GR2 Reprocessing from CNES/CLS IGS Analysis Center: specificities and results

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Introduction

We present in this contribution the main aspects of the reprocessing efforts done at the CNES/CLS Analysis Center. We processed 15 years of GPS and 5 years of GLONASS data on a daily basis with a network of up to 230 stations. In these solutions we gave a particular attention to the standards and we followed the IGS REPRO2 recommendations. An ambition concerns the use of a time variable gravity field. We show the statistical results of our GR2 processing such as ambiguities fixing success rate, orbit residuals, orbit comparisons and one example of station position time series. We focus on the main specificities of our processing and its implementation (zero difference ambiguity resolution). The main events or discontinuities in the solutions results are discussed.

GR2 Reprocessing Results & Products

We present here some results of GR2 processing results. First, the GR2 ambiguity fixing success rate. After, we give some results as orbit carrier, orbit residual and orbit comparison to GPS which reflect the quality and the homogeneity of the results. These results are presented on the following plots.

Station network / Data / Satellites used

The complete network represent up to 275 stations distributed all around the globe.

The GNSS network is a compromise between processing capabilities and data availabilities.

We made a choice by considering the longest time series, the collocated sites, and in the last period the hybrid GPS/GLONASS receivers.

We processed 15 years of GPS data (GPS and GLONASS after mi-2008) from the IGS (International GNSS Service) tracking network.

The different satellites or satellites families used in our processing represent between 23 to 55 GNSS satellites (depending on the period considered).

Standards, Models And Processing Strategy

We do process daily solutions for GNSS. We use the unfiltered ambiguities after May 2000 (the details of the method is described in Loyer et al., 2012). We present in the following table the standards and models used for our ITRF2013 processing (in red the main changes).

<table>
<thead>
<tr>
<th>Software</th>
<th>GRGS/GYNOAD</th>
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<tbody>
<tr>
<td>Reference System</td>
<td>Earth reference system &amp; station coordinates from IGS/GNSS Coordinate reference system from IGS2000: Polar motion &amp; U7I from ERS C04-05; Processed solution from ERS 2010 using MRO orbits. Solid Earth tide displacement and solid pole tide displacement from IERS Conventions; Ocean loading from FES-2002. Total atmospheric loading from 51/52 Pay &amp; Ponte (2003); No non-tidal atmospheric loading is used.</td>
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| Displacement of reference points | Gravity field time varying: EIGEN-6S2 up to degree 95 in radial time variable terms up to degree 96 in a 2002 to 2012, periodic 16.1, 1.5 ppm. Solid Earth tide and Earth pole tide from ERS 2010 conventions; Ocean tides up to degree 50; O5 for GLONASS from FES 2002 (3 principal waves, + 41 harmonics wave). Atmospheric gravity up to degree 12 (the gravity from ECMWF, non-tidal ocean gravity up to degree 1000). Atmosphere tides are computed through the ECMWF atmospheric O5. Ocean tide forcing up to degree 12; Ocean forcing from ECMWF, Earth tide forcing from JPL/USGS, and atmospheric tide forcing from ECMWF, NNSS, GRGS, U.S. and French reanalysis (DE421-LP).
| Troposphere | Tropospheric corrections from B-cp/IGGS/F. Mercier: One earth day being part for the GNSS wet troposphere scale factor adjusted; one day tropospheric gradient per station in north and east direction; one day tropospheric gradient per station in north and east direction.
| Relativity | Schwarcz model + Laser Thinning + geodetic precision.
| Satellite Attitude laws | Kravdal’s model according to IGS recommendations.
| Block-specific satellite thrusting due to ion drag transport model | GPS: applied (IGS-REPRO standards).
| Radiation Pressure model | GOES-13: none.
| Earth radiation | Bond/Kling (method used for solar panels scaled by an adjusted scale factor).
| Additional empirical acceleration terms | Estimated (first-order) time dependent: 1) Solid Earth tide (3 directions); Periodic terms in X-Direction and O-Direction; 2) Set of stochastic pulses per epoch.
| For GPS/Black (not representative for Earth tide in the time domain) to provide consistency with ICD.
| Estimated measurement parameters | Unfiltered least-squares observations (+ upper error component contribution) computed using IGS/CCDC code with ambiguous fixed where possible; several series can be viewed and compared on the same graph. Additional data can also be displayed such as station or network event (e.g. orbiting spacecraft / IGS website). The global map visualises the networks of the DORIS, GPS, SLR, VUB sites analyzed by the GRGS Analysis Centers. It also helps in easily selecting sites data for the time series plots tools, and getting access to site information.

*2012 modified version of GRAU satellites (upgraded) in red blue and weighted in blue. The color discontinuity in the plots reflect evidences between events. Processing changes for the number and type of satellites used. There are two main events, the beginning of ambiguity after 2003 which allows to reduce the number of ambiguities. The second event is the usfication of O5 for GLONASS, this is well seen in the graph. GLONASS ambiguity fixing success rate.

GR2 ambiguities fixing success rate.

Number of GPS satellites and receivers used in our contribution to ITRF2013 processing.

The maximum number of satellites is 21 for GPS and 24 for GLONASS. The maximum number of receivers is 118 (at the beginning of the period) and the maximum number is 235. We can see also the number of satellite removed in the processing. On the right graph the satellite number by block is given.

Station position time series for a collocated site

GRGS is implementing on its web site (http://www.grgslab.fr) a new tool to browse station coordinates time series provided by the GRGS Analysis Centers. The objective is to list and display in real-time position time series of DORIS, GPS, SLR and VUB sites. The tools provided by the web service are:

- a network viewer called MapSHP (see http://www.grgslab.fr) to display time series.
- a plot tool based on the Highcharts/Highglobe libraries (see http://www.highcharts.com) to display time series.

They have been first developed by CLS on behalf of CNES for the International DORIS Service (IDS) (http://www.idsp.org) and the JPL DORIS coordinating center and then adapted by CNES for the Earth Orientation Service (EOS) (http://www.eosweb.larc.nasa.gov). The tools provide a new way for users to select data; to browse displayed time series, add data; changing plot dimensions, and to display a map with the space curves. It is equipped with specific time series; for example, the orbit residuals in a given week, year, month, or day. The main advantage is to allow the users to display a large number of time series simultaneously in the web site.

Example of the obtained station position time series over time. We can see for the collocated station DORIS/GPS at Thule on the west coast of Greenland (distance between the two sites is of the order of 1km). On the second time series, there is an impressive vertical motion related to the melting of the adjacent ice shield.