

## 3.5 Product Centres

### 3.5.1 Earth Orientation Centre

This section presents the activities and main results of the Earth Orientation Centre located at Paris Observatory. 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 (DUT1) and leap second announcements. Earth Orientation Parameters (EOP: Polar motion, Universal Time (UT1), Length of Day (LOD) and Celestial pole offsets) are available to a broad community of users in various domains such as astronomy, geodesy, geophysics, space sciences and time.

EOPs are given in the form of combined solutions derived by the Technique Centers (IGS, IVS, ILRS and IDS). Various solutions are computed: a long-term solution (IERS C01) since 1846 and the Bulletin B given at one-day intervals published monthly with a 30 day delay. Bulletin B is updated in the operational C04.

Another issue is the maintenance of the consistency between the EOP system and the terrestrial reference frame. So far, Earth Orientation Parameters and the terrestrial frame are separately computed. This leads to increasing inconsistencies between both of them. At the end of 2009, these inconsistencies were small but significant for polar motion. All IERS reference solutions (C01, Bulletin B, C04 as well as Bulletin A derived by the Rapid Service/Predictions Center, US Naval Observatory) were recomputed and aligned to the EOP solution associated to the current ITRF2008.

#### **Combined daily series: Bulletin B and 05 C04, statistics over 2008–2009**

This section gives statistics (Tables 1 to 3) in term of formal errors and WRMS of the combined technique centres and individual solutions with respect to the combined solution Bulletin B and 05C04 over the years 2008 and 2009. Only combined solutions derived by the various technique centres are used in the IERS combinations. Statistics concerning individual series are given as a feedback to the analysis centres.

#### **New format of Bulletin B since January 2010**

Bulletin B issued by the IERS EOP Centre was more than 20 years old. Following a survey which was made in 2007 among the community, a new presentation is available since January 2010. The new Bulletin B and its content description are available at [ftp://hpiers.obspm.fr/iers/bul/bulb\\_new/bulletinb.dat](ftp://hpiers.obspm.fr/iers/bul/bulb_new/bulletinb.dat) and [ftp://hpiers.obspm.fr/iers/bul/bulb\\_new/bulletinb.pdf](ftp://hpiers.obspm.fr/iers/bul/bulb_new/bulletinb.pdf).

### 3.5.1 Earth Orientation Centre

*Table 1: Estimated accuracies of individual solutions compared to the combined solutions Bulletin B and 05 C04 over 2008–2009. The satellite techniques provide information on the rate of change of Universal Time contaminated by effects due to non modelled orbit node motion. VLBI-based results have been used to minimize drifts in UT estimates*

Individual solutions		Estimated uncertainties				
		Time	Terrestrial Pole $\mu\text{as}$	UT1 $\mu\text{s}$	LOD $\mu\text{s}$	Celestial Pole $\mu\text{as}$
<b>VLBI – 24 h</b>						
EOP (AUS)	01 R 01	3–4d	150	10.0		85
EOP (BKG)	03 R 02	1–4d	130	9.1		79
EOP (GSFC)	07 R 01	1–4d	111	9.7		70
EOP (IAA)	05 R 02	1–4d	130	8.6		73
EOP (MAO)	03 R 01	1–4d	110	8.7		87
EOP (OPA)	07 R 01	1–4d	130	9.7		74
EOP (USNO)	06 R 02	1–4d	101	8.8		58
EOP (IVS)	02 R 01	1–4d	115	4.4		40
<b>VLBI – Intensive</b>						
EOP (BKG)	03 R 02	1–3 d		18.0		
EOP (GSFC)	06 R 01	1–3 d		17.3		
EOP (SPBU)	05 R 01	1–3 d		14.3		
EOP (USNO)	05 R 01	1–3 d		19.1		
<b>SLR</b>						
EOP (ASI)	03 L 02	1d	230		54.1	
EOP (IAA)	02 L 01	1d	190		31.4	
EOP (MCC)	97 L 01	1d	185		–	
EOP (ILRS)	05 L 01	1d	160		17.2	
<b>GPS</b>						
EOP (CODE)	98 P 01	1d	33		15.0	
EOP (EMR)	96 P 03	1d	54		22.0	
EOP (ESOC)	96 P 01	1d	60		19.3	
EOP (GFZ)	96 P 02	1d	35		14.3	
EOP (IAA)	01 P 01	1d	160		30.1	
EOP (JPL)	96 P 03	1d	45		17.3	
EOP (NOAA)	96 P 01	1d	77		15.9	
EOP (SIO)	96 P 01	1d	45		22.0	
EOP (USNO)	03 P 01	1d	–		23.0	
EOP (IGR)	07 P 01	1d	35		8.0	
EOP (IGS)	96 P 02	1d	25		8.0	

*Table 2: Mean and standard deviation in microarcsecond of the differences between various combined techniques solutions and IERS 05C04 over 2008–2009*

EOP	IGS Comb – IERS 05C04		ILRS Comb – IERS 05C04		IVS Comb – IERS 05C04	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
X ( $\mu\text{as}$ )	–27	23	32	156	–325	121
Y ( $\mu\text{as}$ )	–32	24	–23	166	73	110
UT1 ( $\mu\text{s}$ )					1	4.4
LOD ( $\mu\text{s}$ )	4	8	47	40		
$D\psi\sin\epsilon$ ( $\mu\text{as}$ )					8	40
$D\psi$ ( $\mu\text{as}$ )					–12	35

*Table 3: Mean and standard deviation for Pole components and UT1 of the differences between various solutions and Bulletin B over 2008–2009*

EOP	Unit	Bull A – Bull B		Comb JPL – Bull B	
		Mean	Standard deviation	Mean	Standard deviation
X	$\mu\text{as}$	–66	32	–145	31
Y	$\mu\text{as}$	–5	33	–39	21
UT1	$\mu\text{s}$	–20	9	–25	10

The content of Bulletin B is:

1 - DAILY FINAL VALUES AND PRELIMINARY VALUES OF  $x$ ,  $y$ , UT1–UTC,  $dX$ ,  $dY$

and their respective uncertainties. Angular unit is milliarcsecond ( $\text{mas}$ ), time unit is millisecond ( $\text{ms}$ ).

2 - DAILY SMOOTHED VALUES OF CELESTIAL POLE OFFSETS ( $d\text{Psi}1980$ ,  $d\text{Eps}1980$ )

with respect to IAU 1980 precession-nutation model and their uncertainties.

3 - EARTH ANGULAR VELOCITY: DAILY VALUES OF LOD, OMEGA AT 0hUTC

LOD: Excess of the Length of day – 86400 s TAI

OMEGA: Earth angular velocity

4 - INFORMATION ON TIME SCALES: TAI–UTC, leap second announcements

5 - SUMMARY OF CONTRIBUTED EARTH ORIENTATION PARAMETERS SERIES

**Reset of Bulletin B and C04 to the new system consistent to ITRF2008, new reference solution since 1 February 2011**

Maintaining the consistency between the current EOP solution with the ITRF is essential in the field of geodynamics and satellite orbit computation. The ITRF2005 was the first rigorous combination ensuring ITRF and EOP consistency, based on time series of station positions and Earth Orientation Parameters (Altamimi et al., 2008). The ITRF2008 has the same characteristics than ITRF2005. Its release was the opportunity to re-align the C04 to the ITRF2008 system. Relative to 05C04, changes in the EOP series consist of:

- 1) A negligible bias in x-pole and a bias of about  $-50 \pm 25$  microarcseconds in y-pole in the sense of  $y(08C04) - y(05C04)$ ;
- 2) Changes in UT1-TAI and celestial pole offsets are respectively on the order of 2 microseconds, 1, and 17 microarcseconds which are at the level of the WRMS between IVS individual solutions.

Other IERS EOP series (Bulletin B, C01) have been expressed in this new system consistent with ITRF2008. The Rapid Service/Prediction Center solutions (Bulletin A and daily) are as well expressed in the new reference system.

**Long-term series: C 01 (1846–2008)**

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 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 2011 to be consistent with the reference system associated with ITRF2008. 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).
- 1962–2008: 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 performing the transformation between both terrestrial and celestial frames via the Earth orientation parameters. Gravity field models include the tesseral coefficients  $C_{21}$  and  $S_{21}$  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 2009 (Shiskin et al., 1965). Figure 1 represents the polar motion over 2001–2009 and the path of the mean pole since 1900. The coefficients of the IERS (2010) mean pole model are available in Conventions 2010 (Petit and Luzum, 2010). The table is available at the following address: <<http://hpiers.obspm.fr/eop-pc/>>.

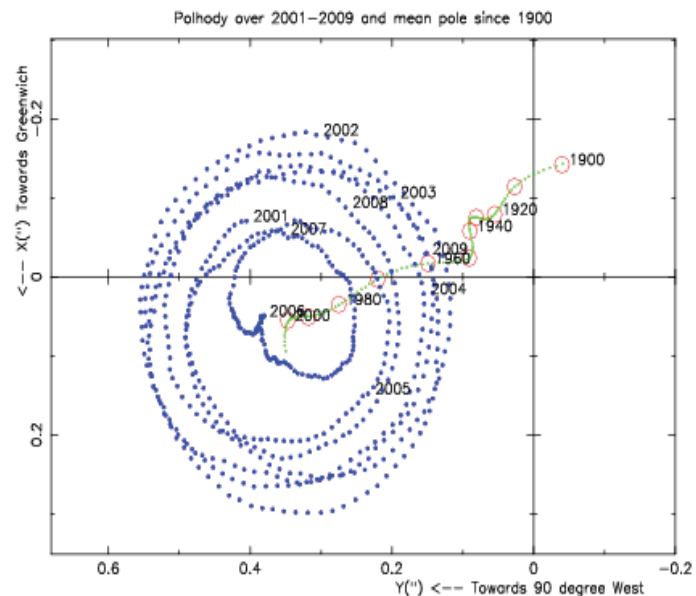


Fig. 1: Mean polar motion (1900–2010) and IERS C04 polhody over 2001 – 2009

### 3.5.1 Earth Orientation Centre

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