Paris Observatory Analysis Center OPAR: Report on Activities, January - December 2007

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Abstract

This report summarizes the activities of the VLBI Analysis Center at the Paris Observatory (OPAR) for calendar year 2007. Quarterly solutions were processed to estimate EOP per session and global terrestrial and celestial reference frames. Additionally, the analysis center organized the operational analysis of weekly IVS-R1 and IVS-R4 sessions for regular submission to the IVS (scheduled to start early 2008). Other activities of the OPAR personnel related to VLBI include two main research topics: (i) the realization of a stable celestial reference frame (in the frame of the IVS/IERS Working Group on the "Second Realization of the ICRF"), and (ii) the analysis of VLBI-derived nutation time series to retrieve deep Earth's interior parameters.

1. Operational Analysis Status

In 2007, the quarterly solutions for Earth's orientation parameter, station coordinates and velocities and radio source coordinates have been submitted regularly to IVS and IERS EOP-PC. For those solutions, all station and source coordinates are estimated as global parameters except for poorly observed sources which are treated as arc parameters. The main difference with other analysis centers' analysis strategies is that we chose to define the orientation of the celestial frame by a no-net-rotation with respect to the ICRF-Ext.2 tie to the [1] (further referred to as MFV) 247 stable sources. The last 2007 solution (2007d, see Figure 1) processed 3,643,608 delays and delay rates in 3,272 sessions. The global postfit rms delay nears 24 ps.

Operational analysis for the production of daily SINEX files has been set up and tested at the end of the year, in order to participate in the IVS SINEX combination. The regular submission of SINEX files to the IVS analysis coordinator's office will begin in early 2008.

The OPAR Web site (http://ivsopar.obspm.fr/) is regularly updated to provide information and data on the latest processings. In addition, we provide some OPAR products in VOTable format as defined by the International Virtual Observatory Alliance (IVOA) on the VO-Corner section of our Web site.

2. Celestial Reference Frame Issues

The production and analysis of time series of radiocenter positions was continued and updated quarterly in 2007. The times series are available at the IVS data center and the OPAR Web site (we provide ASCII data files and plots).

In the framework of ICRF2 elaboration, we investigated the time series in terms of time stability. Our future aim is to derive the best subset of stable radio sources suitable for defining the axes of the next ICRF. In a study presented at the Journées Systèmes de Référence Spatio-Temporels, in Paris [3], we analyzed the position time series of 521 sources observed in more than 10 sessions between 1984.0 and 2007.5 (see Figure 2). It appeared that time series are so noisy or sparse that the only meaningful quantities that can be extracted from the analysis are the weighted rms and a medium-term irregular pattern (through, e.g., a weighted moving average) for each series. We applied a very simple selection scheme only playing with the rms and the slope. The selection

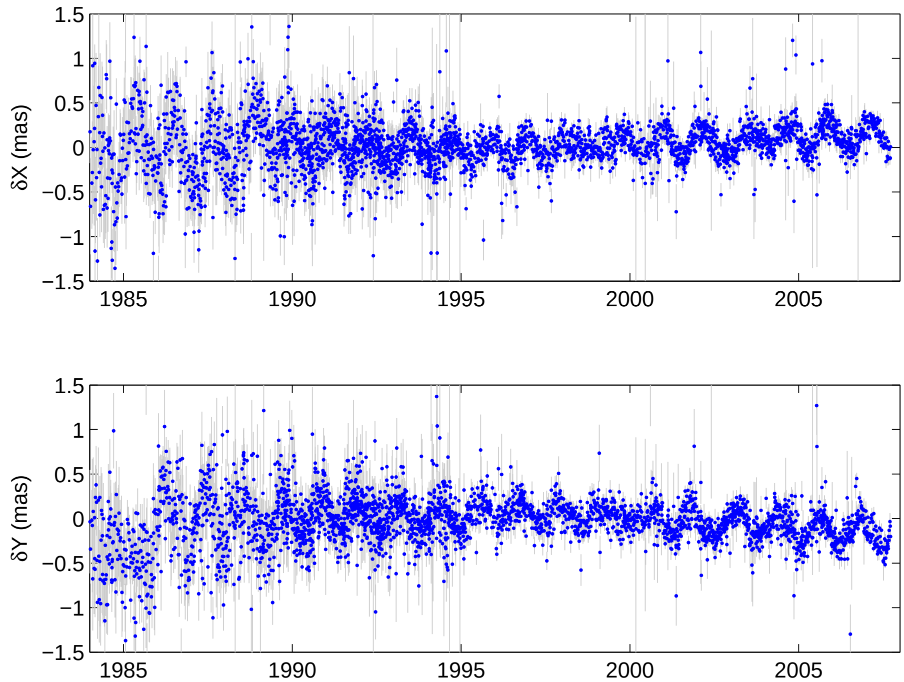

Figure 1. Celestial pole offsets from quarterly solution opa2007d.

parameters have been tuned so that the number of elected sources reaches ∼200. Our subset finally contains 197 sources, of which 32% are part of the 212 ICRF defining sources [6] and 68% are part of the 247 MFV stable sources. The axis stability of the reference frame defined by the above-selected sources was then assessed using a four parameter transformation (3 rotation angles and the tilt parameter dz) between a semi-annual reference frame (defined by the semi-annual coordinates of the selected radio sources) and the reference catalogue ICRF-Ext.2 [2]. It appears that our selection of sources leads to a significantly better stability for the reference frame. It is obvious that this selection must be supplemented by other selections done through other criteria (e.g., refined algorithms, source compactness), particularly since our selection yields a poor number of sources in the southern hemisphere.

3. Geophysics Issues

Since VLBI is a major and powerful technique revealing the deep Earth's interior (along with seismology and gravimetry), one must ask oneself whether the discussions and achievements about the new ICRF can lead to an improvement of the VLBI data in a geophysical sense. Remember that geophysical parameters in the IAU-adopted [7] (referred to as MHB) nutation theory have been adjusted on VLBI nutation time series. If MHB is powerful, it is obviously because of the MHB theoretical framework, but also because of a considerable improvement of VLBI data during the last decade of the XXth century. But, although this theory is very satisfying, challenging questions still remain, like, e.g., the direct observability of the diurnal wobble associated with the free inner core nutation, or, at least, a better determination of its resonant period. Answers to

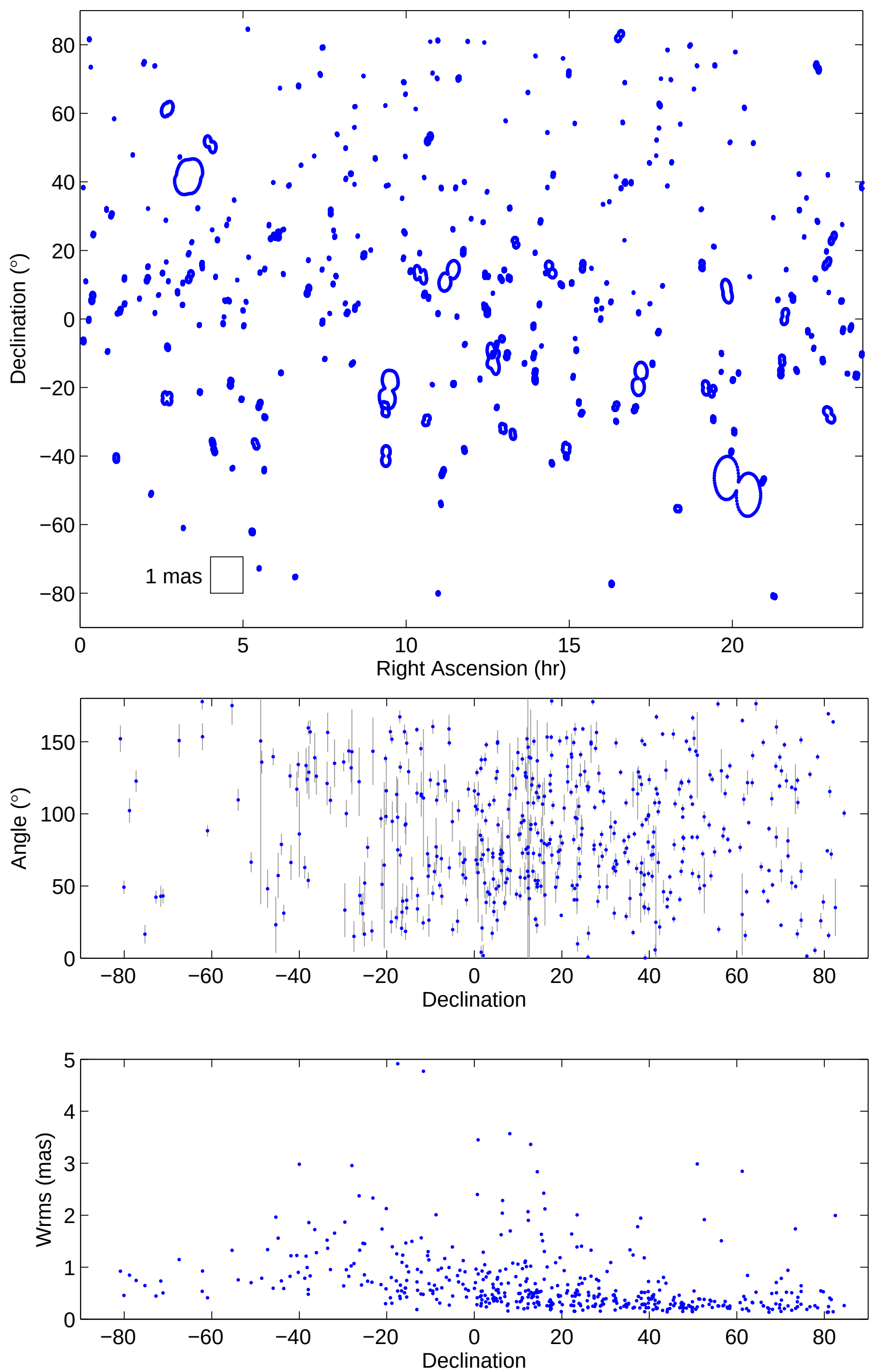

Figure 2. Top: Envelopes of variability (defined as the rms in a given direction) of the 521 radio sources investigated in this study. Middle: Dependence of the angle of maximal variability on the declination. Bottom: Dependence of the rms on the declination.

these questions are currently partly hidden in the noisy nutation residuals and we have either to dig out meaningful information from the noise, or to remove the noise by a wise analysis of VLBI observations at the analysis center level. In the context of the on-going effort to improve the theoretical modeling of the nutation (see, e.g., the recent computation of the torque on the tidally redistributed matter by [4], that was partly omitted in the MHB theory), identifying the various sources of errors in the estimates appears very worthwhile.

Obtaining nutation from VLBI analysis needs to handle correctly the celestial reference frame so that radio source positional instabilities may not unduly perturb the nutation estimates. In a study recently accepted for publication in Astronomy & Astrophysics [5], we tried to estimate the magnitude of these perturbations and to determine their impact on the resonant frequencies associated with the Earth's fluid outer and inner cores. We achieved this playing with the constraints that are applied to the radio source positions during a global analysis. We showed that an additional error of $\sim$15 μas in the estimates of the 18.6 year nutation spectral component and decreasing for shorter periods can be produced by the instabilities in the celestial frame. This leads to an uncertainty of few tenths of day on the fluid outer core resonant period and of 200 on its quality factor, and an uncertainty of less than 100 days on the inner core resonant period and 100 on its quality factor.

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