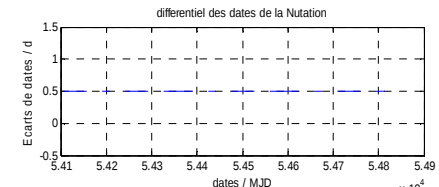
VLBI + GPS cumulated



VLBI : 792 points



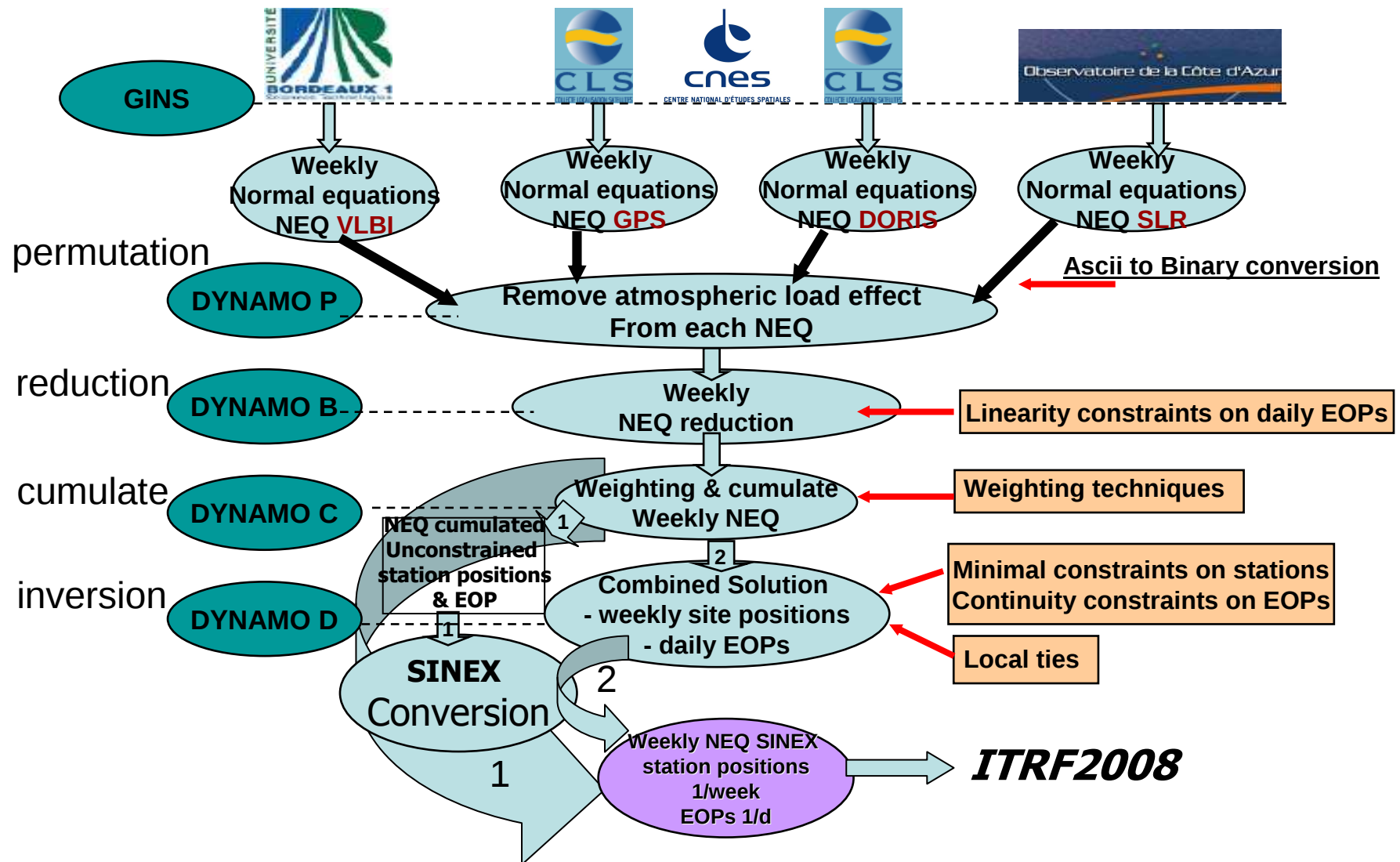
VLBI + GPS : 1415 points



Residuals WRMS

	VLBI Cumulated weeks 792 points	GPS+VLBI Week by week 1515 points	GPS+VLBI Cumulated weeks 1415 points
ϵ	0.355	0.213	0.177
$\Psi \cdot \sin(\epsilon_0)$	0.148	0.205	0.137

Stations Coordinates Determination Contribution to ITRF2008



Combination of techniques for ITRF2008 realization (1/2)

Weekly processes for each technique (VLBI, GPS, DORIS, SLR)

Period: 2007 – 2008 using Weekly Normal Equations from GINS of each AC
format Conversion NEQs GINS → Binary format

- **1- Atmospheric loading Effect removed**
(it is requested not to correct for any geophysical fluid loading effects except for tidal ocean loading)
EOP A priori recent EOP C04
- **2- Reduction : troposphere** parameters with loose constraints
 $\sigma(\text{MZB}) = 0.1\text{E-}4$, $\sigma(\text{MTB}) = 0.1$, $\sigma(\text{MRB}) = 1.0$
- **3- Reduction / Elimination Parameters** from NEQ before inversion
 - Free parameters
EOP: PX, PY, UT, NE, NP introduction of daily linear piecewise constraint on the corrections = 5mm (4 pts/d → 1 pt/d at noon)
Stations Space coordinates SX, SY, SZ (1 point/w)
 - Reduction
Parameters E (orbital elements), F (non gravitational Forces), B (orbit Biases)
 - Elimination
Parameters Q (Quasar), G (gravity field), O (ocean tides)

Combination of techniques for ITRF2008 realization (2/2)

GPS, VLBI, SLR, DORIS **NEQ Combination** unconstrained

- 4- **Generation** of weekly files containing the list of NEQ with their weighting factor. Each technique are used with a same weight during the all period
- Example week 2007/03/04

```
5.212 1 jml /home/jml/gin/batch/eqna/CRC/gps_atm_20070304.v3_bin_journalier
1.927 1 jml /home/jml/gin/batch/eqna/CRC/vlbi_atm_20070304.v1_bin_journalier
1.102 1 jml /home/jml/gin/batch/eqna/CRC/doris_atm_20070304.v0_bin_journalier
1.709 1 jml /home/jml/gin/batch/eqna/CRC/slr_atm_20070304.v2_bin_journalier
```

- 5- **Combination** of the weekly weighted NEQs and **conversion** of the resulting weekly unconstrained NEQ in SINEX files

Deposited on the web site

<http://syte.obspm.fr/~richard/ITRF2008/>

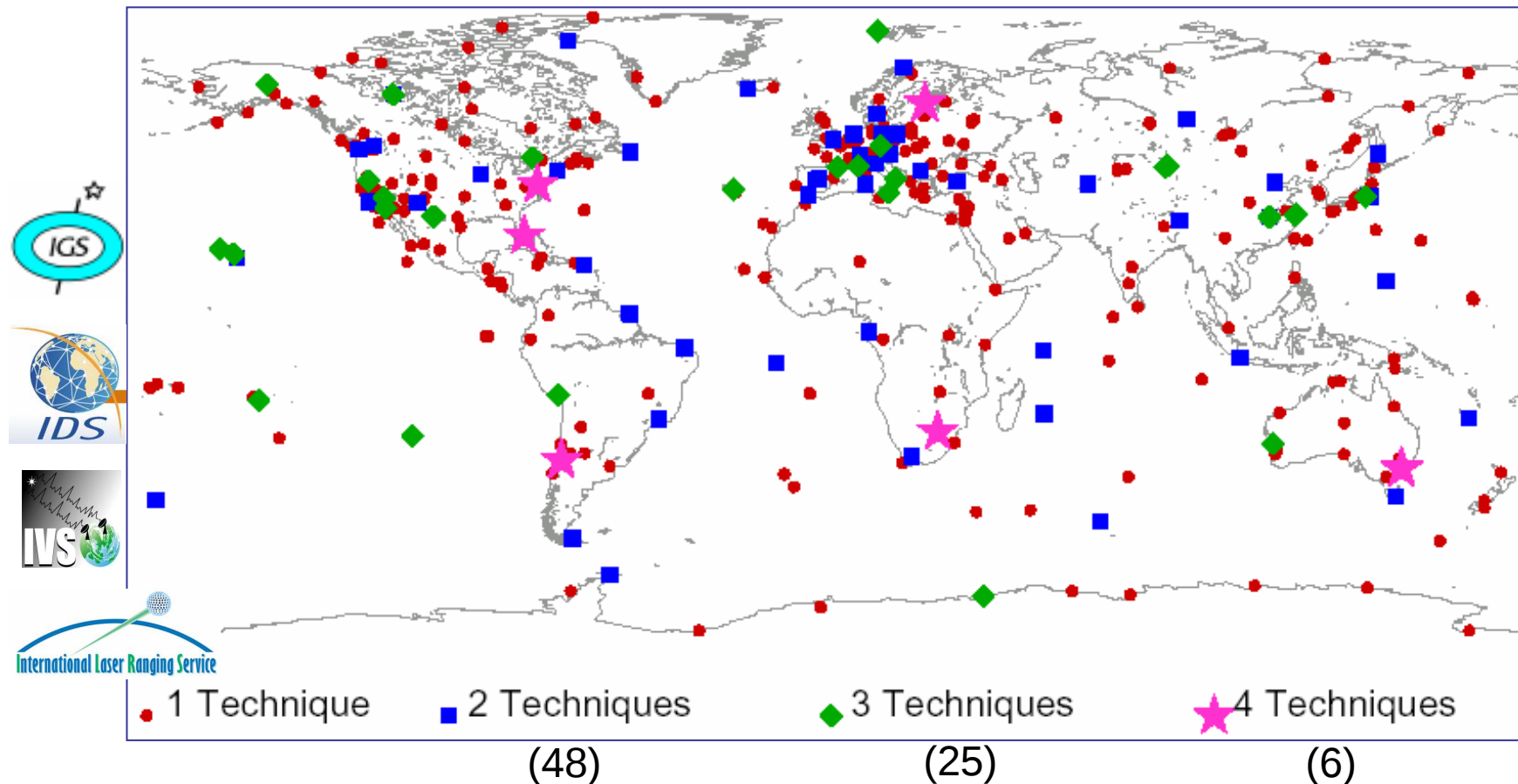
files name → sem_dynamo_yyyymmdd.SNX

EOP Solutions & Stations Space coordinates are calculated by inverting the resultants Normal Equation with some constraints

Choice of parameter to estimate (FREE ou FIXED)

- **Pole X,Y** (PX, PY),
- **UT** (PT),
- **Nutation ϵ, ψ** (NE, NP),
- **Stations Space Coordinates** (SX, SY, SZ)

A priori Terrestrial Referential Frame : ITRF 2005

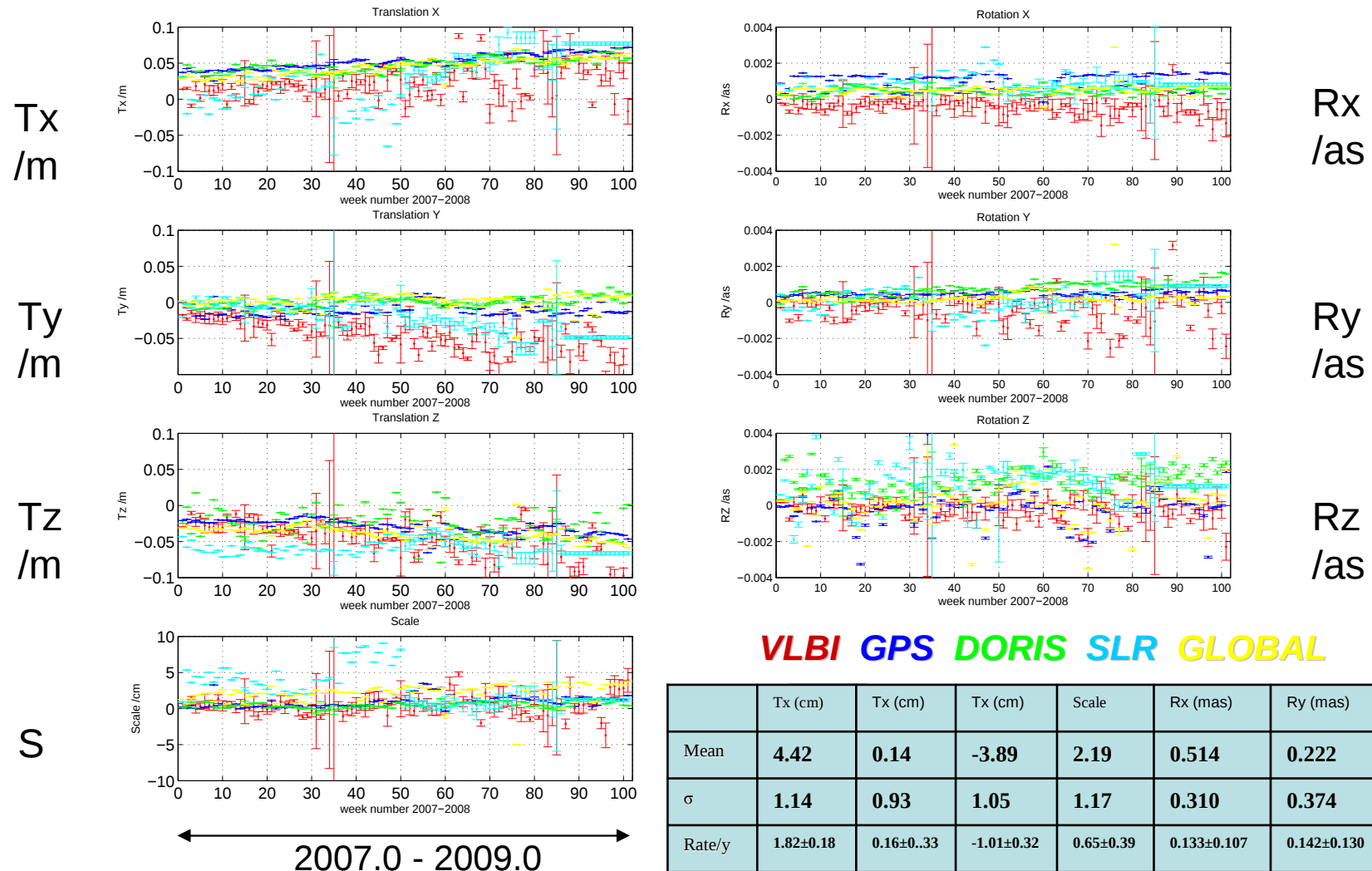


GRGS observations :

GPS	: 90 receivers
DORIS	: 50 stations Spot-2, -3, -4, -5, Topex/Poseidon, Envisat
VLBI	: 17 stations session IVS-R1& IVS-R4 on 2007-2008
SLR	: 30 stations, satellites Lageos-1 & Lageos-2

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Transformation Parameters for each technique GPS DORIS VLBI SLR and for GLOBAL technique with respect to ITRF2005



Global Transformation Parameters

Stations Space Coordinates using Combination at NEQ level, contribution to ITRF2008

Solutions by inversion of weekly unconstrained combined NEQ

Pole UT & Nutation Fixed to a priori **EOP C04**

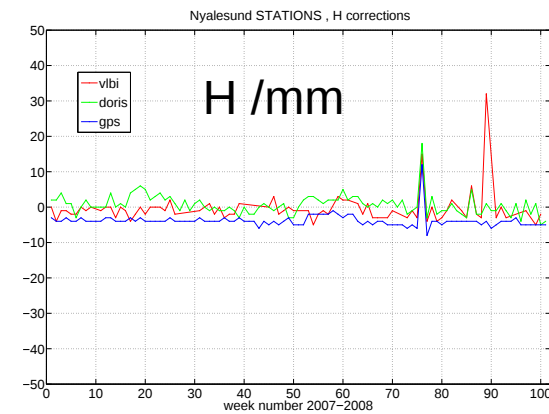
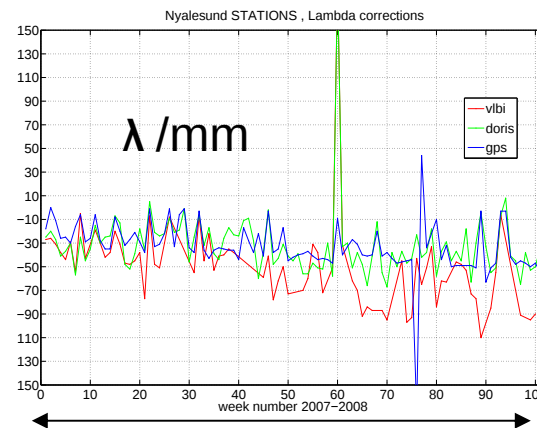
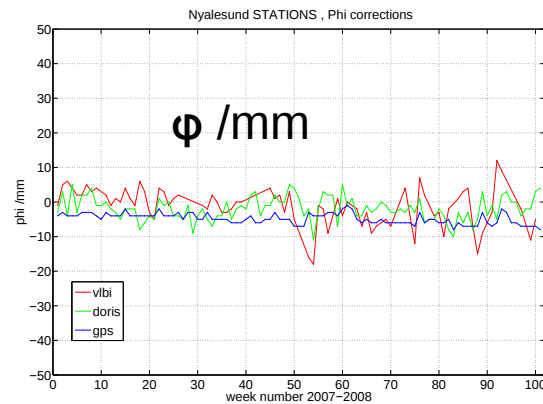
Weekly Station Space Coordinates are obtained with

Systematic Constraints : $\sigma(S_x, S_y, S_z) = 1\text{m}$

Minimal Constraints with 7 Transformations Parameters & $\sigma(T_x, T_y, T_z, D, R_x, R_y, R_z) = 10\text{m}$ (loose)

Ties Constraints on co-located sites (26 actually)

Site **Ny-Alesund** : 3 geodetic Co-located techniques → **VLBI**, **GPS**, **DORIS**



2007.0 - 2009.0

	VLBI	GPS	DORIS	
ϕ (mm)	5.6	5.0	3.9	} RMS / ITRF2005
λ (mm)	61.3	39.0	42.3	
H (mm)	4.6	4.3	2.9	
ϕ rate (mm/y)	-3.4869	-1.4311	-0.2471	} Rate / ITRF2005
λ rate (mm/y)	-23.6638	-13.7912	-7.3709	
H rate (mm/y)	1.0073	-0.3376	-1.1000	

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POLE COORDINATES SOLUTION obtained by NEQ combination for ITRF2008 realization

Pole 1 point/day

A priori EOP C04 05

Nutation & Stations Fixed,

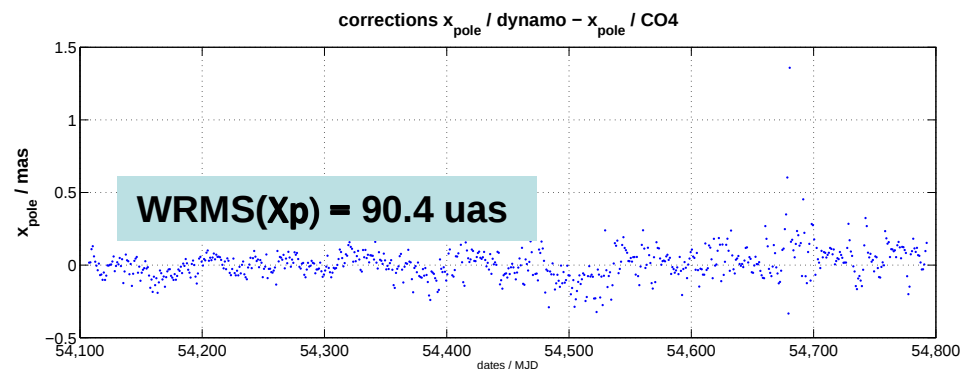
Weighting

GPS	VLBI	SLR	DORIS
5.212	1.927	1.709	1.102

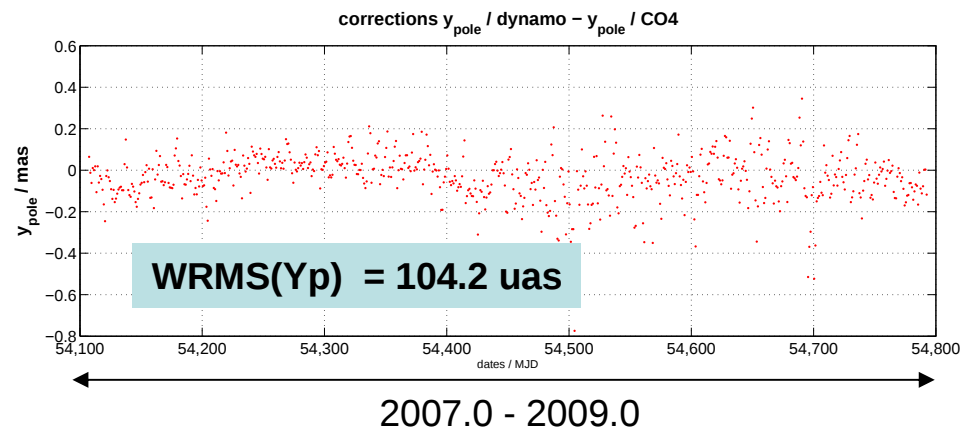
Continuity Constraints on daily Pole coordinates

PX, PY	2×10^{-9} rad	1.27 cm
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X pole – C04



Y pole – C04



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NUTATION SOLUTION obtained by NEQ combination for ITRF2008 realization

Nutation 1 point/day

A priori EOP C04 05

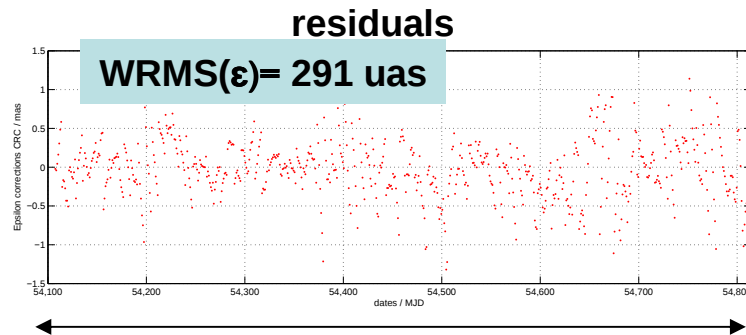
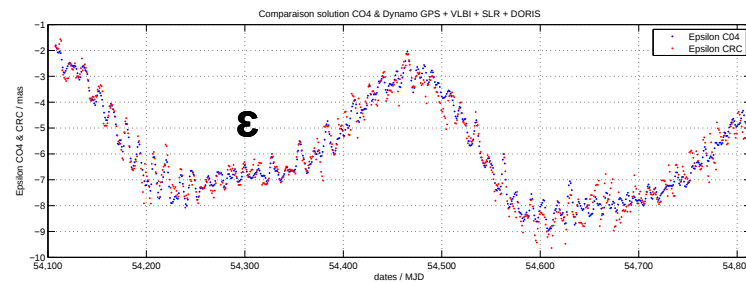
Pole & Stations Fixed

Weighting

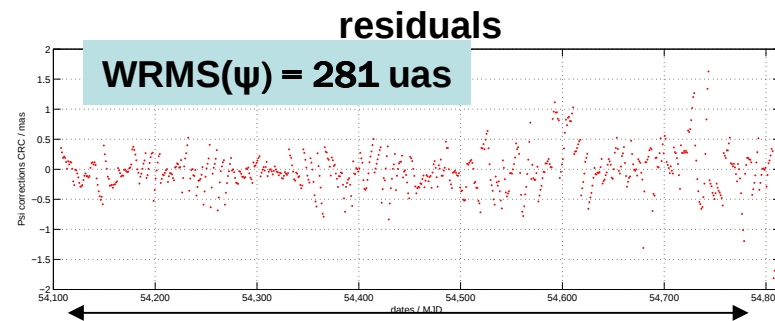
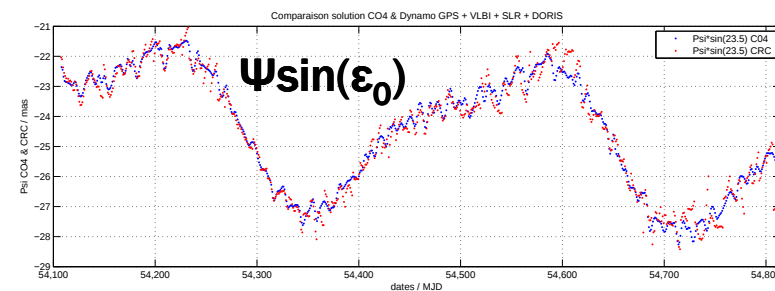
GPS	VLBI	SLR	DORIS
5.212	1.927	1.709	1.102

Continuity Constraints on daily nutation

NE, NP	2×10^{-09} rad	1.27 cm
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2007.0 – 2009.0



2007.0 – 2009.0

FORUM COMBINATION at the Observation Level

<http://grgs.obspm.fr/forum/>

Forum Multi-technique Combinations
Hosted by Observatoire de Paris

Rechercher... Rechercher
Recherche avancée

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[Panneau de contrôle de l'utilisateur \(0 nouveau message\)](#) • [Voir vos messages](#) • [FAQ](#) • [Membres](#) • [Déconnexion \[jyr \]](#)

Nous sommes actuellement le 05 Juin 2009, 15:36
[Panneau de contrôle du modérateur]

Dernière visite le : 04 Juin 2009, 10:31

[Voir les messages sans réponses](#) • [Voir les nouveaux messages](#) • [Voir les sujets actifs](#) • [Marquer les forums comme lus](#)

WELCOME	SUJETS	MESSAGES	DERNIER MESSAGE
Readme First Read First before posting	1	1	par admingrgs 18 Février 2009, 14:09

COMBINAISONS GRGS	SUJETS	MESSAGES	DERNIER MESSAGE
GINS/DYNAMO, Software, Formats... Ici on parle des logiciels en general, m.a.j. , problemes, etc...	11	26	par jyr 04 Juin 2009, 10:31
ITRF2008 Ici on parle de tout ce qui concerne l'ITRF2008	5	18	par jyr 17 Avril 2009, 15:22
Autres Analyses Ici on parle des analyses	2	4	par loyer 06 Mars 2009, 10:26
Troposphere	1	1	par loyer 04 Mars 2009, 11:29

WORKING GROUP IERS ON MULTI-TECHNIQUE COMBINATIONS	SUJETS	MESSAGES	DERNIER MESSAGE
DATA All about DATA	1	1	par jyr 04 Mai 2009, 14:07
ANALYSES All about Analyses	0	0	Aucun message

QUI EST EN LIGNE ?
Au total, il y a 2 utilisateurs en ligne :: 1 inscrit, 0 invisible et 1 invité (basé sur les utilisateurs actifs des 5 dernières minutes)
Le nombre maximum d'utilisateurs en ligne simultanément a été de 5 le 16 Février 2009, 16:12

Utilisateurs inscrits : jyr
Légende: *Administrateurs*, *Modérateurs globaux*

STATISTIQUES
51 messages au total • 21 sujets au total • 18 membres au total • Notre membre le plus récent est **mariak**

[Index du forum](#) L'équipe • Supprimer tous les cookies du forum • Heures au format UTC + 1 heure

Discussion for GRGS processing

GINS/DYNAMO, Software, Formats...

[NEWTOPIC](#) Rechercher dans ce Rechercher

Marquer les sujets comme lus • 11 sujets • Page 1 sur 1

SUJETS	REponses	Vues	DERNIER MESSAGE
Réduction EQN 0 par jyr » 09 Mars 2009, 16:59	7	18	par jyr 04 Juin 2009, 10:31
NNR conditions par jyr » 28 Mai 2009, 17:01	1	3	par lsoudarin 29 Mai 2009, 10:46
Sinex Tool par jyr » 28 Mai 2009, 16:11	0	3	par jyr 28 Mai 2009, 16:11
Modèles dans GINS par jyr » 28 Mai 2009, 09:32	0	5	par jyr 28 Mai 2009, 09:32
Rattachements 0 par jyr » 04 Mai 2009, 16:13	1	15	par Jean-Michel Lemoine 25 Mai 2009, 15:59
Contraintes minimales 0 par jyr » 25 Mars 2009, 16:21	4	15	par jyr 08 Avril 2009, 10:42
Paramètres de transformation 0 par jyr » 31 Mars 2009, 16:10	0	7	par jyr 31 Mars 2009, 16:10
Parametres des QUASARS par jyr » 27 Mars 2009, 17:06	1	5	par gbouda 31 Mars 2009, 08:58
inversion des matrices par jyr » 25 Mars 2009, 13:27	0	9	par jyr 25 Mars 2009, 13:27
Combinaison de UT par jyr » 13 Mars 2009, 15:05	0	6	par jyr 13 Mars 2009, 15:05
Date en Journée CNES par jyr » 06 Mars 2009, 10:55	1	15	par gbouda 06 Mars 2009, 11:47

Exchanges with DGFI,ORB,
Ukrainian Observatory MAO ...
For SINEX Matrix

Combinations Series available at
<ftp://hpiers.obspm.fr/iers/eop/grgs/>

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CONCLUSION and Outlook

Between weekly X, Y, UT1 solutions from DYNAMO we found 2 solutions at 0h
necessity to cumulate 2 consecutives weeks with overlapping of 1 week

Possibility to compare EOP solutions with different software packages

Using SINEXTOOL GRGS software:

Convert EQN GINS format → SINEX format

EQN SINEX format → GINS format

Nutation parameters radian unit in SINEX → mas

Local ties: how to maintain the list of co located stations in up-to-date state
and the changing during the analysis period

UT1: request LOD parameter from geodetic techniques GPS, DORIS, SLR to
combine LOD with UT1 VLBI

Weighting technique: Helmert method for the all period, week by week
or other algorithm taking time variation of uncertainties into account ...

EOP measurements sampling at 3h or 1h and necessity to compare solutions with other
combinations at the same intervals of solutions

Introduction of LLR EOP measurements to combine with other techniques

Authors are grateful to Zuheir Altamimi and Xavier Collilieux (LAREG-IGN)
for your help in this contribution to ITRF2008
and
to Jean-Michel Lemoine, Jean-Charles Marty, Richard Biancale (CNES)
for their assistance and their advices to use GINS/DYNAMO software

Thanks for your Attention