Combination at the Observation Level
IERS Working Group

2nd COL Working Group Meeting
9-10 December 2010
DGFI Munich
(Alfons-Goppel-Str., 11, 80539 München)

Agenda, December 9th

14:00 introduction, reminder of COL objectives, *R. Biancale*

14:15 activities in the COL analysis centres / contributions from the COL test period (10-30 August 2008):

1. *AIUB/BKG, D. Thaller*
2. *DGFI, R. Heinkelmann*
3. *ESOC, T. Springer/D. Svehla*
4. *GFZ, R. Koenig*
5. *GRGS, J.-Y. Richard*
6. *other*

15:30 activities in the COL combination centres

- *compatibility of SINEX files, data and parameter homogeneity, M. Seitz, J.-Y. Richard*
- *a priori models used, toward a set of common standards? S. Loyer/L. Soudarin*
- *comparison strategy and results (polar motion, UT1, nutation, stations…) M. Seitz, J.-Y. Richard*

17:30 *adjourn*

Agenda, December 10th

09:00 discussion on roadmap (tasks and sequence)

09:30 proposal on test reiteration:

1. *standards*
2. *data sets*
3. *parameter sets*
4. *SINEX evolutions*

10:30 discussion on combination *strategy and methods*

1. *objectives to be reached*
2. *planning of work*

11:30 activity report 12:00 summarizing next actions and schedule

12:30 *end of meeting*

COL-WG participants

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Can technique combination at the observation level improve accuracy and consistency of EOP, TRF, CRF?

IERS has created a dedicated framework for studying combination:

2002 – creation of the IERS Combination Research Centres (11 CRCs)
2004 – IERS proposal of Combination Pilot Project (CPP)
2009 (21-22 October) – kick-off meeting of the COL-WG / Warsaw
2010 (3 June) – intermediate meeting / Vienna
2010 (9-10 December) – 2nd COL meeting / Munich

"Combination at the Observation Level" Working Group charter:
COL-WG 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.

Goals of the COL-WG

- to improve precision, resolution and consistency of products (EOP, TRF, CRF) using common standards for a rigorous combination
- to extend the combination approach at the level of observation to several research groups in a planned IERS action
- to inter-compare and to homogenize data- and combination processing from different software packages
- to mutualize physical parameters (e.g. troposphere) and to study technique dependent systematic errors
- to progress in combination methods and strategies (e.g. weighting)
- to validate the rigorous combination approach vs. present realizations (C04, ITRF2008…)
- to prepare future of IERS…

Present COL participants

- AIUB/BKG: BERNESE
- DGFI: DOGS-OC/-CS (+ OCCAM/BERNESE)
- ESOC: NAPEOS
- GFZ: EPOS
- GRGS: GINS/DYNAMO

Other potential COL participants

- JPL: GIPSY/OASIS
- GSFC: GEODYN/SOLVE
- ASI: GEODYN
- …

Prerequisite

processing must be at the quality level of the Technique International Services

Combination at the observation level vs. NEq level

Example: Jason2 - 7 day arc over the period: 17/8/2008 – 23/8/2008

Technique	Nb of observ.	Residuals	Orbit # rms
SLR	2216/224	4.1cm	12.1cm
DORIS	109884/52825	.346mm/s	10.6cm
SLR + DORIS	2247/193 109614/53095	4.2cm .352mm/s	

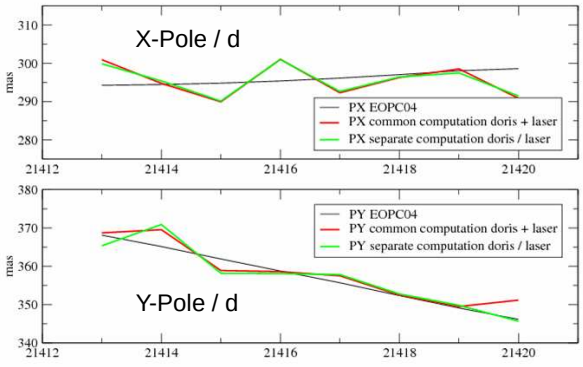
- *difference in data editing*
- *difference in orbits*
- *almost no difference in ERP*

Observation level

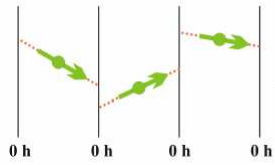
$$\sum_i \frac{\partial Q_i^{calc}}{\partial p_k}\left(\sum_{j=1}^{n}\frac{\partial Q_i^{calc}}{\partial p_j}\Delta p_j - \Delta Q_i\right) = 0 \quad \forall k = 1,n$$

NEq level

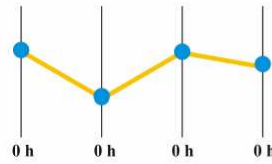
$$\Delta Q_i = Q_i^{obs} - Q_i^{calc} = \sum_{j=1}^{n}\frac{\partial Q_i}{\partial p_j}\Delta p_j$$



Technique of EOP interpolation

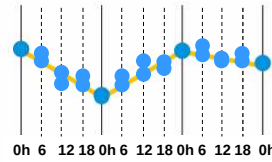


Piece-wise linear **Offset+Drift**
2*n parameters
no continuity at boundaries
continuity constraints reduce #parameters to ***n+1***



Piece-wise linear **Polygon**
n+1 parameters
"real"continuity at boundaries
no continuity constraints needed
not distinguishable from "offset-only" in SINEX

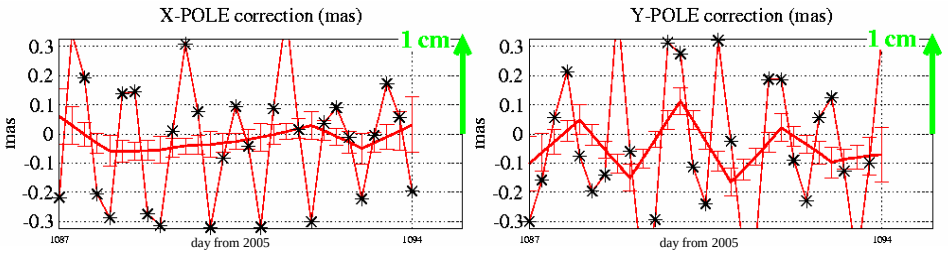
Seitz, Thaller - Workshop on Combination on Observation Level, 21./22.10.09, Warsaw



Densified piece-wise linear **Polygon**
4n+1 parameters
"real"continuity achieved
linearity constraints needed
$\begin{cases} P_j(6h) = \frac{3}{4}P_j(0h) + \frac{1}{4}P_{j+1}(0h) \\ P_j(12h) = \frac{1}{2}P_j(0h) + \frac{1}{2}P_{j+1}(0h) \\ P_j(18h) = \frac{1}{4}P_j(0h) + \frac{3}{4}P_{j+1}(0h) \end{cases}$
not distinguishable from "offset-only" in SINEX

Example of EOP undersampling

GPS - from 6 hr to 1 day



by linearity constraints: $\begin{cases} P_j(6h) = \frac{3}{4}P_j(0h) + \frac{1}{4}P_{j+1}(0h) \\ P_j(12h) = \frac{1}{2}P_j(0h) + \frac{1}{2}P_{j+1}(0h) \\ P_j(18h) = \frac{1}{4}P_j(0h) + \frac{3}{4}P_{j+1}(0h) \end{cases}$

=> One can densify the EOP parameterization (to 3hr for instance) to be closer to the temporal data distribution (mainly for VLBI) and apply linearity constraints afterwards if needed

First actions of the COL-WG

To intercompare results of different software packages

Defining benchmarks: the period chosen for establishing benchmarks is **from August 10 to August 30, 2008**. It includes the intensive **CONT08 VLBI period** (from 12 to 26/08/08). Combined SINEX will be delivered per week. They could be separated per technique.

Estimating parameters: the non reduced parameter set should include EOP (pole, UT1, nutation parameters per day and possibly drifts), station coordinates (per week), troposphere zenith delay ZTD (per hour). In order to reduce the size of SINEX files, troposphere parameters of non collocated GPS stations can be previously reduced.

Schedule:
2009: creation of the COL forum and discussion on a priori models and parameters
February 2010: first delivery of SINEX
June 2010: second delivery of SINEX
End 2010: need for result discussion and reiteration

Roadmap (re-ordered items)

1) **review 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) **insuring 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.