High and Low POD Using GPS at CNES/GRGS

S. Loyer*, F. Perosanz, S. Bruinsma, F. Mercier
* Noveltis, Ramonville, France
CNES, Toulouse, France

10 Years IGS – Wokshop and Symposium *March 1-5, 2004, Berne, Switzerland*

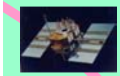
Introduction

- *The CNES/GRGS team has been developing the GINS POD software for more than 30 years*
- *GINS has the capability to compute the orbit of any kind of satellite, including constellations, around the Earth or any other central body in the solar system, using any tracking system (Doppler, Range, Phase, SLR, optical…)*
- *The main contributions to geoscience are the determination of gravity field models of the Earth (in cooperation with GFZ), of Venus and Mars , the estimation of horizontal and vertical global plate motion, geocentre motion, ocean tide models, the determination of thermosphere density models, the participation to IERS*
- *Using GNSS to track LEOs guarantees a dense, continuous and precise observation of the trajectory. This technique is adopted by the actual and future geodetic satellites like CHAMP (2000), GRACE(2002), GOCE(2006)*
- *CNES is involved in a specific effort to develop its capabilities to process GPS and future Galileo observations*

GPS data processing strategy

- *We currently process GPS from a network of around 70 IGS stations. An automatic two steps pre-processing procedure translates the Rinex files into an internal format, detects outliers, cycle slips, and forms « iono-free » linear combinations.*
- *An additional step can generate double differenced observations including or not LEO GPS receivers.*
- *The models and parameterization for GPS, CHAMP and Jason satellites are summarized in table 1*

	GPS Constellation	CHAMP	JASON
Gravity field	Earth (12x12) + sun+moon+planets	Earth (120x120) + sun+moon+planets + solid, oceanic and atmospheric tides	Earth (120x120) + sun+moon+planets
Solar Radiation Pressure	Bar-Sever 2003 for blocks II + 1 scale factor/day + Y-bias/day	Measured by the accelerometer (1 bias and 1 scale / sat. Revolution)	Box and wing s/c model Direct flux + Albedo + IR (one per day empirical 1/rev terms on Tangential and normal directions + one normal bias per day)
Atmospheric drag	Neglected	Measured by the accelerometer (1 bias and 1 scale / sat. Revolution)	DTM Box and wing sat model + 4 adjusted drag factors per day
Reference frame	ITRF2000 positions and velocities + EOPC04 + IERS predictions for Earth orientation	ITRF2000 positions and velocities + EOPC04 + IERS predictions for Earth orientation	ITRF2000 positions and velocities + EOPC04 + IERS predictions for Earth orientation
strategy	Undifferenced iono-free observations. Data sampling: 600 seconds	GPS orbits and clocks fixed Data sampling : 30 seconds	GPS orbits and clocks fixed Data sampling : 30 seconds



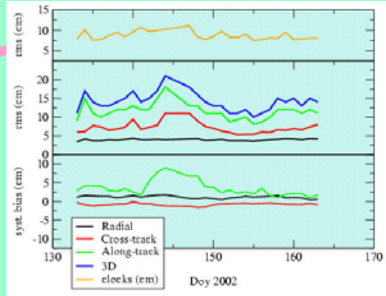


Figure 1 : GPS constellation differences with IGS precise products. Systematic biases (below), RMS (middle) and clock differences (top) in cm for one typical month in 2002.

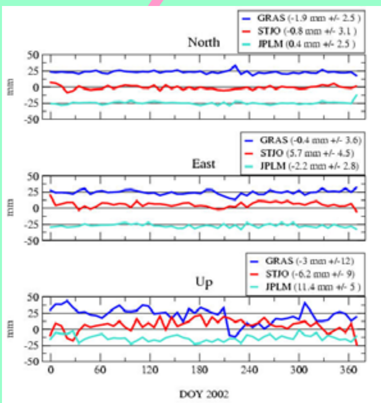


Figure 2 : station coordinate comparison to ITRF2002 for 3 typical IGS sites.
(+/-25 mm have been added to the series for better reading).
Global differences for the complete network (not shown) are around 3-4 mm in North and East directions and 9 mm in the vertical direction.

« High satellites » processing results

We processed one full year of GPS data (civilian year 2002) in order to evaluate our capabilities to recover « IGS like » products.

- ***GPS satellite orbits and clocks :***
  The constellation ephemerides and clocks comparisons to IGS precise products are presented in figure 1 in terms of systematic biases and RMS.
- ***Station coordinate solutions :***
  Figure 3 presents the daily estimates of the station coordinates for 3 typical IGS sites (GRAS,STJO and JPLM) on a 7 days time span
- ***Polar motion** :*
  1/day and 4/day pole coordinates solutions are compared to EOPC04 combined series in figure 4.
- ***SLR residuals on GPS satellites SV35 and SV36***
  are presented on figure 2 for three months in 2002. The RMS of SLR residuals are in good agreement with radial RMS differences with IGS orbits (3 centimetres)

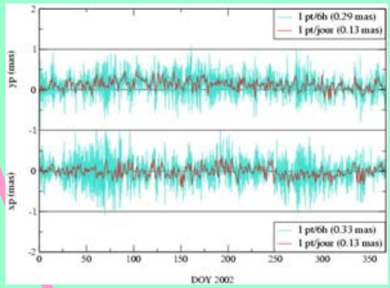


Figure 3: 1/day and 4/day estimates of polar coordinates compared to the combined serie EOPC04 (bottom xp , and top : yp).

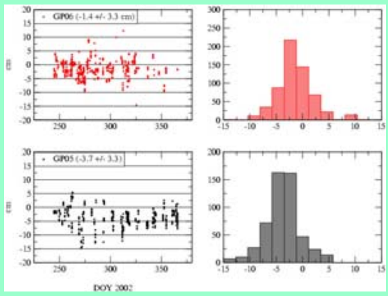


Figure 4: SLR residuals on GPS SV35 (PRN 05) and SV36 (PRN 06) for three months in 2002. Temporal residuals (left) exhibit systematic centimeter level biases clearly visible on the histograms (right).

CHAMP POD results

- *CHAMP satellite orbits are computed on a regular basis since level-2 data are available (May 2001) for accelerometer calibration and earth gravity modelling*
- *Phase and laser residuals are plotted on figure 5 for more than 500 1day arcs (May 2001 to May 2003)*
- *IGS LEO test campaign : (20th to 30th of May 2001) :*
  SLR residuals = 3.97 cm r.m.s.

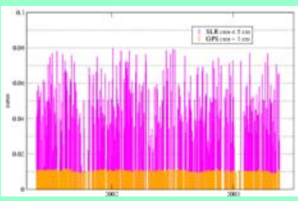
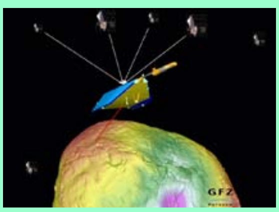


Figure 5: Zero difference GPS phase and SLR observation residuals from May 2001 to May 2003 (1 day arcs).



Jason POD results

- *Jason orbits have been computed on the IGS-LEO 31 days campaign (1st to 30th of June 2002)*
  SLR Residuals = 1.71 cm r.m.s. (DORIS solution)
  SLR Residuals = 2.26 cm r.m.s. (GPS solution)

Conclusions

CNES/GRGS has the capability to produce on a routine basis :

- *GPS satellite orbits and clocks (4 cm Radial, 11 cm 3D RMS vs. IGS)*
- *SLR residuals on SV35 and 36*
- *Global station network coordinates (3 mm 2D, 9 mm vertical)*
- *EOP (0.13 mas 1/day, 0.29 mas 4/day)*
- *LEO orbits (SLR residuals 3D ~ 4 cm CHAMP, ~ 2 cm JASON) using GPS, DORIS and SLR SST.*

CNES has the desire to play a significant role in the future of GNSS. The results presented here demonstrate that a first goal has been reached