Combination of space geodesy techniques for monitoring the kinematics of the Earth

GRGS’ project

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Summary

1- Objectives and organisation

2- Individual results

3- Combination of observations

4- Combination of individual solutions
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Objectives and organization

♦ Objectives

to prove the efficiency of space technique combinations for computation
of Earth Orientation Parameters and Terrestrial Reference Frames

♦ techniques used: SLR, DORIS, GPS, VLBI, LLR

♦ parameters: polar motion (xp and yp), universal time UT1-UTC,
nutation corrections (every 6 hours) and station positions (every week)

♦ homogeneous computational framework

(same software used for all individual computations)

♦ computations made over one year (2002)

♦ two combinations: observations and individual solutions

♦ Organization

Computations based on GRGS’ experience and expertise

♦ with teams of OCA, CNES, LAREG, Noveltis, CLS and
Paris’ Observatory

♦ work started in 2000 with P. Yaya’s PhD (July 2002, 1st)
under direction of N. Capitaine, D. Gambis (Paris’ Obs.) and in
cooperation with CNES/OMP team (R. Biancale)
Combination of observations
Softwares GINS + DYNAMO

Measurements
Physical models
SLR / VLBI normal matrices
 Gins
GPS
DORIS
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Satellite Laser Ranging
OCA/GEMINI : P. Berio & D. Coulot

♣ Satellites LAGEOS-1 et -2 : 7-day orbital arcs
Hill’s empirical modelling for orbital errors on three components
(Radial, Along-track and Across-track)
Satellite Laser Ranging
LAGEOS-1

Impact with a particle

mean = 1.19 cm
rms in cm

mean = 1.00 cm
weighted rms in cm

mean = 1420
mean = 212
number of measurements used
number of eliminated measurements

Day Of Year 2002
Satellite Laser Ranging

**LAGEOS-2**

- **rms in cm**
  - Mean = 1.13 cm

- **weighted rms in cm**
  - Mean = 0.82 cm

- **number of measurements used**
  - Mean = 1269
  - Mean = 228

- **number of measurements eliminated**

Day Of Year 2002
GPS
CNES/OMP/Noveltis : S. Loyer

♀ 2-day orbital arcs
♀ Strategy

Solar Radiation Pressure : Bar-Sever 2003 for blocks II + 1 scale factor/day
+ Y-bias/day

Atmospheric drag neglected
Undifferenced iono-free observations

Station network
GPS
Average of orbit residuals and processed data per arc

Number of stations
Number of satellites

Total number of measurements
Number of eliminated measurements

Range residuals (36,3 cm +/- 0,5)

Phase residuals (5,7 mm +/- 0,6)

Day Of Year 2002
Session A: astronomical sessions

Session E: sessions dedicated to Earth's rotation

Paris Observatory: A.-M. Gontier & CNES/OMP: R. Biancal

Session F: sessions of Japanese network

Session U: intensive sessions for baseline Kooke-Wettzell
DORIS
CLS : L. Soudarin

♦ From Sun 06.01.2002 (GPS week 1148 day 0) to Sat 28.12.2002 (GPS week 1198 day 6)

♦ Arc length: 3.5 days starting on Sunday 0:00 or Wednesday 12:00 (between 1 and 3.5 days in case of orbit correction manoeuvres or data lacks)

♦ Satellites: SPOT2, SPOT4, TOPEX, SPOT5 (start 16.06.2002 = GPS week 1171 day 0) and ENVISAT (start 21.07.2002 = GPS week 1176 day 0)

♦ Reduced parameters: orbit, drag coefficients, solar pressure coefficients, tropospheric zenithal bias, frequency bias, Hill parameters

Station network
DORIS
Average of orbit residuals and processed data per arc

Topex: 106 arcs, residuals rms 0.44 mm/s
18763 measurements (752 rejected)

Envisat: 48 arcs, residuals rms 0.53 mm/s
11174 measurements (1754 rejected)

Spot5: 63 arcs, residuals rms 0.41 mm/s
20929 measurements (4926 rejected)

Spot4: 112 arcs, residuals rms 0.45 mm/s
14719 measurements (1018 rejected)

Spot2: 113 arcs, residuals rms 0.45 mm/s
14273 measurements (892 rejected)
Results for EOPs

Minimal constraints on station positions and continuity constraints on EOPs

$rms = 0.66\,\text{mas}$  $rms = 0.32\,\text{mas}$  $rms = 0.19\,\text{mas}$

$rms = 0.67\,\text{mas}$  $rms = 0.44\,\text{mas}$  $rms = 0.22\,\text{mas}$

CNES Julian Day
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Combination of observations
Softwares GINS + DYNAMO

Measurements

Physical models

Minimum constraints for TRF

Local ties for colocated stations

Constraints on EOPs

SLR / VLBI normal matrices

GINS

GPS

DORIS

DYNAMO/D

Solutions EOPs (6 hours)
TRF (7 days)

Weights for each technique (based on EOPs)

cumulated normal matrices
Combination of observations

Results for EOPs

Constraints of 0.2 mas

$rms = 0.25 \text{ mas}$

Constraints of 0.02 mas

$rms = 0.12 \text{ mas}$

$rms = 0.26 \text{ mas}$

$rms = 0.15 \text{ mas}$

CNES Julian Day
Combination of observations
Results for colocated station positions

Hartebeesthoek

Graph showing time series data with error bars for different stations and methods.
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Combination of individual solutions

Softwares GINS + DYNAMO + CATREF

GINS

SLR normal matrices

Loose constraints

DYNAMO

GPS

DORIS

Solutions for each technique

PROJECTED SINEX files for SLR, GPS & DORIS

CATREF

SLR datum

GPS datum

DORIS datum

Minimum constraints

Combined SINEX EOPs (1 day)
Station mean position and velocity for SLR, GPS & DORIS

GENSINEX

SLR weekly SINEX

GPS weekly SINEX

DORIS weekly SINEX

Removal of loose constraints

Minimum constraints
Combination of individual solutions
Datum, translations and scale for individual solutions

![Map of GPS stations around the world with data graphs showing TX, TZ, TY, and Scale in millimeters from 2002 to 2003.]
Comparison of the two combinations

weights: GPS: 4-6 / SLR: 1-2 / DORIS: 0.8-1

weights: GPS: 6.1 / SLR: 6.2 / DORIS: 3.6