

COL Working Group



*Combination at the
Observation Level
IERS Working Group*

R. Biancale/CNES, D. Gambis/OP, M. Seitz/DGFI

What is the current status of the combination at the observation level (COL) and how it could contribute to the IERS products in the future?

- 1. Advantages of the COL, compared to the current ITRF, ICRF and EOP combination procedures*
- 2. Limiting factors for COL*
- 3. Current progress made within the COL WG?*
- 4. Expectation of future availability of routine COL products?*

Roadmap (2009)

- 1) **reviewing the approach of the various groups**
and their capability to process two or more techniques.
- 2) **elaborating benchmarks**
to intercompare results between groups from the same data set.
- 3) **ensuring SINEX compatibility**
between techniques and with the international technique services and IERS.
- 4) **establishing common processing standards**
for all techniques in order to guarantee homogeneity and consistency.
- 5) **optimizing and unifying parameterization**
for instance for tropospheric parameters in order to minimize globally the degree of freedom of the whole inverse system.
- 6) **studying the appropriate weighting between techniques**
and the use of local ties or identical satellites tracked by several techniques.
- 7) **studying stabilization methods**
and looking for high temporal resolution of parameters.
- 8) **evaluating and comparing results**
to search for compatibility between groups.
- 9) **organizing routine operations**
for a new TRF realization, either in the framework of the next ITRF or as ITRF assessment.

COL Analysis Centers and software packages used

<i>groups</i>	<i>software packages</i>	<i>techniques</i>				<i>COL</i>
• AIUB/BKG	BERNESE		GNSS	SLR		X
• DGFI	DOGS-OC			SLR		X
	BERNESE/DOGS-RI		G...		V...	
• ESOC	NAPEOS	DORIS	GNSS	SLR		X
• GFZ	EPOS	D...	GNSS	SLR		X
• GRGS	GINs	DORIS	GNSS	SLR	VLBI	X
• GSFC	GEODYN	D...	G...	S...		
	CALC-SOLVE				V...	
• ASI	BERNESE/GEODYN		G...	SLR		X
• TUW	VIEVS				VLBI	X

COL Analysis Centers

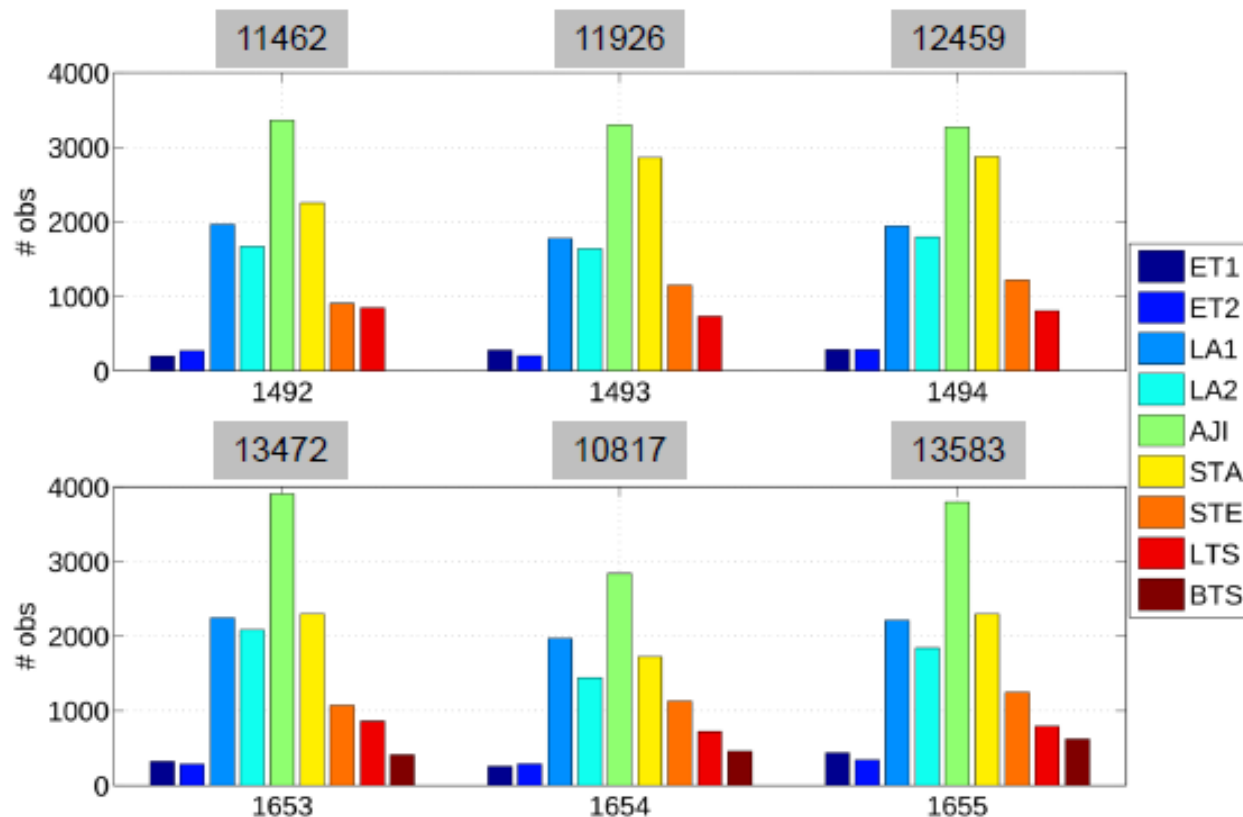
• DGFI	DOGS-CS
• GRGS	DYNAMO

Advantages of the COL, compared to the current ITRF, ICRF and EOP combination procedures

- Process all space geodetic data together on one satellite (e.g. Jason2) or all satellites together (e.g. SLR, GNSS)
- Homogenize models and parameters (e.g. troposphere)
- Test in the equivalent NEq form
- Detect outliers based on all observation data
- Allow high resolution (3hrs EOP)
- Study technique systematics (adjusting Helmert's parameters)
- Introduce space and ground ties at the same level

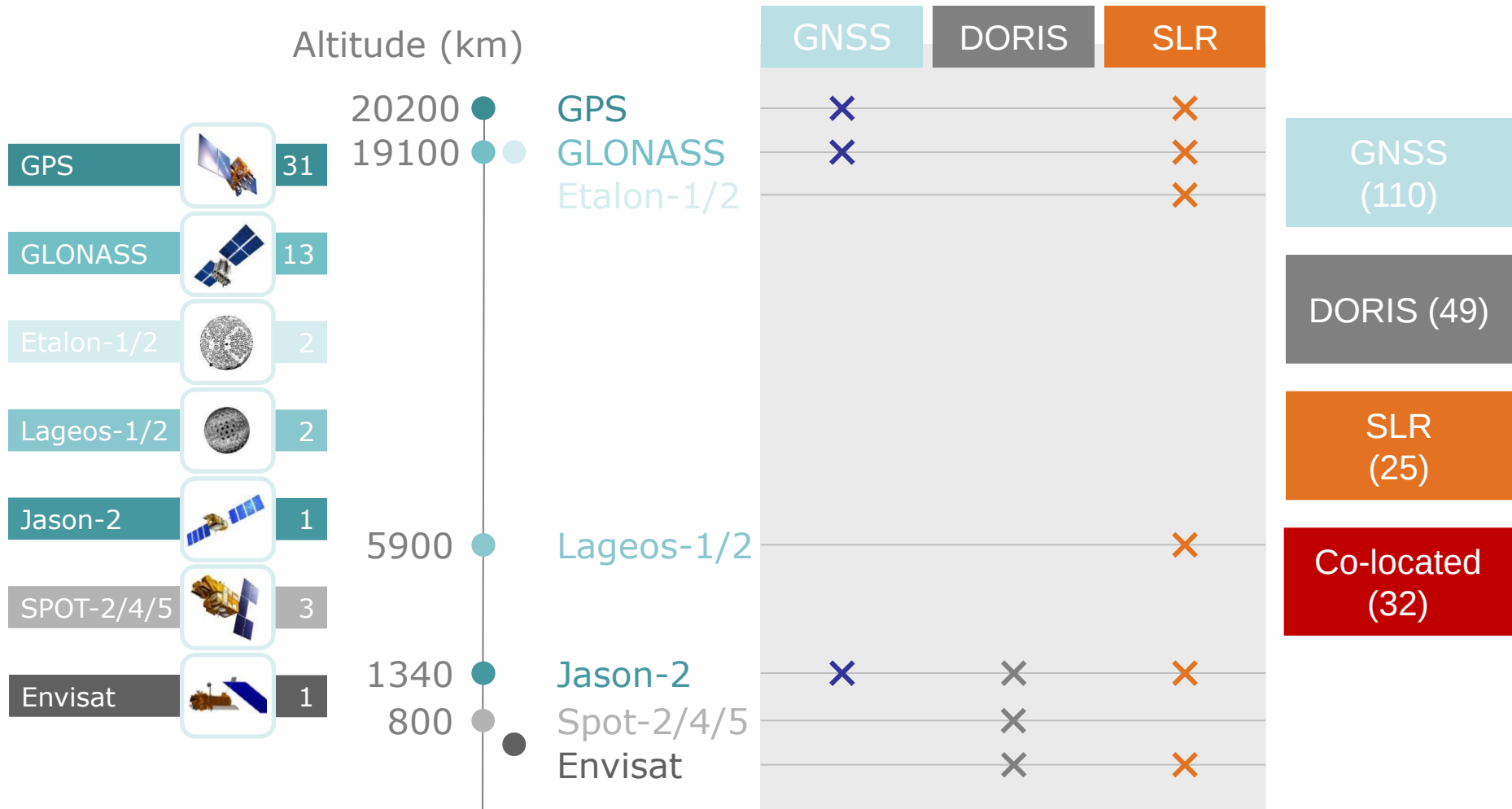
DGFI SLR solution – time period / satellites

- CONT08 period (10.08.2008 – 01.09.2008; gpsweek 1492 - 1494)
 - ET1, ET2, LA1, LA2, AJI, LTS, STA, STE
- CONT11 period (11.09.2011 – 03.10.2011; gpsweek 1653 - 1655)
 - ET1, ET2, LA1, LA2, AJI, LTS, STA, STE, BTS (launched in 2009)



Multi-technique combination at observation level with NAPEOS / ESOC

(Michel Otten, Claudia Flohrer, Tim Springer, Werner Enderle)



Total number of satellites: 53

Typical number of stations: ~184

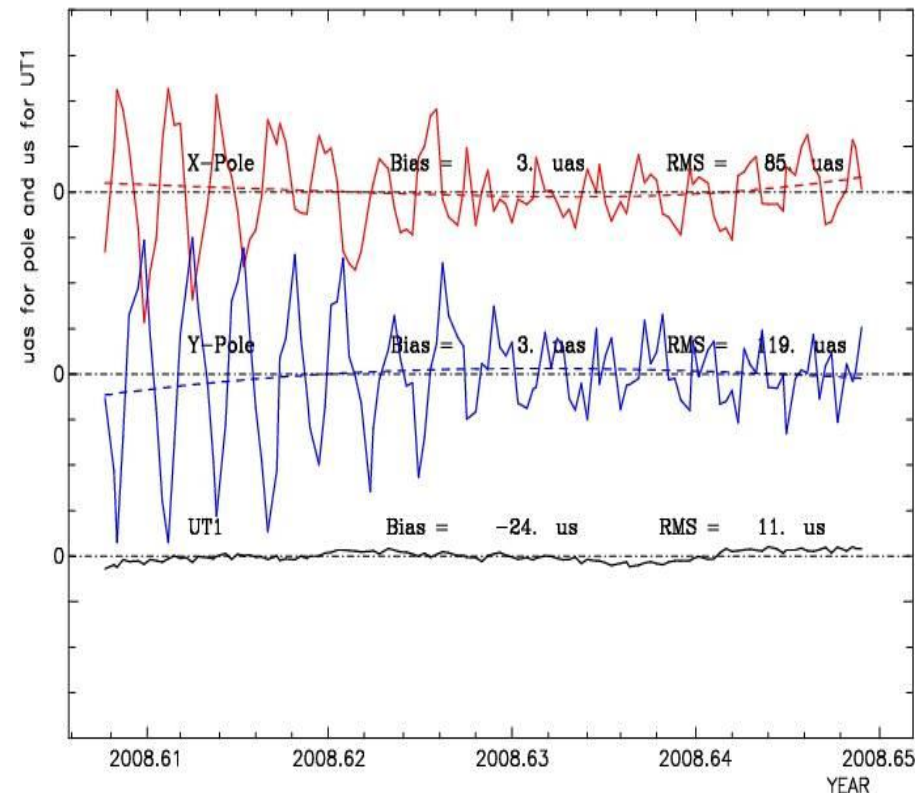
Pole & UT by combination with DORIS-GPS-SLR-VLBI from GRGS normal equations



- 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/>

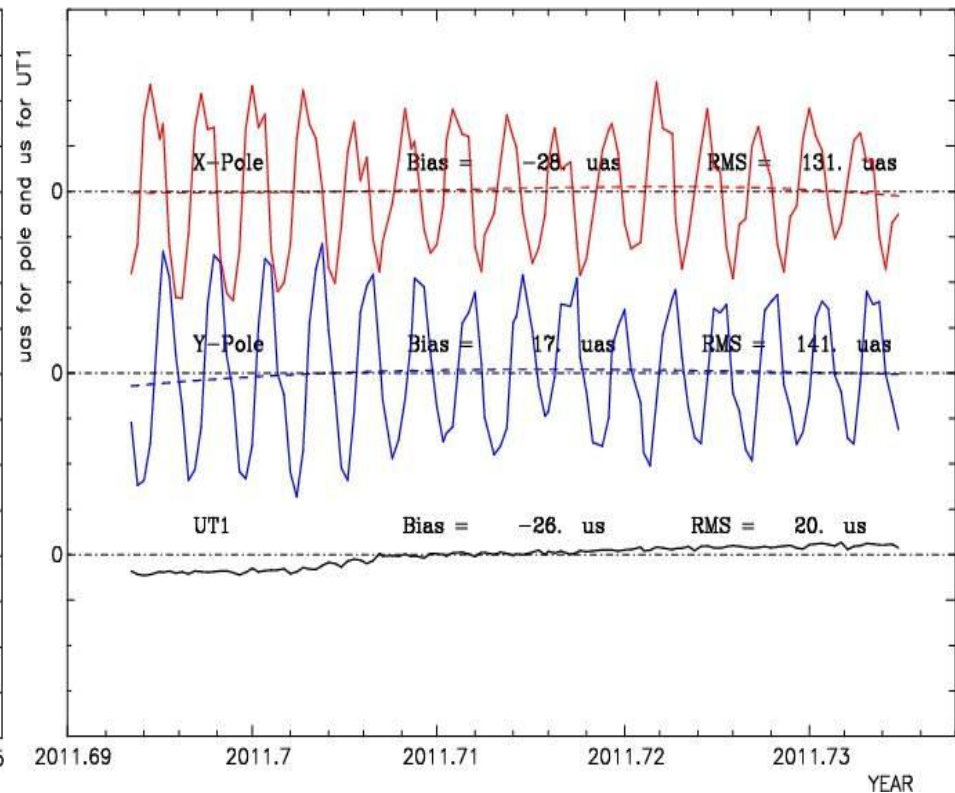
GRGS – IERS C04 over cont08

Sub diurnal estimation, stations and quasars positions estimated



GRGS – IERS C04 over cont11

Sub diurnal estimation, stations and quasars positions estimated

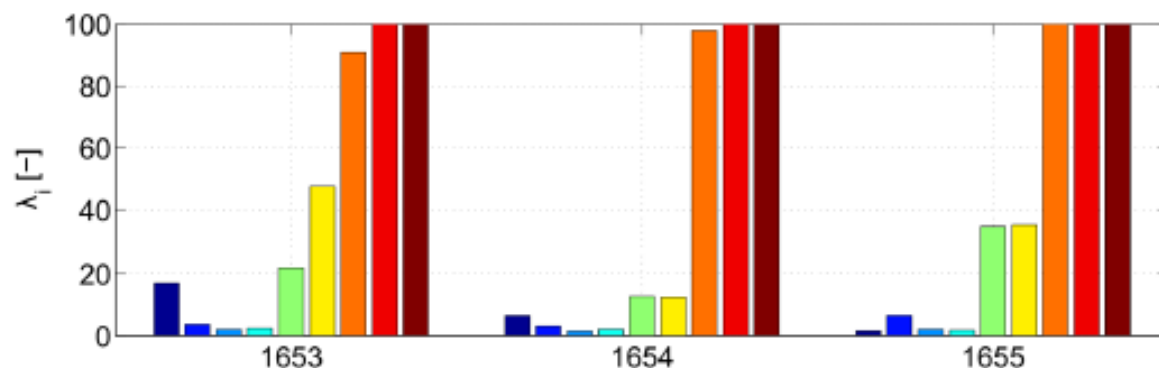
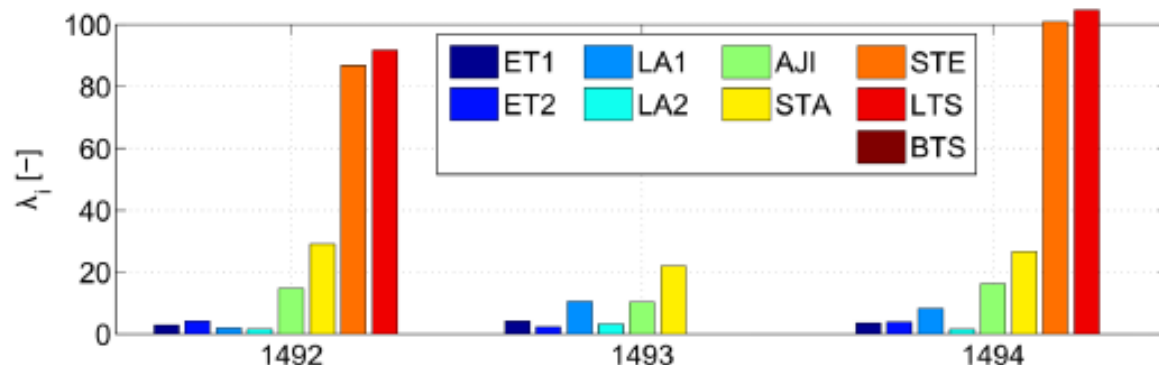


Limiting factors for COL

- Still limited capability for most software packages to process all techniques
- Weighting strategy has to be a priori fixed and refined weekly because of inhomogeneous observation geometry and density
- Latency of certain technique observations (VLBI, DORIS)
- ... still far from operational service

DGFI SLR solution – satellite combination

- Relative weighting of satellite-specific NEQs is done by variance component estimation (VCE)
 - Relative weighting factors λ_i with $i = 1, 2, \dots, 9$ (satellites)
 - Huge for STE, LTS and BTS (CONT08: $\lambda_{\max} = 143$, CONT11: $\lambda_{\max} = 1220$)

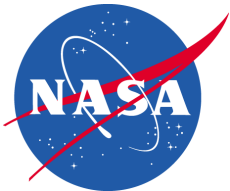


Possible reasons for high λ :

- λ_{BTS} : special reflector type
→ not well designed?
- λ_{STE} : sun-synchronous orbit
→ orbit systematics?
- λ_{LTS} : very low altitude
→ model problems?

Current progress made within the COL WG

- Awareness of the interest among several groups
- Update software capabilities to process multi-techniques together
- Organize tests over VLBI CONT08 and CONT11 periods
- Upgrade and homogenize SINEX format for the multi-technique NEq combination
- Study weighting strategy and way to reduce technique systematism parameters (Helmert's parameter are artifact!)



GEODYN Improvements Underway

VLBI

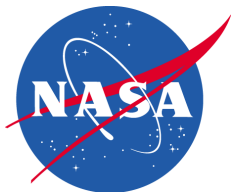
- Addition of ability to estimate nutations into GEODYN.
- Continue inter-calibration of CALC/Solve & GEODYN.

GPS

- Add capability to fix ambiguities.
- Edit half-cycle slips (Jason2)
- Improve radiation pressure modelling (probably implement macromodel, rather than GPSM04).
- Jan Kouba (2009) attitude model is implemented.

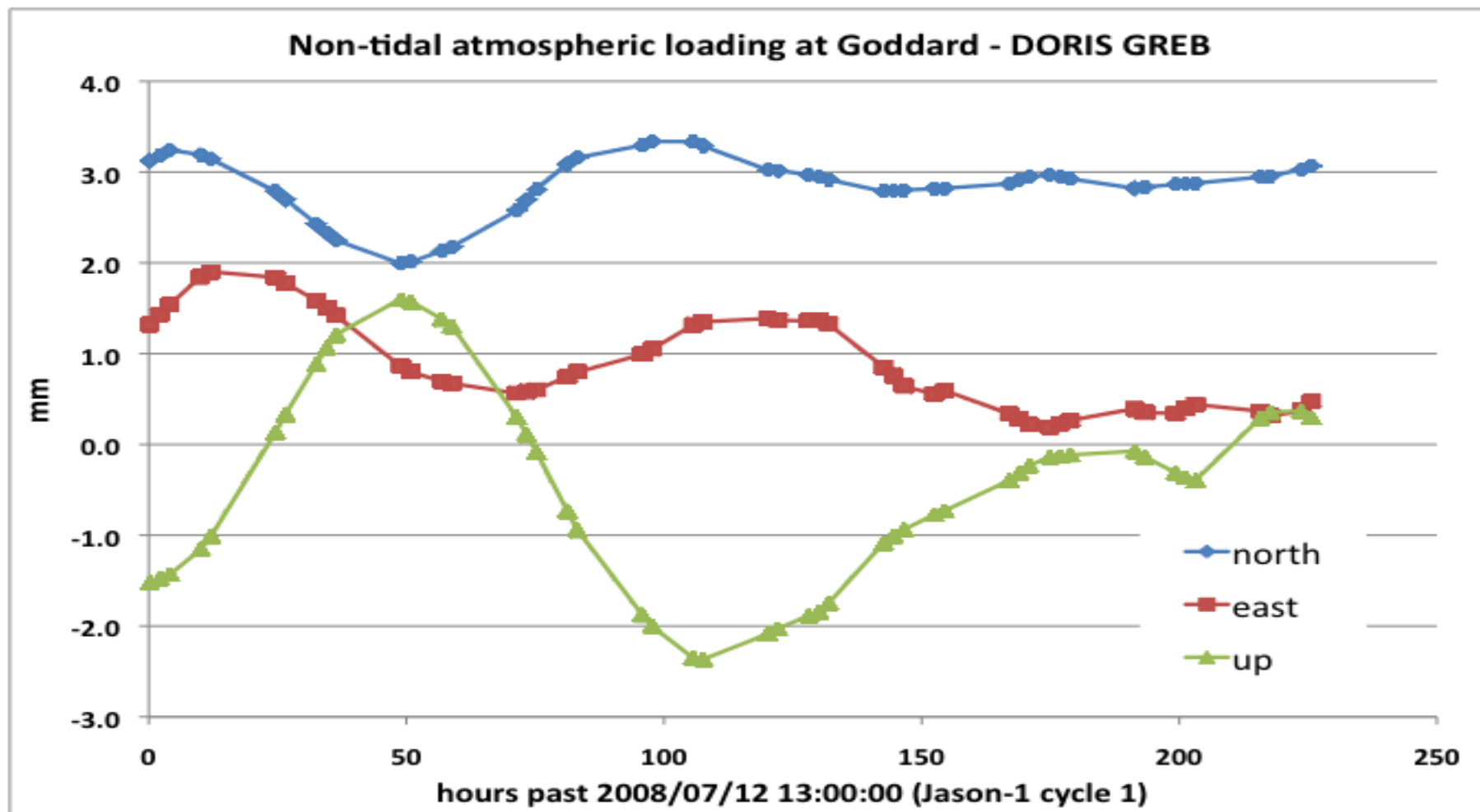
DORIS & SLR

- Improved radiation pressure modelling. Self-shadowing for altimetric & DORIS satellites.
- Improved planetary radiation pressure models.



APLOAD Correction at Greenbelt (from ECMWF-6hr)

(for Jason2 Cycle 1, July 2008)

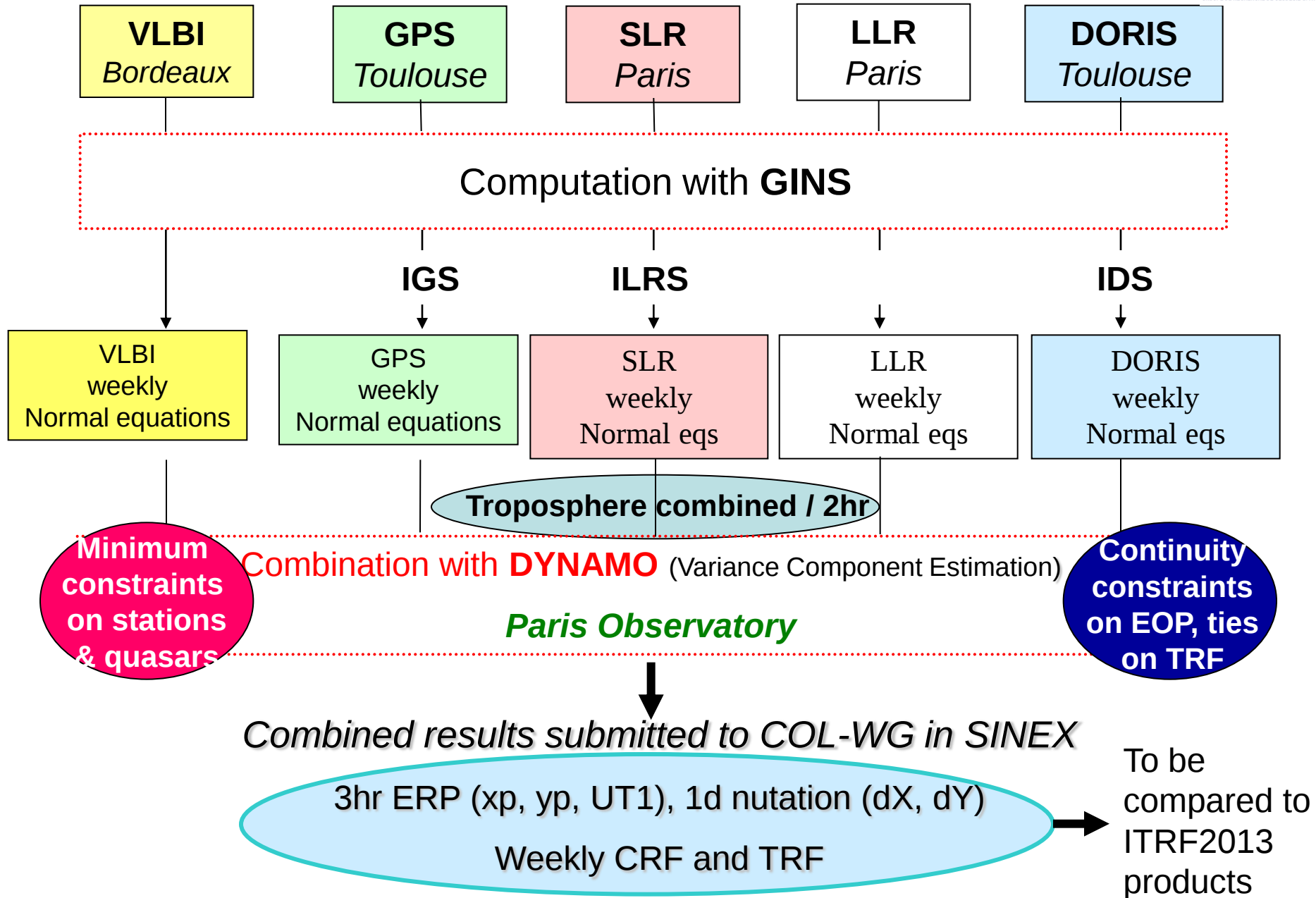


Lemoine et al., GSC AC Report, May 29,
2012

Expectation of future availability of routine COL products

- The major task will be to study methods and advantages of combining techniques at the observation level, searching for an optimal strategy to solve for geodetic parameters.
- Demonstration should be based on weekly combined SINEX files (containing unconstrained normal equations of station coordinates, EOPs, nutation parameters and eventually quasar coordinates) from all space geodetic techniques together and over VLBI CONT campaigns.
- The new products resulting from these combination procedures should be compared to the current IERS products routinely produced.
- As a first step for longer time series, GRGS will combine at least 10-year series which will be achieved for IGS, IDS, ILRS, IVS(?) in the ITRF2013 framework.

Combination at the observation level in GRGS



Multi-technique combination at observation level

In one global run

- Using one software package: NAPEOS

Improve accuracy and consistency of geodetic products

- Combination improves geocenter Z-component
- Combination improves GPS orbits of the ambiguity float solution

Detect inconsistencies between techniques

- Orbit overlap errors increase for the combined solution when fixing ambiguities → orbit model deficiencies?

GOALS of COL

- to progress in combination methods and strategies (weighting, stabilizing, ...)
- to establish the gain of this approach vs. actual realizations (C04, ITRF...)
- to prepare future of IERS