1999 IGS Earth Rotation Parameters

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1 Introduction

The following report summarizes the results of the 1999 Rapid and Final IGS Earth Rotation Parameters (ERP). IGS ERPs are generated for both the Rapid products, daily 17 hours after the last observation, and the Final products, weekly 13 days after the last observation. The IGS ERP combination combines the Polar Motion (PM) for the X- and Y-axis and their rates as well as LOD and UT.

Here we will compare the ERP series of the individual IGS Analysis Centers (ACs) and the combined IGS ERP series to the IERS Bulletin A. This reports complements the Analysis Activities Report found in the 1999 IGS Annual Report [6] and the 1999 Analysis Coordinator Report found in the 1999 IGS Technical Report [7]. The IGS ERP product combinations were described in detail in the IGS annual and technical reports [3, 4]. Therefore they will not be described here.

2 Changes in 1999

During the 1999 Analysis Center (AC) workshop held at the Scripps Institution of Oceanography (SIO) in La Jolla, California, the IGS ACs agreed on adopting the new realization of the ITRS, the ITRF97 [1]. This took effect on 1 August 1999 when the IGS changed its realization of the International Terrestrial Reference System by switching from the ITRF96 to the ITRF97. At the same time the set of reference stations (RF) was slightly enhanced from 47 to 51 sites. The main change was the inclusion of a few sites for which the accuracy was insufficient in the ITRF96 but which are well determined in the ITRF97. A SINEX file containing the necessary information about the 51 reference stations may be found at the IGS Central Bureau. Although the ITRF96 and ITRF97 frames are nominally aligned globally in all 7 Helmert components and their rates, the comparison of the IGS subset of RF sites shows significant differences between the ITRF96 and ITRF97 realizations. The expected differences between the IGS products based

ITRFnn from	to	Epoch (GPS-week)	TX (mm) (mm/y)	TY (mm) (mm/y)	TZ (mm) (mm/y)	RX (mas) (mas/y)	RY (mas) (mas/y)	RZ (mas) (mas/y)	Scale (ppb) (ppb/y)
92	93	782	-20.0	-8.0	-3.0	-1.660	-0.680	-0.550	0.100
			-2.3	-0.4	0.8	-0.120	-0.150	0.040	-0.110
93	94	860	21.0	1.0	-1.0	1.270	0.870	0.540	0.200
			2.7	0.0	-2.0	0.130	0.200	-0.040	0.090
94	96	947	0.0	-1.0	1.0	-0.100	-0.010	-0.220	-0.400
			0.2	-0.9	0.2	-0.020	0.010	0.010	-0.070
96	97	1021	0.3	0.5	-14.7	0.159	-0.263	-0.060	1.430
			-0.7	0.1	-1.9	0.013	-0.015	0.003	0.192

Table 1: Transformation parameters from IGS(ITRFnn) to IGS(ITRFnn). The IERS convention for the transformation parameters was followed. The equivalent changes in polar motion may be obtained using PMx = RY and PMy = RX.

on the ITRF96 and ITRF97 reference frames are given in Table 1. More information about this ITRF change may be found in IGSMAIL #2432. Besides this last IGS terrestrial reference frame change, Table 1 contains all previous IGS terrestrial reference frame changes and the associated transformations for the IGS products. The epochs of the transformations is given by the GPS week in which the terrestrial reference frame change took effect. More information about the earlier reference frame changes may be found in previous IGS Annual and Technical Reports, and in the IGSMAIL archives.

It is interesting, but also a bit disturbing, to notice the relatively large differences between the ITRF96 and ITRF97. Especially the Z-translation (-14.7 mm) and the scale (1.4 ppb) constitute quite large changes given the fact that the ITRF96 and ITRF97 nominally have the same orientation (i.e., ITRF94). Also the X-, and Y-rotations are quite significant (0.159 and -0.263 mas). The cause of these relatively large transformation parameters for the IGS RF station subset of the ITRF97 is not exactly known. However, it seems to be related to the fact that for the alignment of the ITRF97 the full station covariance matrices were used, for the first time in the ITRF history. When the ITRF96 and ITRF97 realizations are compared using only the diagonal of their covariance matrices very similar transformation parameters are found as those given in Table 1.

3 IGS ERP Comparison Results

Table 2 gives the comparison statistics between the individual AC ERP series (both Final and Rapid) to the IERS Bulletin A series. The IGS Final and Rapid ERP series are also included in this comparison table. Figures 1 and 2 show the time series of ERP differences over 1999 in X-, and Y-pole and their rates, for the Final AC solutions and the IGS Final and Rapid ERP products, compared to the IERS Bulletin A series. Figure 3 shows the time series of LOD differences over 1999, for the Final AC solutions and the IGS Final and Rapid ERP products, compared to the IERS Bulletin A series. Note that all LOD results reflect the actual LOD estimates and not LOD values derived from UTC.

In Figure 1 we can observe the small jumps in the X- and Y-pole caused by the change of the reference frame realization on 1 August. For X-pole the largest reference frame change was expected (-0.263 mas) and the effect is visible in practically all the individual time-series. For Y-pole the expected reference frame change was smaller (0.159 mas) and consequently it is more difficult to observe in the individual series. The change of reference frame actually brought the X-pole closer to the Bulletin A series whereas for the Y-pole the opposite effect is observed but with a smaller magnitude. So overall the bias between the IGS series and the IERS Bulletin A series has been reduced. It should be noted that, in Table 2, both the mean and the standard deviation for X- and Y-pole are affected by these reference frame jumps. The standard deviations for X- and Y-pole after the reference change are below the 0.1 mas for the best AC Final solutions and the IGS Final products. After the reference frame change the mean offset for the X-pole is significantly reduced to well below the 0.1 mas level whereas the mean offset for the Y-pole has increased to about the 0.2 mas level.

In the pole comparisons, Table 2, it is impressive to see the quality of the IGR ERP series (available 17 hours after the end of the observations). The standard deviation of the IGR series is clearly better than the standard deviation of the individual AC Rapid solutions. Also the IGR series shows a 100% availability which none of the ACs has managed. This shows the importance of the IGS combinations; both the reliability and the quality of the combined products are improved compared to the individual AC solutions.

4 Outlook

The plans for the new and improved IGS ITRF (IGSRF) realization, as proposed during the 1997 Analysis Center workshop [5] have been finalized in March 2000. Starting with GPS week 1050 the weekly IGSRF realization, as generated at NR-Can by Remi Ferland [2], has become official (see IGSMAIL #2740). In this new IGSRF realization the IGS Final combined orbits are made consistent with the combined IGSRF solution by using both the transformation parameters and the combined ERPs stemming from the IGSRF combination. Furthermore sometime in the year 2000 the IGS will switch from using the ITRF97 to using it's own internal IGS realization of the ITRF97. Because this IGS realization will be tied to the ITRF97 this change should not cause any discontinuities in the IGS ERP series. Of course this change will require careful monitoring of the results and the change will be announced through the usual channels, e.g., IGSMAIL.

Also in March 2000, the IGS started the generation of more rapid and frequent IGS products for (near-) real-time usage: "Ultra rapid products". These products, which are delivered every 12 hours (twice a day), contain a 48 hour orbit arc from which 24 hours are real orbit estimates and 24 hours are orbit predictions and corresponding ERP estimates/predictions. The latency of this product is 3 hours. The first Analysis Center Ultra rapid solutions were provided by GFZ by the end of October 1999. The generation of a combined ultra rapid product (IGU) has started in March 2000 based on contributions from up to five different Analysis Centers. Like the IGS Predicted orbits (IGP) the Ultra rapid products are available for real-time usage, but the quality should be significantly better because the average age of the predictions is reduced from 36 to 9 hours. In the months to come, the quality and the reliability of the IGS Ultra rapid (IGU) orbits will be assessed against the IGS Predicted (IGP) and IGS Rapid (IGR) products. When it reaches a satisfactory level the IGU products will replace the IGS prediction products. Contrary to the IGP products the IGU products come with corresponding ERP values. These IGU ERP products may be quite useful for the IERS Bulletin A products.

References

[1] C. Boucher, Z. Altamimi, and P. Sillard. The 1997 International Terrestrial Reference Frame (ITRF97). IERS Technical Note 27, Central Bureau of IERS – Observatoire de Paris, Paris, May 1999.

[2] R. Ferland. 1999 ITRF Reference Frame Working Group. In *IGS 1999 Technical Reports*, 2000. to be published.

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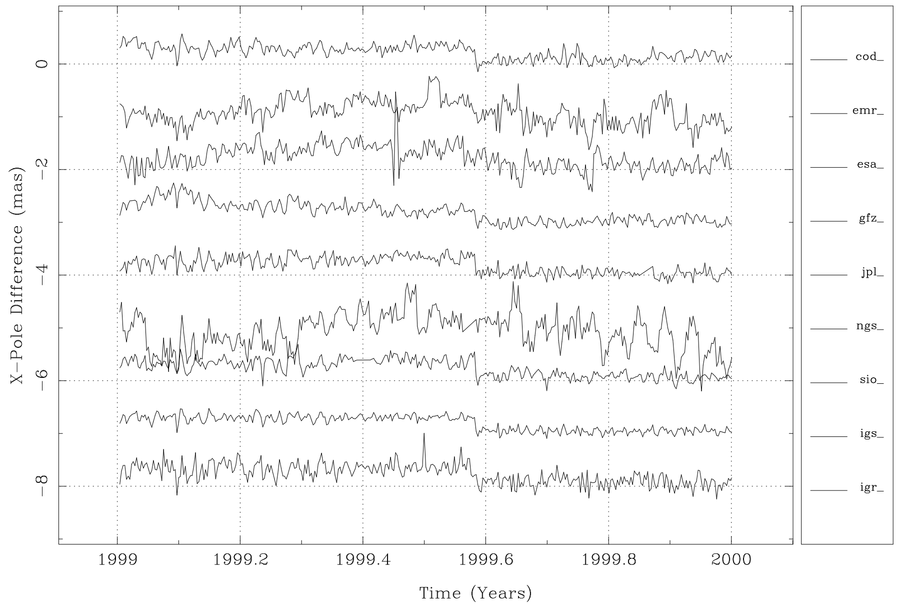
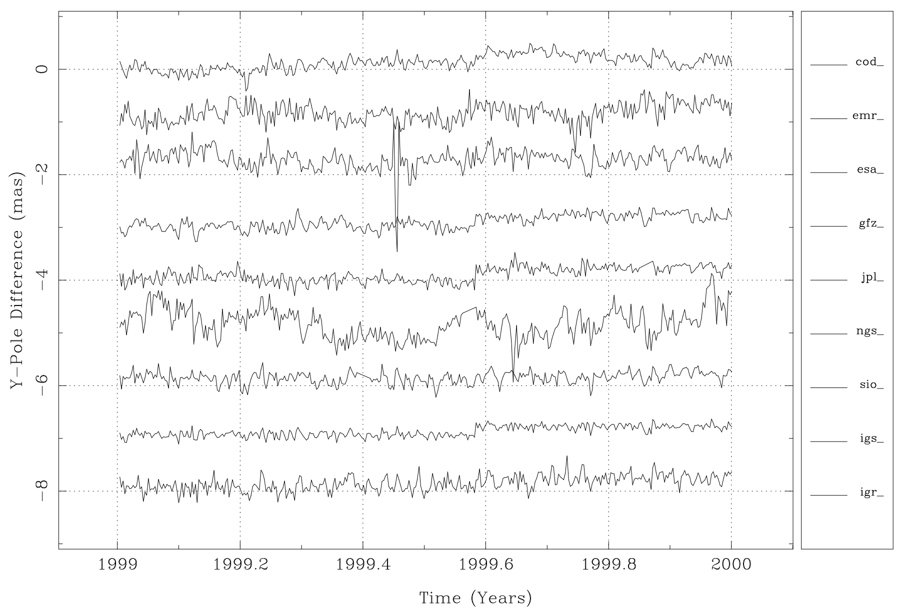
A Tables and Figures

AC	Days	X-Pole (mas)		Y-Pole (mas)		X-Rate (mas/d)		Y-Rate (mas/d)		LOD (μs/d)	
		Mean	σ	Mean	σ	Mean	σ	Mean	σ	Mean	σ
cod	365	0.222	0.138	0.128	0.146	0.000	0.192	-0.004	0.198	13	35
emr	365	0.077	0.234	0.168	0.180	-0.551	0.583	0.112	0.605	2	39
esa	365	0.224	0.227	0.289	0.198	0.030	0.448	0.009	0.733	-16	34
gfz	365	0.193	0.190	0.102	0.133	0.005	0.160	0.008	0.167	3	28
jpl	358	0.187	0.160	0.102	0.141	-0.081	0.279	-0.085	0.310	15	40
ngs	358	-0.078	0.350	0.173	0.286	0.209	0.782	0.499	1.137	10	79
sio	358	0.232	0.164	0.150	0.114	0.010	0.111	-0.004	0.123	7	36
igs	365	0.195	0.143	0.133	0.099	-0.019	0.147	0.018	0.170	1	23
igr	365	0.232	0.187	0.152	0.145	0.068	0.313	0.106	0.353	2	28
cod	363	0.162	0.272	0.029	0.264	-0.022	0.316	0.006	0.273	3	43
emr	313	0.141	0.327	0.450	0.329	-0.188	1.128	0.002	1.101	5	64
esa	330	0.194	0.319	0.316	0.276	0.332	0.678	0.036	0.987	-18	39
gfz	356	0.285	0.221	0.173	0.211	0.076	0.366	0.152	0.394	2	41
jpl	227	0.180	0.503	0.254	0.627	-0.004	0.444	-0.020	0.486	8	81
ngs	310	0.266	0.371	-0.042	0.370	0.405	1.145	0.490	1.368	1	82
sio	322	0.265	0.466	0.090	0.463	0.118	1.103	0.201	0.990	15	91
usn	347	0.276	0.216	0.167	0.167	-0.089	0.610	0.006	0.625	-5	37

Table 2: Mean and standard deviation (σ) of the daily ERP values (X-, and Y-pole), their rates and LOD compared to the IERS Bulletin A pole. The upper part of the table is based on the Final solutions and the lower part is based on the Rapid solutions of the ACs.

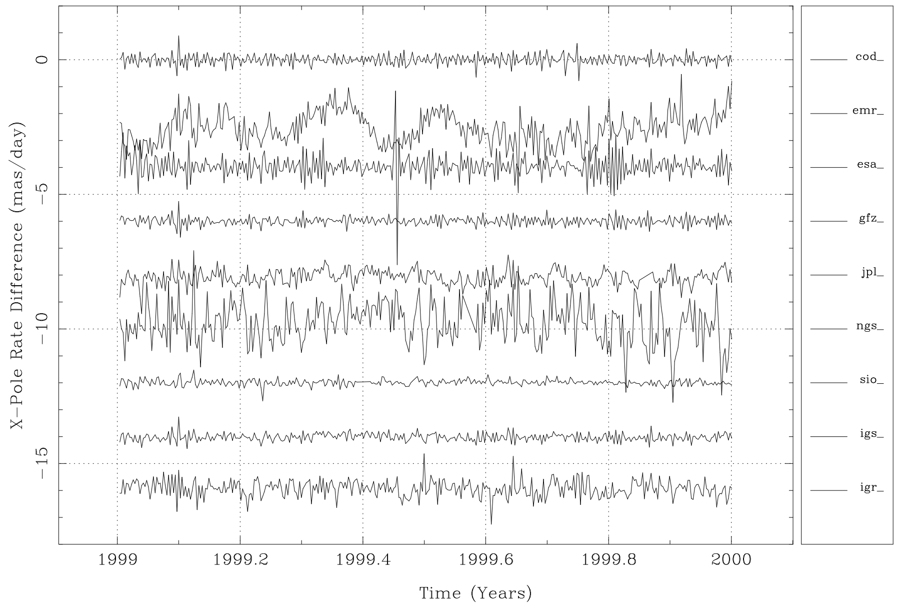


(a) X-Pole

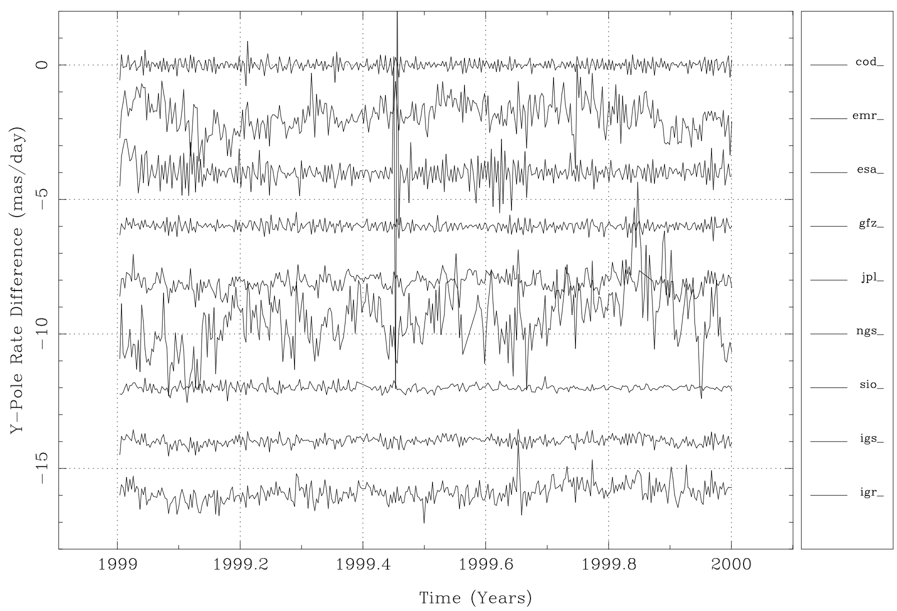


(b) Y-Pole

Figure 1: Daily AC Final Pole differences with respect to IERS Bulletin A pole. The individual series are shifted by 1 mas.



(a) X-Rate



(b) Y-Rate

Figure 2: Daily AC Final Pole-rate differences with respect to IERS Bulletin A pole. The individual series are shifted by 2 mas/day.

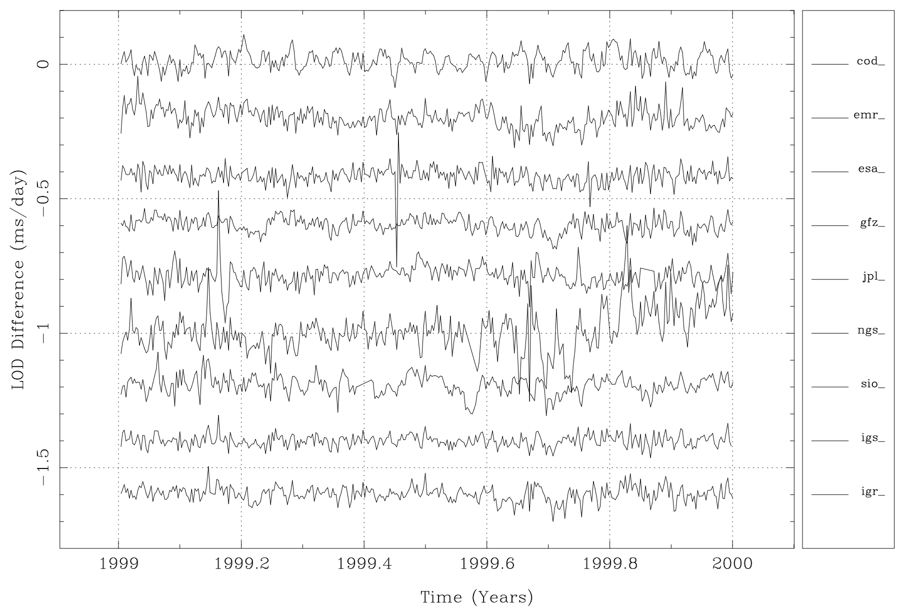


Figure 3: Daily AC Final LOD differences with respect to IERS Bulletin A pole. ACs are shifted by 0.2 ms/d.