# GRGS-CLS GNSS Precise Orbit Determination


S. LOYER [(1)], F. PEROSANZ [(2)], H. CAPDEVILLE[(1)]

(1) CLS, Collecte Localisation Satellites, 8-10 rue Hermès, 31526, Ramonville Saint Agne, France
(2) CNES Centre National d'Etudes Spatiales, 18 av Edouard Belin, Toulouse, France
(Contact e-mail: sloyer@cls.fr; felix.perosanz@cnes.fr; hcapdeville@cls.fr.)


## INTRODUCTION

GRGS and CLS teams process regularly GPS data from a worldwide network of IGS permanent stations. We compute precise GPS orbits together with Earth rotation parameters and stations coordinates at the sub centimeter level. Our solutions have been submitted since January 2004 to the International Earth Rotation Service in the framework of the Combination Research Center experiment.

Here we present the method used as well as the evaluation of the derived products in comparison to IGS. Our capability to compute IGS-like precise products at the required level of precision and delay is demonstrated. GLONASS and Galileo data will also be processed in the future for precise geodetic applications.

## Measurements Models

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| **Data Preprocessing:** Preprocessing of the GPS data at the undifferenced and single-difference level to determine cycle slip remove outliers and eliminate short passes. |
| **Basic Observables:** Undifferenced ionosphere-free linear combination on carrier phase and code (for clocks determination) from IGS network (see Figure 1).<br>Elevation angle cutoff : 15 degrees ; Sampling rate: 10 minutes<br>Weighting: 3.5 mm for un-differenced ionosphere-free phase observations at zenith; elevation-dependent weighting function 1/cos(z)**2 |
| **Geometric model:** Ground antenna phase center : Absolut Elevation-dependent phase center corrections are applied according to the absolute model IGS05_1421.atx.<br>Satellite center of mass offsets and phase center calibration taken from IGS05_1421.atx |
| **Troposphere:** Met data input: ECMWF (6 hours maps).<br>Estimation: 1 zenith delay/2hour |
| **Ionosphere:** Not modeled (first-order effect eliminated by forming the ionosphere-free linear combination of L1 and L2). |
| **Site displacement:** ITRF2005 station velocities fixed.<br>Tidal displacement: Solid earth tidal displacement: complete model from IERS Conventions 2003<br>Pole tide : applied (IERS, 2003) nominal mean pole :m1=0.065;m2=0.330 arcsec.<br>Ocean loading: Amplitudes and phases by FES2004.<br>Atmospheric loading: Applied using ECMWF 6 hour pressure fields. |
| **Relativity corrections:** Periodic, -2(R*V/c): applied; Dynamical: applied (IERS, 1996, Ch.11, Eq.1). |

## Dynamical Models

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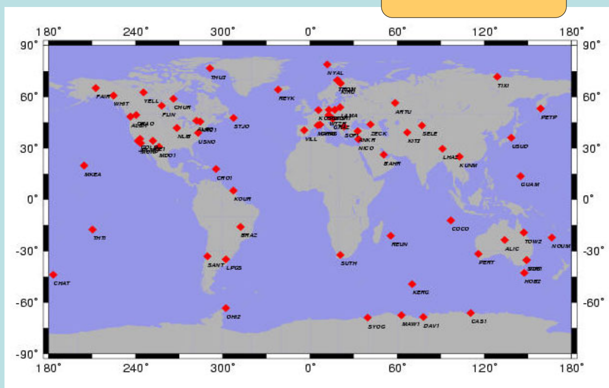
|---|
| **Geopotential:** EIGEN_GL04S_annuel model up to degree and order 12(+C21+S21);GM = 398600.4415 $km^3/sec^2$; AE = 6378.13646 km |
| **Third-body:** Sun, Moon and major planets as point masses (Ephemeris: JPL DE405; $GM_{sun}$=132712440018 $km^3/sec^2$ · $GM_{moon}$=4902.7991 $km^3/sec^2$) |
| **Solar radiation pressure:** Direct solar pressure + albedo |
| **Tidal forces:** Solid earth tides: frequency independent (Love's number $K_2$=0.3)<br>Ocean tides: FES2004 up to degre and order 12. |
| **Relativity:** Applied (IERS 1996, Chapter 11, Eqn.1) |
| **Numerical Integration**: Cowell order 8 with 10 minutes for integration step ; Arc length: 48 hours ( Current Day – 1, 12H at Current Day +1,12H ) used to compute one day overlaps. |

Figure 1



The 68 stations used today in our processing. Future plans is to increase the number of stations of the network in the operationnal processing and to add Glonass receiver. Numerous stations are collacations with other systems (DORIS/LASER and VLBI)

## PERSPECTIVE

Signals from different GNSS will be available in a near future : GLONASS is being revitalized ; Galileo and COMPASS are launching their first satellites.

Many applications will benefit from a combined use of different GNSS and it is clear that future geodetic receivers will be Hybrid multi-GNSS systems.

In this framework, the GRGS-CLS team is being implementing into the GINS software, multi-GNSS processing capabilities in order to soon be able to :

- Combine GPS and GIOVE signals in order to evaluate the Galileo POD process and to contribute to the Galileo system evaluation : signal quality, on-board clock stability,…
- compute precise GLONASS products from the full IGS network of GPS/GLONASS receivers
- Join the IGS Global Analysis Center Team delivering successively GPS, GLONASS and Galileo geodetic products


**References on GIOVE-A:**
-S. Melachroinos, F Deleflie, F. Perosanz, O. Laurain, R. Biancale, P. Exertier, GIOVE -A and GPS-35/36 satellite orbits: analysis of dynamical properties on SLR-only tracking data, 15th International Laser Ranging Workshop, 16 October 2006, Canberra, Australia
-Mercier F., Laurichesse D., Delporte J., Perosanz F., Boulanger C., First GIOVE-A orbit determination at CNES, EGU General Assembly 2007, Vienne, Autriche, 15-20 avril 2007.


## RESULTS/QUALITY

| Product | Quality |
|---|---|
| Orbit | 25-40 mm 3DWRMS |
| Weekly Stations Coordinates | 3 mm horizontal<br>< 1 cm vertical |
| Diurnal Pole Coordinates | 10-20 microas |

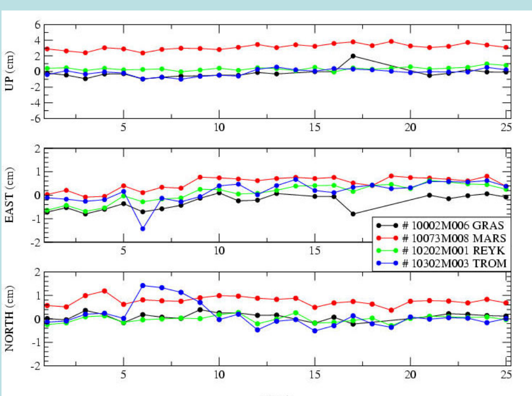




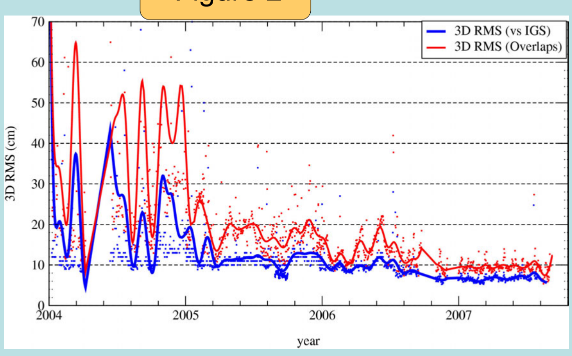
Figure 3

Examples of temporal series of stations coordinates (residuals to a priori models/ 1pt per week).

**Adjusted Parameters**

**Stations coordinates (1 set/week)**
**Polar coordinates (1 set/day)**
**Troposphere (1ZTD/2hour/station)**
**Clocks (1 per sat./sta. per epoch)**
**Ambiguity (1 per pass)**
**Dynamical parameters:**
**-6 initial state vector per sat.**
**-1 set of empirical acceleration per sat.**
**(1 scale of solar pressure force, 1 Y-bias, Periodic terms in the orthogonal plane).**

Figure 2





3D (**unweigthed** RMS) overlaps and comparisons to IGS final orbits since 2002. Todays orbits are sent within 10 days to the IGS analysis coordinator.