3.5 Product Centres
3.5.1 Earth Orientation Centre

This section presents activities and main results concerning the Earth Orientation Centre located in Paris Observatory over 2005. General presentation of the IERS Earth Orientation Parameters (EOP), operational activities and yearly analyses are presented at the web site (<http://hpiers.obspm.fr/eop-pc>). According to the IERS Terms of Reference, the Earth Orientation Centre is responsible for monitoring Earth orientation parameters including long term consistency, publications for time dissemination and leap second announcements. The Earth Orientation is making available different products to a broad community of users: long-term and operational series of Polar motion, Universal Time (UT1), Length of Day (LOD) and Celestial pole offsets.

Determination of EOP is in the form of combined solutions derived by the analysis centres of the different techniques. Various solutions are computed: long-term solution (IERS C01), normal values at five-day intervals (IERS C02) and the operational smoothed solution Bulletin B at one-day intervals published monthly and providing EOP with a delay of 30 days with respect to the date of publication. Bulletin B is updated in an operational mode in the IERS C04 which is computed twice weekly. After the presentation of the new interactive tools implemented on our web site, we will present the different combined EOP solutions available.

WEB interactive tools: real time atmospheric excitation

We continued the development of interactive tools, mostly written in PHP language and devoted to the EOP time series analyses.

The principal novelty concerns the tool devoted to the comparison of the observed excitation in polar motion and LOD to atmospheric excitation. The procedure has been extended to the operational Atmospheric Angular Momentum function determined on a daily basis by the NCEP (National Centers for Environmental Prediction, USA). This allows the comparison with the up-to-date excitation derived from EOP.

Combined daily series: Bulletin B and EOP(IERS) C 04

As reported the last year, the algorithm and Fortran numerical code for the C04 series computation have been significantly improved. The new C04 solution is available on the WEB/FTP server (experimental solution). It should become the operational reference solution.

Predictions

Our service is participating in the EOP Prediction Campaign organized by Harald Schuh (TU Wien), by sending every week since October 2005 two predictions, one computed by D. Gambis, the other one computed by C. Bizouard.

Table 1: Estimated accuracies of individual and combined solutions entering the combined solutions in 2005.

Individual solutions		Estimated uncertainties				
		Time	Terrestrial Pole 0.001"	UT1 0.0001s	LOD 0.0001s	Celestial Pole 0.001"
VLBI – 24 h						
EOP (AUS)	1 R 1	3–4d	0.17	0.08		0.11
EOP (BKG)	3 R 4	1–4d	0.17	0.09		0.12
EOP (GSFC)	4 R 2	1–4d	0.14	0.07		0.10
EOP (IAA)	5 R 2	1–4d	0.14	0.09		0.10
EOP (MAO)	3 R 1	1–4d	0.19	0.10		0.13
EOP (SPBU)	3 R 3	3–4d	0.14	0.08		0.11
EOP (USNO)	6 R 1	1–4d	0.16	0.10		0.10
VLBI – Intensive						
EOP (BKG)	3 R 2	1–3 d		0.20		
EOP (GSFC)	4 R 1	1–3 d		0.22		
EOP (IAA)	5 R 1	1–3 d		0.15		
EOP (SPBU)	2 R 1	1–3 d		0.19		
EOP (USNO)	5 R 1	1–3 d		0.18		
SLR						
EOP (ASI)	3 L 2	1d	0.18		0.24	
EOP (IAA)	2 L 1	1d	0.15			
EOP (MCC)	97 L 1	1d	0.17		0.48	
EOP (OCA)	5 L 1	1d	0.19			
EOP (ILRS)	5 L 1	1d	0.16		0.40	
GPS						
EOP (CODE)	98 P 1	1d	0.03		0.19	
EOP (EMR)	96 P 3	1d	0.04		0.20	
EOP (ESOC)	96 P 1	1d	0.04		0.35	
EOP (GFZ)	96 P 2	1d	0.03		0.22	
EOP (IAA)	1 P 1	1d	0.13		0.33	
EOP (JPL)	96 P 3	1d	0.03		0.33	
EOP (NOAA)	96 P 1	1d	0.08		0.24	
EOP (IERS)*	95 P 1	1d	0.02	0.20	0.18	

** The satellite techniques provide information on the rate of change of Universal Time contaminated by effects due to unmodelled orbit node motion. VLBI-based results have been used to minimize drifts in UT estimates*

Long-term series: C 01 (1846–2006)

EOP(IERS) C 01 is a series of the Earth Orientation Parameters given at 0.1 year interval from 1846 to 1889 (polar motion only) and 0.05 year interval from 1890 until now (polar motion, celestial pole offsets, UT1–UTC since 1962). For many decades, the observations were made using mostly visual and photographic zenith telescopes. Since the advent of the space era in the 1960's, new geodetic techniques were used for geodynamics. Now, the global

Table 2: Uncertainty of the current solution and the estimated accuracies of the predictions for horizons of 5 days to 1 year for 2005.

Solutions		Terrestrial Pole mas	UT1 ms	Celestial Pole mas
Analysis daily	1-d	.08	.01	0.10
Prediction	1-d	.50	.20	0.10
	5-d	2	.60	0.10
	10d	6	1.5	0.10
	30d	12	2.	0.10
	90d	40	5.	0.10
	180d	20	8.	0.10
	1-yr	50	12.	0.10

Table 3: Mean and standard deviation of the differences between various combined techniques solutions and IERS C04 over 2005

EOP	IGS Comb – IERS C04		ILRS Comb – IERS C04		IVS Comb – IERS C04	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
X (μas)	–133	31	–50	246	–190	220
Y (μas)	296	38	255	251	176	112
UT1 (μs)	5	45			4	10
LOD (μs)	2	34	5	71		
Dψsinε (μas)					5	70
Dε (μas)					4	84

Table 4: Mean and standard deviation of the differences between various solutions and IERS C04 over 2005

EOP	Unit	BullA – IERS C04		Comb JPL – IERS C04	
		Mean	Standard deviation	Mean	Standard deviation
X	μas	–76	57	–159	37
Y	μas	120	41	38	28
UT1	μs	–106	18	–108	15

observing activity involves Very Long Baseline Radio Interferometry (VLBI), Lunar (LLR) and Satellite Laser Ranging (SLR), Global Positioning System (GPS) and more recently DORIS.

The C 01 series was recomputed in the course of 2003. It is a composite series based on following temporal solutions:

1846–1899: Fedorov *et al*. (1972) polar motion solution derived from three series of absolute declination programs (Pulkovo, Greenwich, Washington).

1900–1961: Vondrak *et al.* (1995) solution derived from optical astrometry analyses based on the Hipparcos reference frame. The series gives polar motion, celestial pole offsets and Universal Time (since 1956).

1962–2006: BIH and IERS solutions (BIH and IERS annual reports).

Mean Pole with respect to the IERS reference origin

The analyses of the observations of space geodesy require to perform the transformation between both terrestrial and celestial frames via the Earth Orientation Parameters. Gravity field models include the tesseral coefficients C21 and S21 coefficients. These terms describe the position of the Earth's figure axis with respect to the Terrestrial Reference Frame. This axis should coincide with the observed position of the rotation pole averaged over the same time period.

The mean polar motion is affected by a long-term drift westward (direction 70.7 deg West, rate: 4.2 mas/yr). The mean rotation axis with respect to the IERS Terrestrial Reference Frame, can be considered as the long-term trend obtained after filtering out the Chandler and seasonal terms, every year from 1900 to 2006 (Shiskin *et al.*, 1965). Figure 1 represents the polar motion over 2001–2006 and the path of the mean pole since 1900. The table is available in Conventions 2003 (McCarthy and Petit, 2004) and at the following address: <http://hpiers.obspm.fr/eop-pc/>.

Normal Point Solutions: C 02 (1962–2006)

Other series, based on normal points solutions given at various time intervals, are also proposed to users, i.e. C 02 (5-day intervals, polar motion, UT1–UTC, $d\psi$, $d\varepsilon$), C 03 (one-day intervals, polar motion, UT1–UTC) (Gambis, 1997; Eisop and Gambis, 1997). These series are respectively consistent one to another. They use the full correlation matrix when available. Recently there were new developments in the normal point series C 02 and C 03 in which the estimation of the solution given at the central dates of the n-day interval is made using a least-square fit for all EOP components. Although the L2 estimation has been extensively used for data analysis, it has some drawbacks linked to problems of ill-conditioning and in the non-detection of outliers. Alternative methods based on robust estimators like M-Huber can be used. These estimators are a generalization of both the L1 and L2 class. They have been imple-

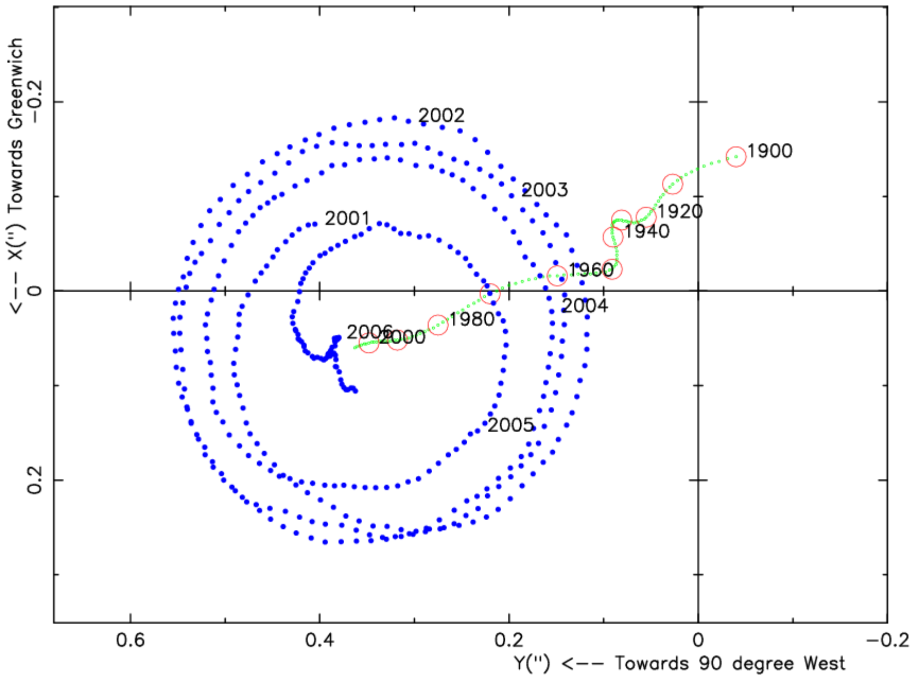

Figure 1 Mean polar motion (1900–2010) and IERS C04 polhody over 2002 – 2006.

mented in our analyses and are now currently used (Bougeard *et al.*, 2000). Table 5 reflects the evolution of the mean uncertainties of C02 solution since 1962.

Table 5: EOP(IERS) C 02 : Evolution of the mean uncertainty of the normal point solution given at five-day intervals

YEARS -- Unit	σ(X) -- 0.001"	σ(Y) -- 0.001"	σ (UT1) -- 0.0001s	σ(δψ) -- 0.001"	σ(δε) -- 0.001"
1962–1967	30	30	20	–	–
1968–1971	25	25	17	–	–
1972–1979	11	11	10	–	
1980–1983	2	2	3	2	1
1984–1989	.40	.40	.20	.5	.2
1990–2000	.20	.20	.20	.3	.1
2001–2006	.06	.06	.11	.09	.07

Evaluation of EOP derived from a simultaneous combination of TRF and EOPs

Although the current determination of reference frames and EOP temporal series are derived from the same software, rigorous approaches for simultaneously determining reference frames and EOP are not currently applied. This is however a more satisfactory approach to ensure a better consistency. Different approaches are currently being developed within the IERS (Altamimi *et al.*, 2005). The first approach is based on combination at the observation-equation level. Anderson (1995) has developed a software package, called GEOSAT, for the combined analysis of VLBI, GPS, SLR and other types of satellite tracking data (e.g., GLONASS, DORIS, Precise Range And Range-rate Estimation (PRARE) and satellite radar altimetry). Here, the observations are combined at the observation-equation level with a consistent model and consistent analysis strategies.

In another project (Yaya, 2001; Biancale *et al.*, 2002), the observations of the different techniques (VLBI, SLR, LLR, DORIS and GPS) are processed separately by the same single software package: GINS/DYNAMO, which has been developed at the GRGS (Groupe de Recherches de Géodésie Spatiale) since 1962. Here, the normal matrices are stacked to derive both the terrestrial frame and EOP. With this approach, it is essential that the results be optimal for the different techniques before a global solution be performed.

The project started in January 2005. Now the analyses are performed on an operational basis. For each individual technique, the processing of data is performed at different locations: GPS at Noveltis, Toulouse (S. Loyer), Doris at CLS, Toulouse (L. Soudarin), SLR at Cerga, Grasse (P. Bério), LLR at CNES, Toulouse (R. Biancale) and at the Observatoire de Paris (G. Francou), VLBI at CNES, Toulouse (R. Biancale) and at the Observatoire de Bordeaux (G. Bourda, P. Charlot). The final combination as well as the validation and various analyses are performed at the Observatoire de Paris (Gambis *et al.*, 2006).

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