COMBINATIONS OF EOP MEASUREMENTS: COMB97 & POLE97

EOP(JPL) 98 C 02
EOP(JPL) 98 C 03

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A Kalman filter has been used to combine independent measurements of the Earth's orientation taken by optical astrometry and the space-geodetic techniques of LLR, SLR, VLBI, and GPS. The approach taken is the same as that used in generating previous such combinations (e.g., Gross, "Combinations of Earth Orientation Measurements: SPACE94, COMB94, and POLE94", J. Geophys. Res., 101, 8729-8740, 1996) and will be only briefly described here. Prior to incorporation of the optical astrometric measurements, the space-geodetic measurements were first combined together, resulting in the combined EOP series EOP(JPL) 98 C 01 (also known as SPACE97), the description of which can be found elsewhere in this volume. The incorporation of the optical astrometric measurements was then done in two stages: (1) the BIH optical astrometric series (Li, BIH Annual Report for 1984, pp. D31-D63) was first combined with SPACE97 to form COMB97, and (2) the International Latitude Service (ILS) optical astrometric series (Yumi and Yokoyama, Results of the ILS in a Homogeneous System, 1980) was combined with COMB97 to form POLE97.

Prior to forming COMB97, the BIH astrometric series was first corrected to have the same bias and rate as SPACE97, the stated measurement uncertainties of the BIH series were adjusted by applying a constant multiplicative scale factor that made the BIH residual, when differenced with SPACE97, have a reduced chi-square of one; and those BIH data points whose residual values were greater than three times their adjusted uncertainties were deleted. In addition, in order to correct for systematic, seasonally varying effects in optical astrometric measurements, the annual term of the BIH series was adjusted to be in agreement with the annual term exhibited by SPACE97. The corrections thus determined and applied to the BIH series prior to its combination with SPACE97 are shown in Tables 1 and 2, with the 1-sigma formal uncertainties in determining these bias, rate, and annual term corrections being shown in parentheses.

The result of combining the corrected BIH optical astrometric EOP measurements with SPACE97 is designated EOP(JPL) 98 C 02 (also known as COMB97), spans January 20, 1962 to January 1, 1998 at 5-day intervals, and consists of values of PMX, PMY, UT1-UTC, their 1-sigma formal uncertainties, and correlations.

The ILS optical astrometric series was then combined with COMB97 to form POLE97 after first: (1) correcting the ILS series to have the same bias, rate, and annual term as COMB97, (2) applying a constant multiplicative scale factor to the stated measurement uncertainties of the ILS series so that its residual, when differenced with COMB97, had a reduced chi-square of one, and (3) deleting those data points whose residual values were greater than three times their adjusted uncertainties (see Tables 1 and 2 for the values of the corrections applied to the ILS series). The result of combining the corrected ILS optical astrometric polar

motion measurements with COMB97 is designated EOP(JPL) 98 C 03 (also known as POLE97), spans January 20, 1900 to December 21, 1997 at 30.4375-day intervals, and consists of values of PMX and PMY, their 1-sigma formal uncertainties, and correlations.

ACKNOWLEDGMENTS. I would like to thank all those involved in taking and reducing the raw Earth orientation measurements that have been combined into COMB97 and POLE97. This study would not have been possible without their considerable efforts. The work described in this paper was performed at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

TABLE 1. ADJUSTMENTS TO BIAS, RATE, AND UNCERTAINTY

DATA SET NAME	BIAS (mas)			RATE (mas/yr)			UNCERTAINTY SCALE FACTOR		
BIH	PMX	PMY	UT1	PMX	PMY	UT1	PMX	PMY	UT1
	-0.597	-2.224	-8.971	0.986	0.864	4.666	1.822	1.628	1.896
	(0.837)	(0.658)	(0.724)	(0.476)	(0.181)	(0.310)			
ILS	PMX	PMY	UT1	PMX	PMY	UT1	PMX	PMY	UT1
	-49.669	-0.869	---	-0.070	-0.298	---	2.012	1.558	---
	(2.206)	(1.719)		(0.453)	(0.352)				

Reference date for rate adjustment of BIH series is 1980.0
Reference date for rate adjustment of ILS series is 1970.0

TABLE 2. ADJUSTMENTS TO ANNUAL TERM

DATA SET NAME	COEFFICIENT OF SINE TERM (mas)			COEFFICIENT OF COSINE TERM (mas)		
BIH	PMX	PMY	UT1	PMX	PMY	UT1
	-5.755	-6.433	5.214	-3.333	9.244	-1.074
	(1.005)	(0.630)	(0.768)	(1.060)	(0.693)	(0.820)
ILS	PMX	PMY	UT1	PMX	PMY	UT1
	-0.462	7.918	---	9.174	-10.284	---
	(3.085)	(2.401)		(3.119)	(2.428)	

Reference date for adjustment of BIH series is 1980.0
Reference date for adjustment of ILS series is 1970.0

ATTACHMENT 1

Technical description of solution JPL 98 C 02

1 - Technique: Combined

2 - Analysis Center: Jet Propulsion Laboratory

3 - Software used: Kalman Earth Orientation Filter (KEOF) OP-B

4 - Data span: Jan 62 - Dec 97 at 5-day intervals

5 - Celestial Reference Frame: Not Applicable

a - Nature:

b - Definition of the orientation:

6 - Terrestrial Reference Frame: Not Applicable

a - Relativity scale:

b - Velocity of light:

c - Geogravitational constant:

d - Permanent tidal correction:

e - Definition of the origin:

f - Definition of the orientation:

g - Reference epoch:

h - Tectonic plate model:

i - Constraint for time evolution:

7 - Earth orientation: EOP(JPL) 98 C 02

a - A priori precession model: Not Applicable

b - A priori nutation model: Not Applicable

c - Short-period tidal variations in x, y, UT1:

When necessary, diurnal and semidiurnal tidal variations have been removed from the individual EOP series prior to their combination into EOP(JPL) 98 C 02. Diurnal and semidiurnal tidal terms have not been added back and are therefore not included in the values reported in EOP(JPL) 98 C 02.

8 - Estimated Parameters:

a - Celestial Frame:

b - Terrestrial Frame:

c - Earth Orientation: PMX, PMY, UT1-UTC

d - Others:

ATTACHMENT 2

Technical description of solution JPL 98 C 03

1 - Technique: Combined

2 - Analysis Center: Jet Propulsion Laboratory

3 - Software used: Kalman Earth Orientation Filter (KEOF) OP-B

4 - Data span: Jan 1900 - Dec 1997 at 30.4375-day intervals

5 - Celestial Reference Frame: Not Applicable

a - Nature:

b - Definition of the orientation:

6 - Terrestrial Reference Frame: Not Applicable

a - Relativity scale:

b - Velocity of light:

c - Geogravitational constant:

d - Permanent tidal correction:

e - Definition of the origin:

f - Definition of the orientation:

g - Reference epoch:

h - Tectonic plate model:

i - Constraint for time evolution:

7 - Earth orientation: EOP(JPL) 98 C 03

a - A priori precession model: Not Applicable

b - A priori nutation model: Not Applicable

c - Short-period tidal variations in x, y, UT1:

When necessary, diurnal and semidiurnal tidal variations have been removed from the individual EOP series prior to their combination into EOP(JPL) 98 C 03. Diurnal and semidiurnal tidal terms have not been added back and are therefore not included in the values reported in EOP(JPL) 98 C 03.

8 - Estimated Parameters:

a - Celestial Frame:

b - Terrestrial Frame:

c - Earth Orientation: PMX, PMY

d - Others:

JPL Kalman Earth Orientation Series : COMB97 27-FEB-98 17:23:32 IERS Series Designator : EOP(JPL) 98 C 02

MJD	PMX (10**-6 arcsec)	PMY	UT1-UTC (10**-7 sec)	LOD	XSIG (10**-6 arcsec)	YSIG	USIG (10**-7 sec)	LSIG	XDOT (10**-6 arcsec/day)	YDOT	XDSIG	YDSIG	CORRELATIONS XY	XU	YU	YR	MO	DAY
37684.00	-30923	268611	242146	7519	9347	7796	9271	1156	-306	362	743	667	-0.01	0.00	0.00	62	1	20.0
37689.00	-32044	270365	254198	10714	8478	7265	8928	1098	-143	348	660	598	-0.01	0.00	0.00	62	1	25.0
37694.00	-32281	272154	252574	11393	8194	7185	9121	1059	62	372	601	552	0.00	0.00	0.00	62	1	30.0
37699.00	-31342	274150	254074	12243	8210	7278	9334	1047	317	434	564	527	0.00	0.00	0.00	62	2	4.0
37704.00	-29108	276586	229380	17862	8318	7384	9366	1057	573	550	545	518	0.00	0.00	0.00	62	2	9.0
37709.00	-25611	279653	214240	10642	8416	7461	9347	1068	827	666	537	514	0.00	0.00	0.00	62	2	14.0
37714.00	-20817	283114	219480	11220	8464	7492	9427	1071	1093	705	533	512	0.00	0.00	0.00	62	2	19.0
37719.00	-14677	286589	210616	14021	8452	7460	9601	1064	1361	677	531	510	0.00	0.00	0.00	62	2	24.0
37724.00	-7249	289787	201093	12158	8377	7359	9712	1057	1603	591	529	510	0.00	0.00	0.00	62	3	1.0
37729.00	1238	292372	184350	18920	8226	7198	9648	1048	1775	430	529	510	0.00	0.00	0.00	62	3	6.0
37734.00	10359	293958	144085	16151	8008	6999	9281	1061	1860	191	532	513	0.00	0.00	0.00	62	3	11.0
37739.00	19703	294182	135859	11695	7778	6832	8937	1059	1864	-110	534	514	0.00	0.00	0.00	62	3	16.0
37744.00	28920	292825	124880	15382	7595	6736	8758	1051	1821	-432	535	513	0.00	0.00	0.00	62	3	21.0
37749.00	37909	289882	103312	14457	7502	6725	8715	1052	1775	-741	535	512	0.00	0.00	0.00	62	3	26.0
37754.00	46609	285491	91127	14950	7515	6795	8858	1050	1692	-1005	533	511	0.00	0.00	0.00	62	3	31.0
37759.00	54727	279979	50161	21831	7608	6910	9075	1057	1547	-1180	531	511	0.00	0.00	0.00	62	4	5.0
37764.00	62031	273879	16832	13929	7753	7056	9367	1061	1374	-1241	532	513	0.00	0.00	0.00	62	4	10.0
37769.00	68460	267674	4182	15127	7924	7215	9638	1071	1198	-1238	534	515	0.00	0.00	0.00	62	4	15.0
37774.00	74020	261537	-23613	17384	8118	7374	9890	1086	1027	-1214	537	517	0.00	0.00	0.00	62	4	20.0
37779.00	78745	255555	-46175	14283	8330	7535	10221	1089	863	-1179	538	519	0.00	0.00	0.00	62	4	25.0
37784.00	82662	249742	-72759	20636	8531	7678	10501	1088	705	-1149	537	519	0.00	0.00	0.00	62	4	30.0
37789.00	85839	244013	-123809	18584	8681	7778	10605	1100	573	-1152	537	521	0.00	0.00	0.00	62	5	5.0
37794.00	88451	238152	-142625	13592	8764	7833	10671	1108	475	-1198	539	522	0.00	0.00	0.00	62	5	10.0
37799.00	90609	231934	-161707	16548	8791	7859	10772	1096	388	-1302	542	522	0.00	0.00	0.00	62	5	15.0
37804.00	92332	225052	-185793	14260	8777	7839	10705	1090	302	-1453	544	522	0.00	0.00	0.00	62	5	20.0
37809.00	93654	217437	-194205	13620	8741	7768	10424	1092	231	-1585	545	524	0.00	0.00	0.00	62	5	25.0
37814.00	94664	209319	-220343	17467	8690	7669	10029	1102	173	-1647	545	527	0.00	0.00	0.00	62	5	30.0
37819.00	95418	201085	-229873	8672	8629	7585	9787	1109	134	-1637	546	529	0.00	0.00	0.00	62	6	4.0
37824.00	96025	193061	-213224	8640	8571	7555	9913	1103	108	-1557	547	529	0.00	0.00	0.00	62	6	9.0
37829.00	96489	185552	-204473	9258	8537	7580	10266	1093	75	-1453	547	526	0.00	0.00	0.00	62	6	14.0

2567 records not shown

50669.00	144736	502347	4789774	14781	175	64	285	361	2245	-1791	144	104	0.00	0.00	0.00	97	8	9.0
50674.00	155366	492270	4723434	11584	128	73	147	247	2044	-2106	139	108	-0.04	-0.06	0.01	97	8	14.0
50679.00	165060	481598	4655190	17074	186	79	140	258	2018	-2301	150	114	-0.05	-0.02	0.00	97	8	19.0
50684.00	176724	470196	4565131	15520	229	86	178	309	2510	-2013	155	115	-0.01	0.00	0.01	97	8	24.0
50689.00	188062	461603	4497820	13096	202	94	184	276	2182	-1774	154	118	0.00	-0.03	0.00	97	8	29.0
50694.00	200236	452688	4425792	16066	155	79	88	291	2511	-1834	151	114	-0.11	-0.35	0.03	97	9	3.0
50699.00	209642	440850	4347076	14849	210	77	204	266	1506	-2650	150	112	-0.01	0.01	0.00	97	9	8.0
50704.00	216473	428209	4274797	16383	199	74	133	248	950	-2151	151	109	0.00	-0.02	0.00	97	9	13.0
50709.00	218645	416732	4168482	24498	201	82	196	296	472	-2476	160	111	-0.02	-0.23	0.03	97	9	18.0
50714.00	221366	404116	4063712	17609	171	83	154	275	220	-2829	151	110	-0.03	-0.02	0.01	97	9	23.0
50719.00	221020	388160	3973379	19709	217	95	225	282	-37	-3113	151	121	0.01	-0.17	0.03	97	9	28.0
50724.00	221691	373356	3872409	20564	190	96	236	295	224	-3185	151	118	-0.01	-0.05	0.00	97	10	3.0
50729.00	222484	359766	3776816	18254	130	63	68	233	17	-2366	147	105	-0.05	-0.23	0.01	97	10	8.0
50734.00	223758	347284	3671383	24746	191	89	235	277	563	-2616	151	116	0.00	0.00	0.00	97	10	13.0
50739.00	225979	333738	3545583	22553	216	93	142	248	411	-2990	152	119	0.00	0.00	0.00	97	10	18.0
50744.00	228131	319961	3449536	17569	137	85	168	281	-158	-2573	147	114	-0.04	-0.07	0.04	97	10	23.0
50749.00	223955	305570	3356574	20154	158	92	230	325	-1449	-3165	145	117	-0.03	0.01	0.00	97	10	28.0
50754.00	217571	289547	3251589	21344	255	86	122	306	-743	-2619	156	114	0.00	0.00	0.00	97	11	2.0
50759.00	214762	278114	3146309	23172	194	61	166	269	-595	-2250	143	101	0.00	-0.01	0.00	97	11	7.0
50764.00	210134	266149	3018860	26179	137	65	83	283	-1446	-2564	147	106	-0.07	-0.30	0.02	97	11	12.0
50769.00	202879	254713	2913593	16347	179	69	184	258	-1192	-2150	143	107	0.00	0.00	0.00	97	11	17.0
50774.00	195975	242568	2834082	16094	210	87	131	252	-1722	-2924	146	117	0.00	0.00	0.00	97	11	22.0
50779.00	185853	230220	2752783	15748	165	92	206	305	-2370	-1800	158	118	-0.07	-0.11	0.01	97	11	27.0
50784.00	173747	221199	2680532	13833	193	92	163	280	-2058	-2068	155	119	-0.03	-0.07	0.00	97	12	2.0
50789.00	163906	212037	2599668	20529	192	98	119	334	-2321	-1785	149	122	0.00	0.00	0.00	97	12	7.0
50794.00	153591	203547	2490345	19819	189	93	110	237	-1823	-1495	144	119	-0.01	0.00	0.00	97	12	12.0
50799.00	141186	193968	2408691	14611	129	79	59	199	-2457	-1935	140	113	-0.10	-0.36	0.07	97	12	17.0
50804.00	129476	188107	2329678	16773	170	109	163	261	-2863	-1386	145	125	0.00	0.00	0.00	97	12	22.0
50809.00	115381	180024	2248514	14271	202	117	243	360	-2630	-1445	153	127	0.00	-0.01	0.00	97	12	27.0
50814.00	102429	174626	2181370	14867	172	100	271	370	-2373	-874	154	123	-0.05	-0.09	0.00	98	1	1.0

JPL Kalman Earth Orientation Series: POLE97 11-MAR-98 IERS Series Designator: EOP(JPL) 98 C 03

MJD	PMX	PMY	XSIG	YSIG	XDOT	YDOT	XDSIG	YDSIG	COR	YEAR	MO	DAY
	(10**-6 arcsec)		(10**-6 arcsec)		(10**-6 arcsec/day)				XY			
15039.67361111	-724	-1182	19449	16053	604	-1293	730	689	0.00	1900	1	20.7
15070.11111111	96	-33639	19195	15896	-458	-806	728	687	0.00	1900	2	20.1
15100.54861111	-22697	-51267	19130	15864	-951	-425	725	686	0.00	1900	3	22.5
15130.98611111	-52886	-62290	19129	15861	-939	-317	725	685	0.00	1900	4	22.0
15161.42361111	-76651	-70537	19119	15862	-599	-184	725	685	0.00	1900	5	22.4
15191.86111111	-90700	-71740	19105	15865	-402	147	725	685	0.00	1900	6	21.9
15222.29861111	-103320	-60259	19100	15866	-437	590	725	685	0.00	1900	7	22.3
15252.73611111	-116022	-36718	19106	15864	-343	928	725	685	0.00	1900	8	21.7
15283.17361111	-121570	-6634	19115	15860	4	986	725	685	0.00	1900	9	21.2
15313.61111111	-115011	19465	19117	15858	429	668	725	685	0.00	1900	10	21.6
15344.04861111	-95915	32380	19109	15860	824	190	725	685	0.00	1900	11	21.0
15374.48611111	-68056	35153	19099	15862	927	147	725	685	0.00	1900	12	21.5
15404.92361111	-40010	43364	19096	15863	919	277	725	685	0.00	1901	1	20.9
15435.36111111	-13247	49853	19101	15861	834	197	725	685	0.00	1901	2	20.4
15465.79861111	12953	52212	19107	15859	922	-214	725	685	0.00	1901	3	22.8
15496.23611111	40547	31299	19109	15857	820	-1146	725	685	0.00	1901	4	22.2
15526.67361111	60506	-12942	19103	15858	510	-1633	725	685	0.00	1901	5	22.7
15557.11111111	69105	-65045	19096	15860	-81	-1783	725	685	0.00	1901	6	22.1
15587.54861111	51793	-114739	19093	15861	-1007	-1299	725	685	0.00	1901	7	22.5
15617.98611111	12989	-138878	19097	15859	-1461	-302	725	685	0.00	1901	8	22.0
15648.42361111	-33132	-136837	19102	15857	-1536	335	725	685	0.00	1901	9	21.4
15678.86111111	-79469	-121414	19103	15857	-1484	683	725	685	0.00	1901	10	21.9
15709.29861111	-121092	-92733	19099	15857	-1180	1274	725	685	0.00	1901	11	21.3
15739.73611111	-147208	-41925	19093	15859	-485	2063	725	685	0.00	1901	12	21.7
15770.17361111	-148791	28762	19091	15859	365	2457	725	685	0.00	1902	1	21.2
15800.61111111	-125921	102376	19094	15858	1138	2322	725	685	0.00	1902	2	20.6
15831.04861111	-78929	165424	19098	15857	1959	1717	725	685	0.00	1902	3	23.0
15861.48611111	-9266	200665	19099	15856	2525	512	725	685	0.00	1902	4	22.5
15891.92361111	68312	193353	19095	15857	2463	-1012	725	685	0.00	1902	5	22.9
15922.36111111	131939	140972	19091	15858	1557	-2334	725	685	0.00	1902	6	22.4

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1116 records not shown

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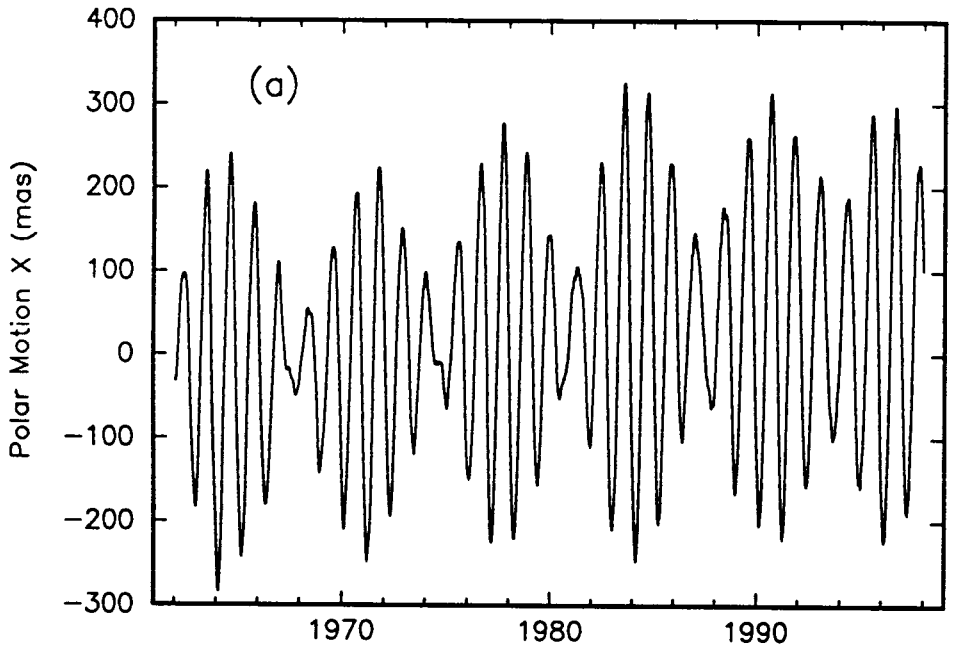
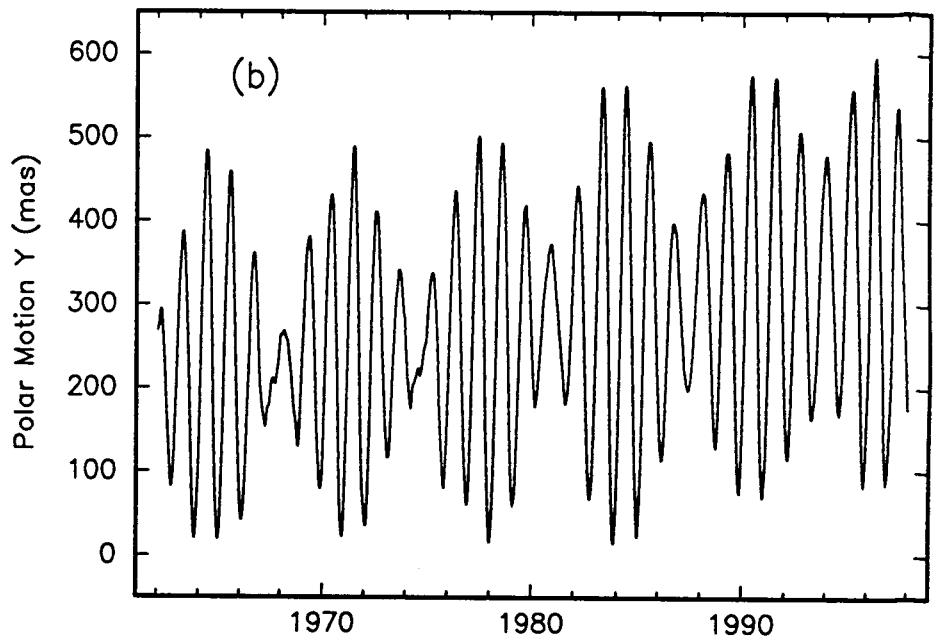
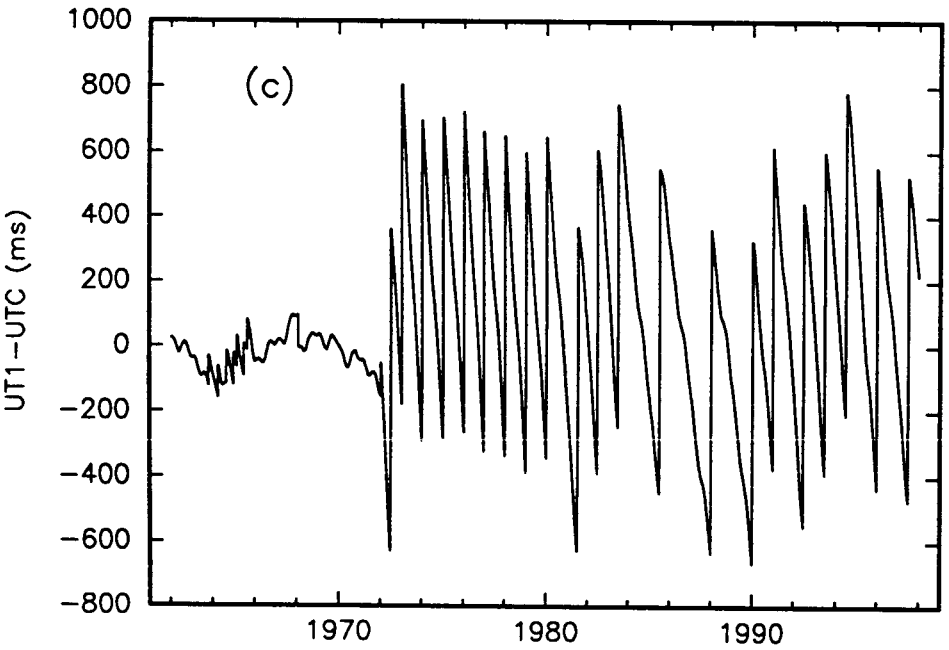
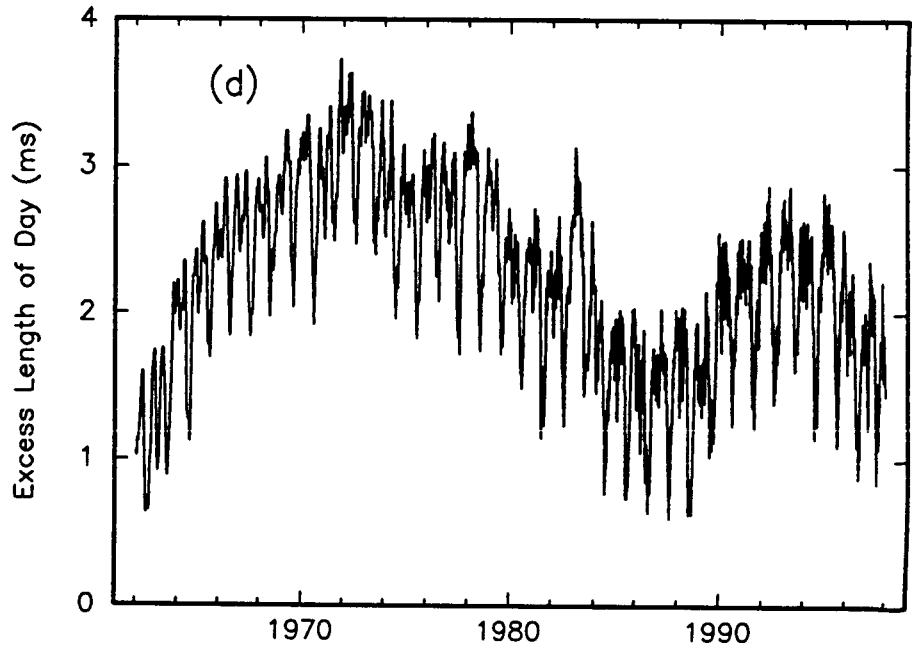
49921.04861111	287048	299102	130	106	-454	-3966	126	119	0.02	1995	7	23.0
49951.48611111	246237	190665	106	70	-2028	-2841	121	112	0.03	1995	8	22.5
49981.92361111	165438	118139	95	76	-3242	-1735	124	119	-0.04	1995	9	21.9
50012.36111111	60976	85491	152	75	-2964	-58	133	118	-0.23	1995	10	22.4
50042.79861111	-53097	96822	59	67	-4140	876	114	111	0.04	1995	11	21.8
50073.23611111	-157308	161185	113	109	-1884	3098	130	124	-0.03	1995	12	22.2
50103.67361111	-207484	255264	109	99	-1547	3526	133	119	0.00	1996	1	21.7
50134.11111111	-220951	365004	76	77	-479	3283	114	121	0.00	1996	2	21.1
50164.54861111	-176029	480291	166	114	1807	3290	132	116	-0.01	1996	3	22.5
50194.98611111	-94668	557979	107	126	3314	1998	117	128	0.01	1996	4	22.0
50225.42361111	22851	595223	99	77	4189	46	125	116	0.01	1996	5	22.4
50255.86111111	148738	566479	139	119	3939	-1388	133	128	-0.07	1996	6	21.9
50286.29861111	241609	488437	98	78	1267	-2929	137	111	0.02	1996	7	22.3
50316.73611111	293603	385031	96	67	1240	-3534	129	108	0.05	1996	8	21.7
50347.17361111	281912	263223	81	53	-590	-3228	120	103	-0.07	1996	9	21.2
50377.61111111	221114	165397	131	79	-2573	-2500	130	117	-0.02	1996	10	21.6
50408.04861111	122092	99570	115	71	-2851	-843	123	106	0.04	1996	11	21.0
50438.48611111	13703	90237	112	71	-2793	540	142	113	0.00	1996	12	21.5
50468.92361111	-79443	124603	119	83	-2727	2050	132	115	0.00	1997	1	20.9
50499.36111111	-155660	194253	156	82	-2137	2292	142	113	-0.01	1997	2	20.4
50529.79861111	-189597	295370	167	57	-62	3682	139	104	0.00	1997	3	22.8
50560.23611111	-173430	404894	163	66	770	3618	148	105	-0.01	1997	4	22.2
50590.67361111	-106738	490044	136	58	2354	2239	126	102	0.00	1997	5	22.7
50621.11111111	-16707	532780	156	48	4052	496	142	92	0.00	1997	6	22.1
50651.54861111	97330	524039	161	78	3548	-1119	150	113	-0.04	1997	7	22.5
50681.98611111	171683	474625	202	75	2439	-2331	154	110	0.00	1997	8	22.0
50712.42361111	220738	408343	236	75	551	-2530	157	116	0.00	1997	9	21.4
50742.86111111	228037	322820	112	68	330	-2462	147	110	-0.01	1997	10	21.9
50773.29861111	197159	244578	200	83	-1654	-2794	144	117	0.00	1997	11	21.3
50803.73611111	130225	188462	172	111	-2811	-1304	146	125	0.00	1997	12	21.7

COMBINED EARTH ORIENTATION SERIES: COMB97

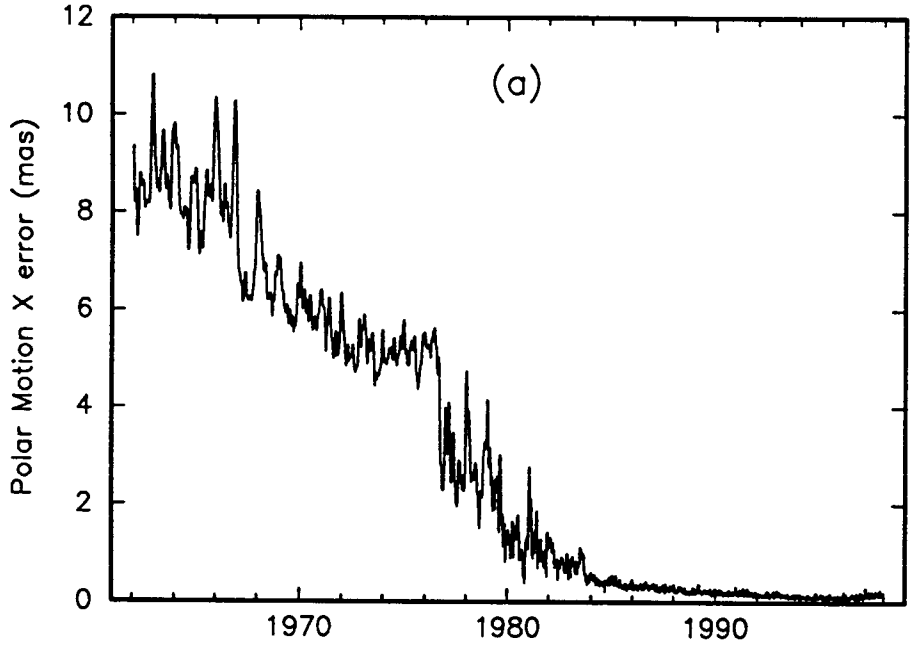


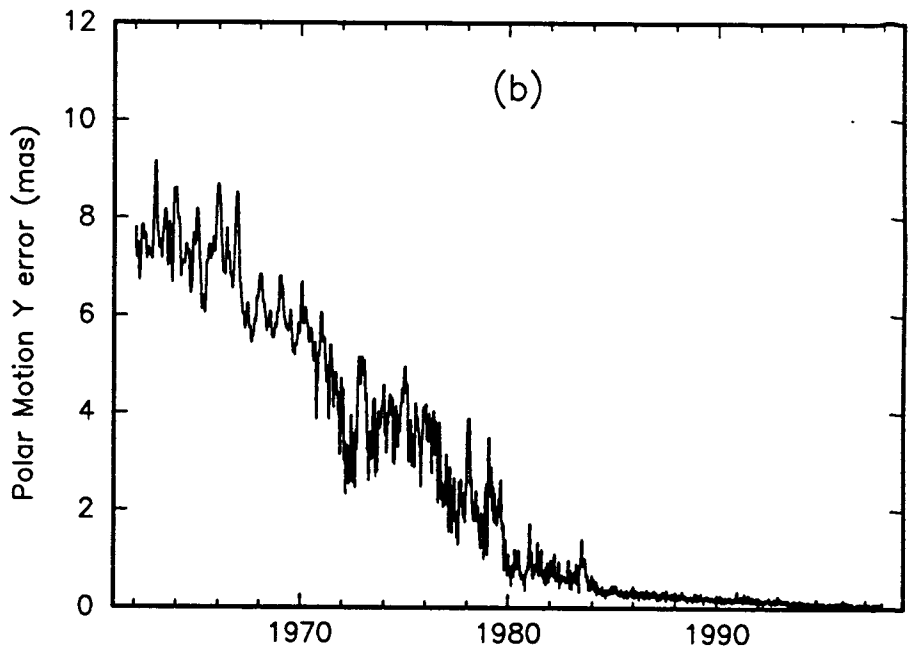


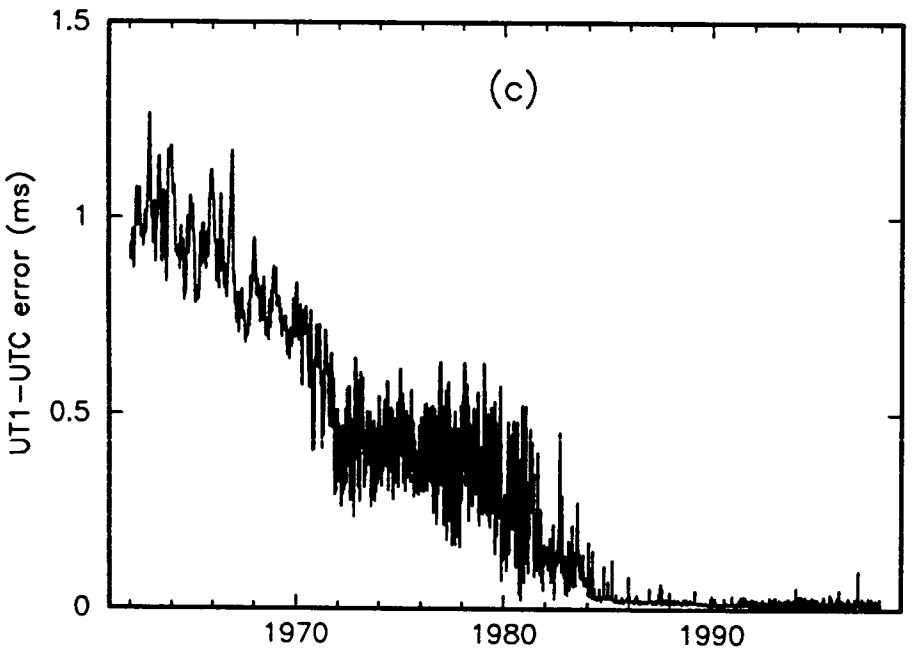


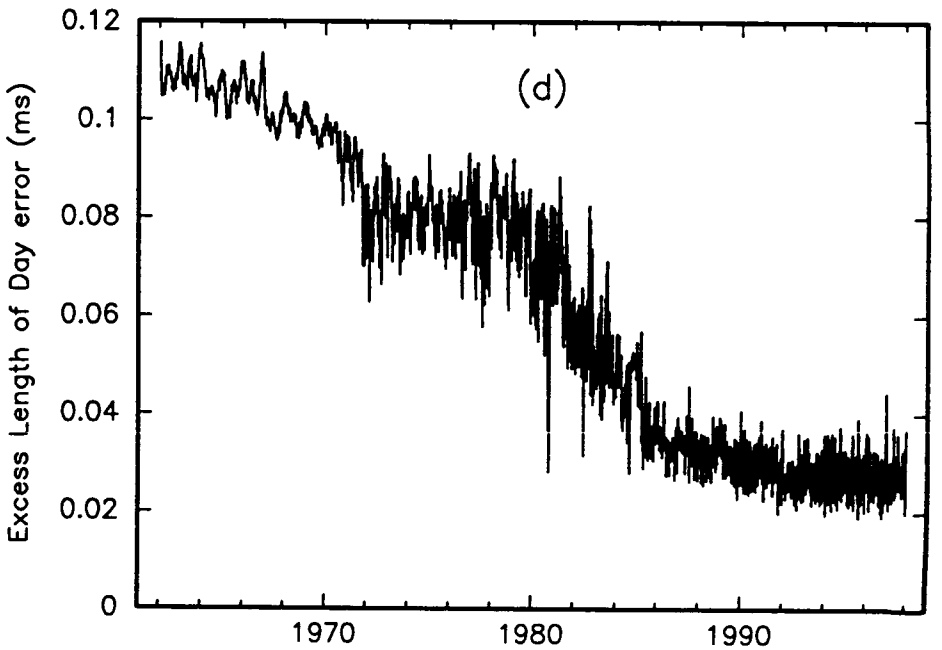


COMBINED EARTH ORIENTATION SERIES: COMB97









COMBINED EARTH ORIENTATION SERIES: POLE97