IERS Contributions

IERS References
Contribution of the Central Bureau of IERS

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1 The International Terrestrial Reference Frame

The main ITRF event in 1997 of interest to IGS is the generation of a new solution, namely the ITRF96, which is used as reference by IGS starting on March 1, 1998.

1.1 ITRF96

The ITRF96 solution represents a new generation of realization of the International Terrestrial Reference System (ITRS). It is achieved by combining simultaneously positions and velocities using full variance- covariance information provided, in SINEX format, by the IERS analysis centers. Moreover, a rigorous weighting scheme is used, based on the analysis and estimation of the variance components using Helmert method.

A brief description of the ITRF96 solution could be found in the 1997 IGS Annual Report, Volume 1. For more details about the results and analysis of the ITRF96, see (Boucher et al, 1988). Moreover, in Volume 1, we also provided some information about the selection of 47 ITRF96 reference stations to be used by IGS. For more details, see also (Altamimi, 1998). All the ITRF96 related files are available via the Web at:

http://lareg.ensg.ign.fr/ITRF/ITRF96.html

Here, we will provide more information on ITRF96 of interest to IGS.

The ITRF96 global combination is achieved using the following properties:

- 17 selected space geodetic solutions provided by the IERS analysis centers and 70 SINEX files, containing positions and covariances computed from local ties.
- The reference frame definition (origin, scale, orientation and time evolution) of the combination is achieved in such a way that ITRF96 is in the same system as the ITRF94.

- Velocities are constrained to be the same for all points within each site.
- Matrix Scaling Factors have been rigorously estimated during this combined adjustment, which was then iterated.

1.2. IGS Contribution to ITRF96

6 global IGS/GPS solutions were included in the ITRF96 adjustment. Moreover, two European GPS solutions, computed by CODE, were also included as part of EUREF contribution to the ITRF. These GPS solutions contain about 194 stations. Table 1 lists these solutions together with solutions coming from the other IERS techniques. Figure 1 shows the coverage of the 4 IERS technique sites implied in the ITRF96.

To have an idea about the quality of the individual solutions used to generate the ITRF96, Table 1 lists the global 3D Weighted RMS in position as well as in velocity. In position, the best level reached in 3D precision is greater than 1 cm for VLBI and GPS, around 1 cm for SLR, and 3 cm for DORIS. In velocity, the best 3D precision is about 2 mm/year for SLR and VLBI, 4 mm/year for GPS, and 8 mm/year for DORIS.

Conversely, the largest discrepencies (excepting 2 outliers) between the origins and scales of the individual solutions are respectively 4 cm and 4 x 10^{-9}.

Table 1. ITRF96: Used data and global residuals per solution.

Solution		Number of points	Data Span yy-yy	Position RMS mm	Epoch yy:doy	Velocity RMS mm/y
VLBI						
SSC(GSFC)	97 R 01	120	79-97	5.80	93:001	1.90
SSC(GIUB)	97 R 01	43	84-96	13.60	93:001	.50
SSC(NOAA)	95 R 01	111	79-94	14.70	93:001	1.90
SSC(JPL)	97 R 01	8	91-96	20.70	93:001	
SLR						
SSC(CSR)	96 L 01	89	76-96	11.10	93:001	3.80
SSC(GSFC)	97 L 01	38	80-96	10.90	86:182	1.70
GPS						
SSC(EMR)	97 P 01	36	95-97	10.00	96:001	3.50
SSC(GFZ)	97 P 02	66	93-96	16.80	94:365	3.30
SSC(CODE)	97 P 02	100	93-97	7.10	95:076	1.90
SSC(EUR)	97 P 04	39	95-96	2.40	96:090	.30
SSC(EUR)	97 P 03	58	96-97	2.90	96:339	.30
SSC(MIT)	97 P 01	132	94-97	8.50	97:151	9.20
SSC(NCL)	97 P 01	114	95-97	5.40	96:001	6.30
SSC(JPL)	97 P 02	113	91-96	9.40	96:001	3.80
DORIS						
SSC(GRGS)	97 D 01	48	93-96	26.90	93:001	8.00
SSC(CSR)	96 D 01	54	93-96	26.10	93:001	10.60
SSC(IGN)	97 D 04	62	90-97	28.30	95:100	12.80

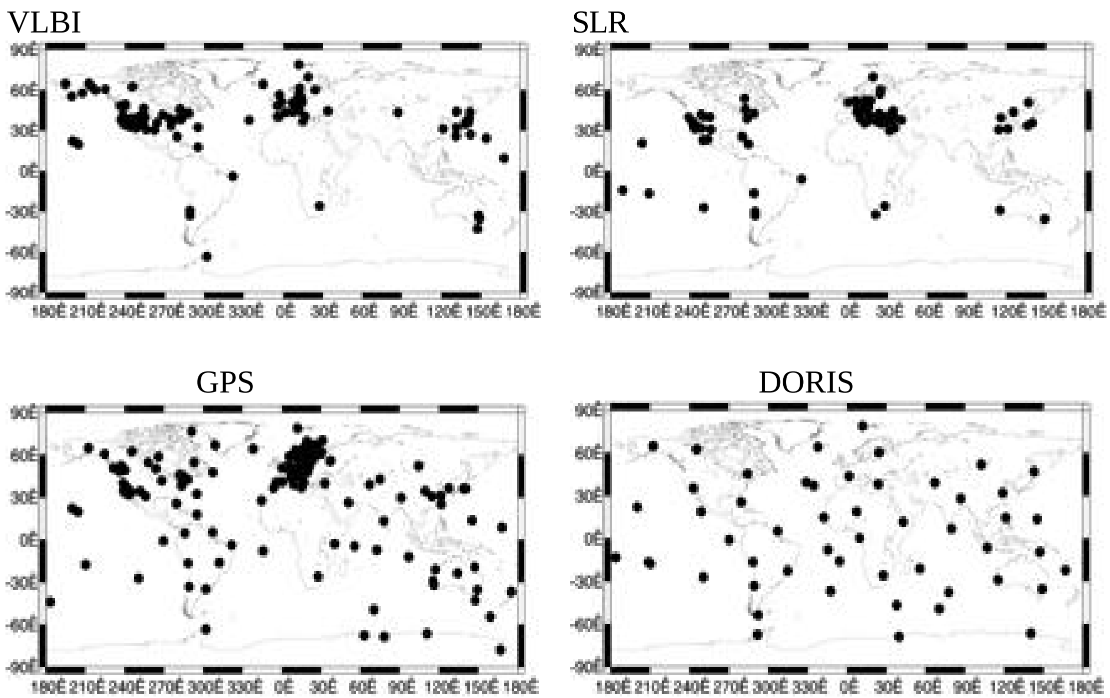

Figure 1. ITRF96 Sites

2. Earth Orientation

2-1 Contribution of GPS to Polar Motion and LOD

GPS EOP solutions (polar motion and LOD) have a significant contribution in the multi-technique combined solutions derived by the IERS. Since 1994, a combined solution of the various GPS series is performed and is used in our current analyses. Table 2 shows the mean differences and the unbiased RMS agreements of the various series GPS which contributed to this combined solution, and of different solutions derived from other techniques to (IERS) C04. These statistics reflect the accuracy reached by the different techniques. Note the significant improvement (shown in brackets) in the consistency between the various solutions due to the adoption of the ITRF96 in the GPS data analysis after March 1998. The relative weighting of GPS in the IERS C04 solution is now about 70 %.

Table 2 - biases and unbiased RMS of the differences of various solutions to (IERS) C04

Differences to (IERS) C04	X- bias mas	RMS mas	Y-bias mas	RMS mas	lod-bias .1 ms	RMS .1 ms
GPS solutions						
CODE 98 P 01	.33	.16 (11)	-.10	.19 (11)	.15	.31 (16)
EMR 96 P 03	.12	.21 (20)	.40	.22 (17)	.09	.45 (34)
ESOC 96 P 01	.13	.22 (14)	.21	.27 (14)	-.10	.37 (28)
GFZ 96 P 02	.24	.13 (09)	.14	.18 (14)	-.06	.37 (24)
JPL 96 P 03	.12	.14 (10)	.03	.17 (10)	.11	.67 (34)
NOAA 96 P 01	.54	.49 (26)	.22	.54 (26)	.06	.57 (39)
SIO 96 P 01	.20	.19 (16)	.04	.19 (16)	.00	.61 (37)
IGS 96 P 02	.32	.18 (17)	.17	.25 (13)	.00	.31 (24)
IERS 97 P 01	.00	.08 (06)	-.01	.11 (05)	-.02	.28 (20)
Other individual series						
USNO 97 R 08	.04	.20 (18)	.02	.15 (12)	-.13	.39 (28)
CGS 98 L 01	.38	.43	.03	.40 (11)		
CSR 95 L 01	-.34	.21 (21)	-.04	.23 (12)		
DUT 98 L 01	.64	.38 (47)	.50	.39 (41)		
GZ 98 L 02	.53	.25	.55	.28		
IAA 98 L 01	.06	.14 (16)	-.11	.15 (13)	.04	.14 (14)
Combined series						
USNO 98 C 01	-.07	.10 (09)	-.10	.12 (07)		
SPACE 98 C 01	-.05	.19 (11)	-.02	.14 (11)		

Figures 2a, 2b and 2c show for x-pole, y-pole and LOD, the plots of the differences of the seven individual GPS series, and other series with the combined IERS C04.

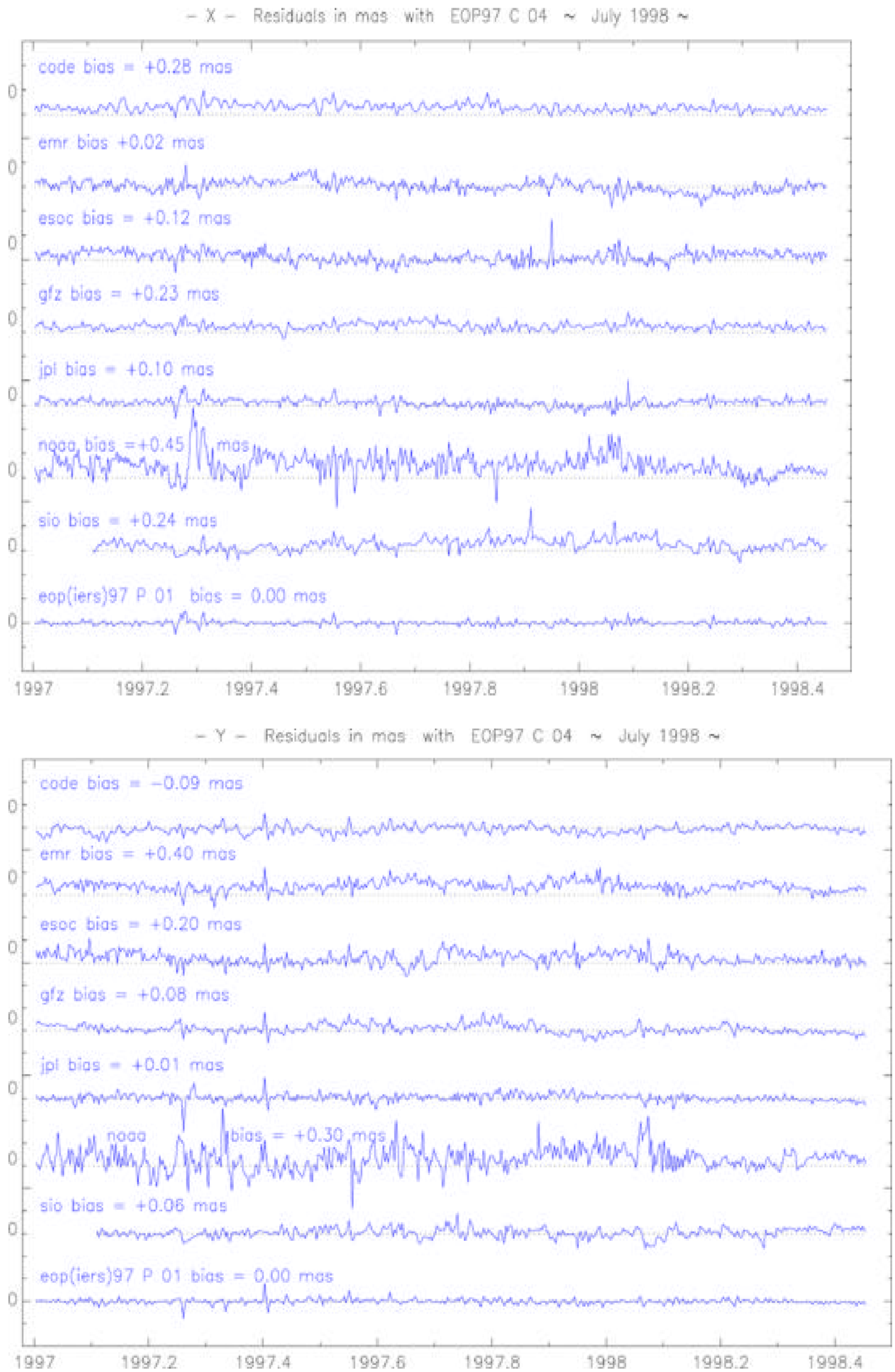

Figure 2a and 2b - x and y-pole coordinates in 1997/1998. Daily differences of individual GPS series with IERS C04.

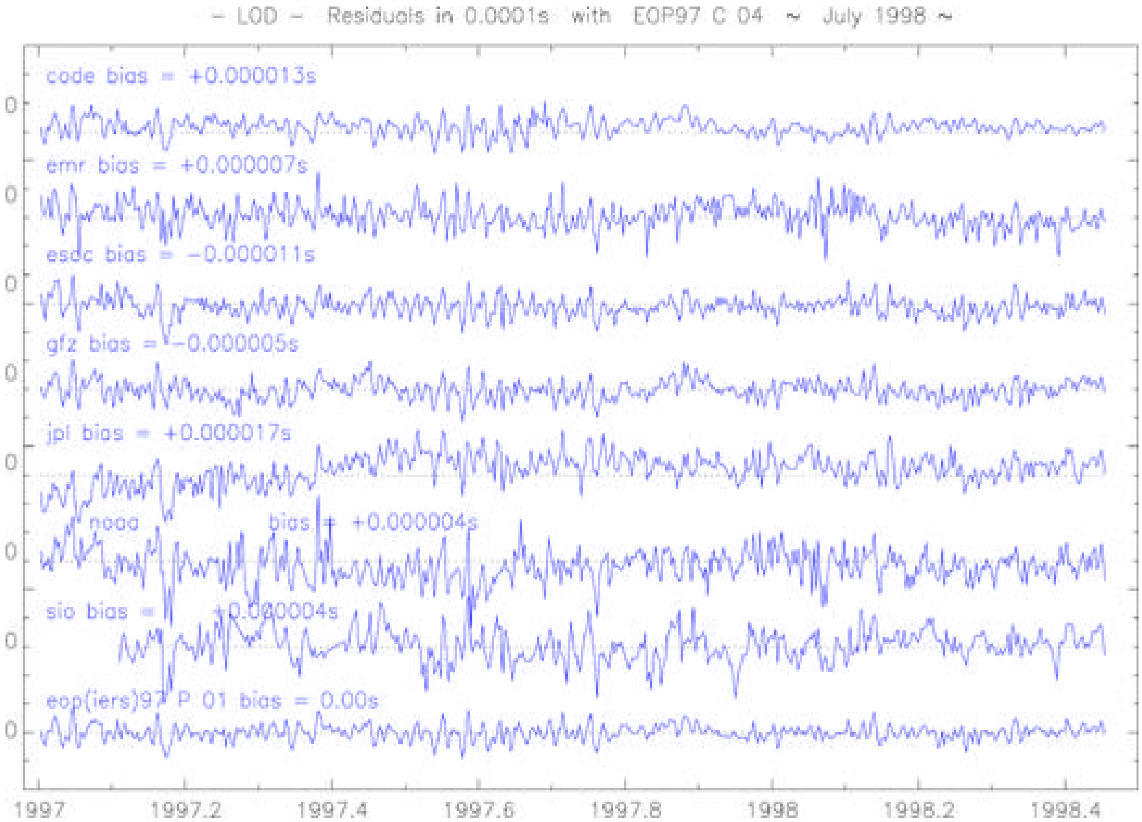

Figure 2c - LOD in 1997/1998. Daily differences of individual GPS series with IERS C04.

2-2 Use of GPS LOD Estimates for Near-real Time Universal Time Determination

Due to the difficulty of determining the long-term behaviour of the non rotating system realized through the orbit orientation, Universal Time UT1 cannot be accurately derived from satellite techniques but only from inertial methods like VLBI. On the other hand, these techniques can determine the length of day variations (lod), derivative of Universal Time together with the orbital parameters; of course their spectrum show similar systematic errors than those of Universal Time directly estimated. Various studies (Gambis et al 1993, Gambis 1996) have shown that the high-frequency signal contained in the lod estimates on time scales limited to a couple of months derived fron SLR and GPS can be used to densify the series obtained by the VLBI technique and also for near-real time earth orientation monitoring.

The published near-real Universal Time was so far extrapolated from VLBI determinations. The present rapid availability of the GPS LOD solutions allows to significantly improve it when VLBI UT1 determination is available and consequently it gives a much better UT prediction. The following table represents the results obtained by this procedure over one year of operational analysis (1997.5 to 1998.5). The C04 solution is now permanently computed. On tuesdays, 5 GPS LOD estimates are available whereas no VLBI UT1 solution is. Table 3 shows the accuracy reached using these GPS LOD estimates compared to regular predictions from the last available VLBI value. This corresponds to a near-real time service. The improvement is significantly of one order of magnitude for a 5-day time lag.

Table 3 - RMS errors (in microseconde) of the Universal Time solution based on GPS and compared to the current prediction based on an auto-regressive process.

UNIT: 1 ms	5 days
Pure Prediction	1000
GPS estimates	100

3 References

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