Paris Observatory Analysis Center (OPAR): Report on Activities, January - December 2012

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Abstract

We report on activities of the Paris Observatory VLBI Analysis Center (OPAR) for calendar year 2012 concerning the development of operational tasks, the development of our Web site, and various other activities: monitoring of the Earth's free core nutation, measuring of the post-seismic displacements of some stations, and the analysis of the recent IVS R&D sessions, including observations of quasars close to the Sun.

1. Operational Solutions for Diurnal and Intensive Sessions

A reanalysis of the complete diurnal session database was done (identified as opa2012a), and resulting EOP series and radio source catalogs were sent to the IVS. This solution estimated EOP and rates as session parameters, station coordinates and velocities as global parameters, and most of the sources' coordinates as global parameters. Troposphere and clock parameters were estimated every 20 minutes and 60 minutes, respectively, and gradients were estimated every six hours (at all sites). Axis offsets were estimated as global parameters for a list of 80 stations. We used up-to-date geophysical and astronomical modeling to compute the theoretical delay and partials, including the IAU 2006 nutation and precession, the Vienna mapping functions 1, the FES 2004 ocean loading model, and the antenna thermal deformations as provided by A. Nothnagel (2009, J. Geod., 83, 787). Since the solution was released after the March 11, 2011 earthquake that occured in Japan, the displacement of the 32-m antenna at Tsukuba was modeled by splines, as was done earlier for Fairbanks and the TIGO antenna at Concepción. Constraints were applied to the 295 ICRF2 defining sources (no-net rotation) and to 24 stations (no-net rotation and no-net translation of positions and velocities). We used the latest version of the Calc/Solve geodetic VLBI analysis software package. More details can be found at

http://ivsopar.obspm.fr/earth/glo

Diurnal sessions were analyzed routinely within 24 hours after their version 4 databases were submitted to the IVS. The operational solution was aligned to the opa2012a global solution. Unconstrained normal equations relevant to EOP, rates, and station and source coordinates were sent to the IVS in SINEX format for combination in the framework of the IVS analysis coordinator's task.

An operational solution analyzing Intensive sessions after 2006, started in 2011, was also continued (opa2011i) together with corresponding SINEX files. The solution opa2011i processed Intensive sessions in order to produce UT1 consistent with VTRF 2008A, ICRF2, and the IERS EOP 08 C 04 Earth orientation data.

All the above products, except SINEX files, were also published on the OPAR Web site. The SINEX files were only sent to the data centers.

2. Other Products and Improvements of the Web Site

Station and radio source coordinate time series were also updated. For each source, a page displays the time series and provides links to source information at various external databases (e.g., the French Virtual Observatory software package Aladin that provides the optical counterpart of the VLBI quasars, or the Bordeaux VLBI Image Database that gives the VLBI structure). In late 2012, we used Google's application programming interface (API) to insert Google Earth and Google Sky views in our Web pages to display telescopes and radio sources on Earth and sky maps. These features are available in the sections 'Radio Sources' and 'Stations' of the OPAR Web site.

We used also the *dygraphs* JavaScript visualization library to plot recent EOP data and TIGO and Tsukuba coordinates. This interface offers interactive, zoomable charts of the time series, so that the user can easily manipulate, explore, and interpret them.

3. Follow-up of Various Phenomena

3.1. Assessment of R&D Sessions Including Observations Close to the Sun

In late 2011, the IVS decided to re-observe quasars at low angular distances to the Sun, typically lower than 15° (whereas this lower limit has been imposed on all schedules since 2002). These observations were scheduled during R&D experiments, at a rate of about 5 to 10 sources out of a total of a hundred sources observed in the session, in order to check that they do not degrade the other VLBI products.

In dedicated pages on the OPAR Web site, the R&D experiments are analyzed with a standard parameterization as used for the operational analysis. The Calc/Solve analysis software package is used in independent mode. All Earth orientation parameters (EOP) and rates are estimated as session parameters together with station and source coordinates. To avoid degeneracy of the solution of the system of equations, no-net rotation and no-net translation conditions are applied to the station coordinates (with respect to VTRF 2008A), excluding TIGO at Concepción and the Japanese stations within the Tokyo area because of the strong 2010 and 2011 earthquakes. For similar reasons, a loose no-net rotation condition ($\sigma = 2$ mas) is applied to the source coordinates with respect to ICRF2, excluding the 39 sources which needed special handling in the ICRF2 work. Troposphere parameters are estimated every 20 minutes and gradients every six hours. Clock parameters are estimated every 30 minutes. The post-Newtonian parameter γ is fixed to unity. The results of the analysis of nine R&D sessions (November 2011 to September 2012) can be seen at

http://ivsopar.obspm.fr/rd

This analysis work will be continued for all upcoming R&D sessions that observe sources close to the Sun.

3.2. Free Core Nutation

The free core nutation (FCN) is a free oscillation of the Earth's figure axis in space due to the presence of a liquid core rotation inside the viscoelastic mantle. Its period is close to 430 days and is retrograde. Understanding the excitation of the FCN and its amplitude and phase variations is still an open question, although the community generally believes that the key resides in improved

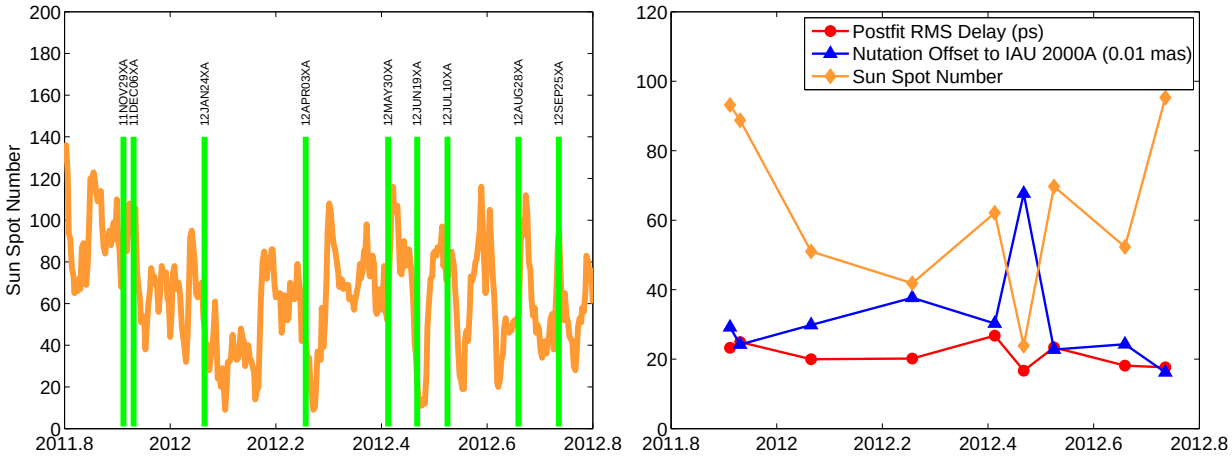

Figure 1. Left: the Sun Spot Number as given by the Solar Influence Data Center (SIDC) at Royal Observatory of Belgium, and the IVS R&D experiments. Right: the postfit RMS delay and nutation offsets to IAU 2000A estimated from the R&D sessions, along with the Sun Spot Number.

atmospheric and oceanic circulation modeling at diurnal and subdiurnal frequencies. At OPAR, we maintain a FCN model directly fitted to routinely estimated nutation offsets (Figure 2).

In addition to the FCN, amplitudes and phases of a set of 42 prograde and retrograde tidal waves are also fitted to the data. These tidal terms are interpreted as small deficiencies of the IAU 2000A nutation model. More explanations and material can be found at

http://ivsopar.obspm.fr/nutation

3.3. Huge Post-seismic Displacements

Still using the routinely analyzed diurnal sessions, we monitored the displacements of the station of TIGO at Concepción after the 27 February 2010 earthquake and of the radio telescope at Tsukuba after the 11 March 2011 earthquake. Figure 3 displays the East coordinates of the two sites with respect to the mean position as given in the VTRF 2008A. The monitoring is continued at

http://ivsopar.obspm.fr/eq

4. Staff Members

Staff members who contributed to the OPAR analysis and data centers in 2012 are listed below:

- Sébastien Lambert, Analysis Center manager, responsible for data analysis, development of GLORIA analysis software,
- Christophe Barache, Data Center manager, data analysis,
- Daniel Gambis, responsible for the IERS Earth Orientation Center, interface with IERS activities.

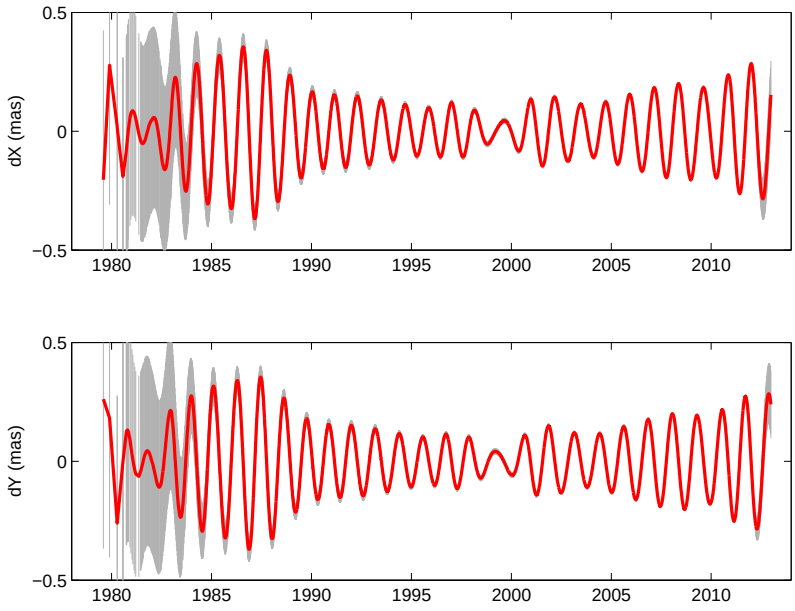

Figure 2. The free core nutation fitted to opa2012a nutation offset time series with respect to the IAU 2000A nutation and IAU 2006 precession models.

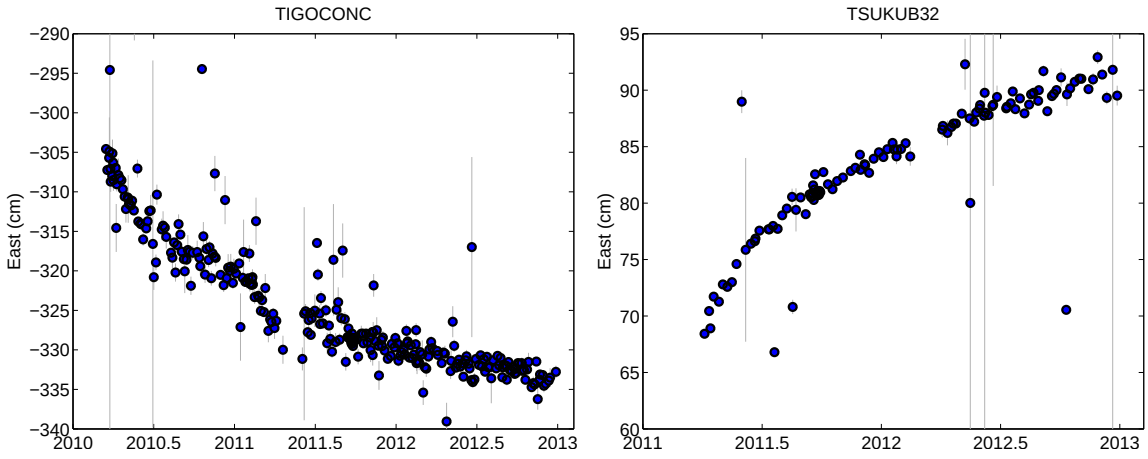

Figure 3. The East coordinates of the TIGOCONC and TSUKUB32 antennas with respect to the VTRF 2008A solution.