COMPARISON OF POLAR MOTION DATA FROM THE 1980 PROJECT MERIT SHORT CAMPAIGN

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ABSTRACT. Polar motion coordinates obtained during the MERIT short campaign by various techniques, as well as their variations, have been compared directly and through a smoothing procedure. In the direct comparison, values at selected dates were differenced in all combinations and the rms values computed. Through the smoothing procedure the amplitudes of the annual and Chandler motions as well as the centers of the polhodes were estimated and compared with predicted values based on the previous six years of polar motion data. The results are somewhat inconclusive, mainly due to the shortness of the campaign and the (practically) real time data reduction techniques. To resolve the issue of possible systematic differences, the proposed MERIT main campaign seems an absolute necessity.

1. INTRODUCTION

The short campaign of MERIT (a program of international collaboration to Monitor Earth Rotation and Intercompare the Techniques of observation and analysis) was held during the three-month period August to October, 1980. The participation was quite extensive and varied in techniques: 82 instruments from 22 countries provided classical astrometric data; the U.S. Defense Mapping Agency and GRGS (France) through the MEDOC network supplied Doppler satellite observations; 900 passes of Lageos and 780 passes of Starlette were observed from as many as 27 laser ranging stations and analyzed by SAO (Smithsonian Astrophysical Observatory, Cambridge, Mass.), CNES (Centre National d'Etudes Spatiales, Toulouse, France), UTX (University of Texas at Austin), and GSFC (NASA/Goddard Space Flight Center, Greenbelt, Md.; very long baseline radio interferometry at about ten stations around the world. Comparison of the above data set is the subject of this paper. Additional observations were made by connected-element radio interferometry at Green Bank, W.Va., and at Cambridge, U.K.; lunar laser ranging at the McDonald Observatory, Texas. Data from these techniques is not included in this comparison because they either did not provide continuous data throughout the campaign, or the data was not readily available through the

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Coordinating Center at the BIH in Paris.

2. PREDICTION OF POLAR MOTION

Based on the analysis of polar motion behavior, the possibility of predicting polar motion for a long time interval (1-2 years in advance) with sufficient accuracy has been found. The best estimated Chandler period is taken as constant, and six years of data are used to estimate the amplitudes, phases and ellipticity of the Chandler and annual motions. These estimated parameters are then used to predict the next year's (or next two years') polar motion. In making the prediction, possible linear trends are also taken into consideration.

The data used for prediction were those of the BIH, IPMS and DMA, from 1968 to 1980 (DMA from 1972 to 1980). Polar motions have been predicted for one year in advance and compared to smoothed observed ones: the mean rms of the differences (predicted minus observed) is about 0".02. Differences between relative polar motions are much smaller: for a time interval of 20-30 days, the rms difference is about 0".01 (30 cm) through the whole year. Compared with the best available VLBI results (from 1977 to 1980), the rms difference is only 0".013; and the rms difference of the relative polar motions (with time interval less than or equal to two months) is 0".008, both values being remarkably small.

The predicted polar motion can be used for geodetic purposes. It seems that the accuracy of the prediction is high enough for any practical purpose that requires real time polar motion up to an accuracy of, say, 50 cm. This would include rather sophisticated applications such as control of space probes. Details may be found in "Prediction of Earth Rotation and Polar Motion," by Y.S. Zhu, Dept. of Geodetic Science Rep., Ohio State Univ. (in press).

3. MERIT DATA INTERCOMPARISON BASED ON RAW DATA

The BIH has already analyzed the MERIT data using BIH Circular D as a reference. Since new techniques are expected to obtain better accuracies than now available from the BIH, it was thought that a mutual comparison may be more rational than using Circular D as a common reference. Both raw data and smoothed data were used.

3.1 Absolute Comparison

The standard errors of the five-day polar coordinate differences of each of the two Analyzing Centers were computed in all combinations with the following results:

	$\sigma_{\Delta x}$	$\sigma_{\Delta y}$	mean
DMA - MEDOC	0."040	0."044	0."042
CNES(Lageos) - CNES(Starlette)	0.031	0.053	0.042
SAO - CNES(Starlette)	0.040	0.036	0.038
Astrometry - SAO	0.022	0.025	0.024
Astrometry - DMA	0.022	0.025	0.023
Astrometry - UTX	0.019	0.026	0.023
DMA - SAO	0.010	0.011	0.011
UTX - SAO	0.014	0.012	0.013
UTX - DMA	0.014	0.010	0.012
SAO - CNES(Lageos)	0.009	0.014	0.012
UTX - CNES(Lageos)	0.010	0.017	0.014
SAO - Circular D	0.009	0.009	0.009
UTX - Circular D	0.011	0.013	0.012
VLBI - Circular D	0.014	0.008	0.012
VLBI - Astrometry	0.022	0.026	0.024
VLBI - SAO	0.008	0.007	0.008
VLBI - DMA	0.007	0.012	0.010
VLBI - UTX	0.015	0.005	0.012
VLBI - DMA (from daily values)	0.018	0.015	0.017

From the above values it is suggested that the standard errors are approximately 0."04 for MEDOC and for CNES(Starlette); 0."02 for classical astrometry; 0."008 - 0."01 for SAO, DMA, UTX, CNES(Lageos), and VLBI.

3.2 Relative (Variation of Polar Motion) Comparison

Relative polar motion comparison is used to detect possible systematic errors (other than a constant due to the difference of origins). Systematic errors will most likely be smaller in relative polar motion.

The standard deviations of polar motion variations are given below.

	$\sigma_{\delta\Delta x}$	$\sigma_{\delta\Delta y}$	mean
DMA - MEDOC	0."039	0."039	0."039
UTX - SAO	0.010	0.010	0.010
UTX - DMA	0.014	0.008	0.011
DMA - SAO	0.010	0.009	0.010
Astrometry - SAO	0.017	0.022	0.020
Astrometry - DMA	0.024	0.022	0.023
Astrometry - UTX	0.017	0.024	0.021
SAO - Circular D	0.005	0.004	0.005
UTX - Circular D	0.011	0.010	0.010

Since every σ_{Δ} is more or less larger than $\sigma_{\delta\Delta}$, it appears that there may be systematic errors among the Analyzing Centers. VLBI data was

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not used in this comparison because the data set taken between 27 September - 23 October 1980 was discontinuous between 4-16 October 1980.

4. MERIT DATA INTERCOMPARISON AFTER SMOOTHING

The above comparisons gave reason to expect systematic differences between the results of the earth rotation parameters as obtained from different techniques. A smoothing process was attempted to find the properties of these differences in terms of the amplitudes of the Chandler ($\sqrt{k_4^2 + k_5^2}$) and annual motions ($\sqrt{k_2^2 + k_3^2}$) and the centers of the polhodes (k_1 and k_6), using the following well known circular model:

$$x = k_1 + k_2 \cos A + k_3 \sin A + k_4 \cos C + k_5 \sin C$$

$$y = k_6 - k_2 \sin A + k_3 \cos A - k_4 \sin C + k_5 \cos C$$

where $A = 2\pi\ (\mathrm{MJD} - 42413)/365$ (annual frequency)
$C = 2\pi\ (\mathrm{MJD} - 42413)/435$ (Chandler frequency)

These coefficients are listed in Table 1 together with their predicted values obtained as explained in Section 2. The values of coefficients k_1 and k_6 were plotted on a graph with their standard deviations (see figure). They correspond to the x and y coordinates of the centers of the circles depicting the pole movement. This figure shows that systematic differences may exist in the pole origin. The tabulated amplitudes of the annual and Chandler motions indicate the same thing. The agreement between the predicted and SAO values is truly remarkable.

The relatively large standard deviations and the shortness of the data span naturally cast a shadow of doubt on the validity of these coefficients. For this reason another adjustment was performed in which the amplitudes of the Chandler and annual motions (coefficients k_2 - k_5) were constrained to their predicted values and only the coordinates of the polhode centers (k_1 and k_6) were computed. The results are in the last two columns of Table 1 and in view of the preliminary data set the agreement is remarkable. There seems to be very little evidence of systematic differences in the pole origin.

5. CONCLUSION

The data avilable for the MERIT Short Campaign as expected was not really sufficient to enable us to arrive at conclusive evidence regarding the systematic differences and their estimation. The noise level was also quite high; thus the importance of the intercomparison of data to be made available through the MERIT Main Campaign cannot be overemphasized.

All results in this paper were based on the data distributed during the campaign by the Coordinating Center at the BIH except for the GSFC

Table 1 COEFFICIENTS OF ANNUAL AND CHANDLER MOTIONS WITH THEIR STANDARD DEVIATIONS
All values are in milli-arcseconds.

	k_1	σ	k_2	σ	k_3	σ	k_4	σ	k_5	σ	k_6	σ	Motion Amplitude				k_1 [4]	σ	k_6 [4]	σ
													Annual[2]	σ	Chandler[3]	σ				
Prediction[1]	26	2	- 13	3	- 109	3	- 41	3	134	3	272	2	110	4	140	4				
Raw BIH	108	37	-264	183	- 317	188	87	215	526	222	285	36	426	163	533	222	35	6	321	6
DMA Doppler	36	30	-145	153	- 26	152	139	185	166	176	299	30	147	152	217	177	31	5	330	5
MEDOC Doppler	439	274	923	1372	-2391	1434	-2333	1657	1928	1669	585	272	2563	1423	3027	1621	69	14	274	13
CNES(Lageos) Laser	-118	96	492	472	668	476	- 107	542	-926	574	359	92	829	489	932	575	42	8	317	8
GSFC[5] Laser	- 47		-240		342		433		-187		266		418		471		34		314	
SAO Laser	17	26	- 76	134	84	134	147	159	- 6	159	249	26	113	134	147	159	35	3	284	3
UTX Laser	60	32	-400	132	- 241	164	271	159	511	191	231	27	467	148	579	175	17	5	300	6
NGS VLBI	- 10	7	- 87	38	245	35	215	44	-162	42	308	8	260	35	269	43	50	4	286	4

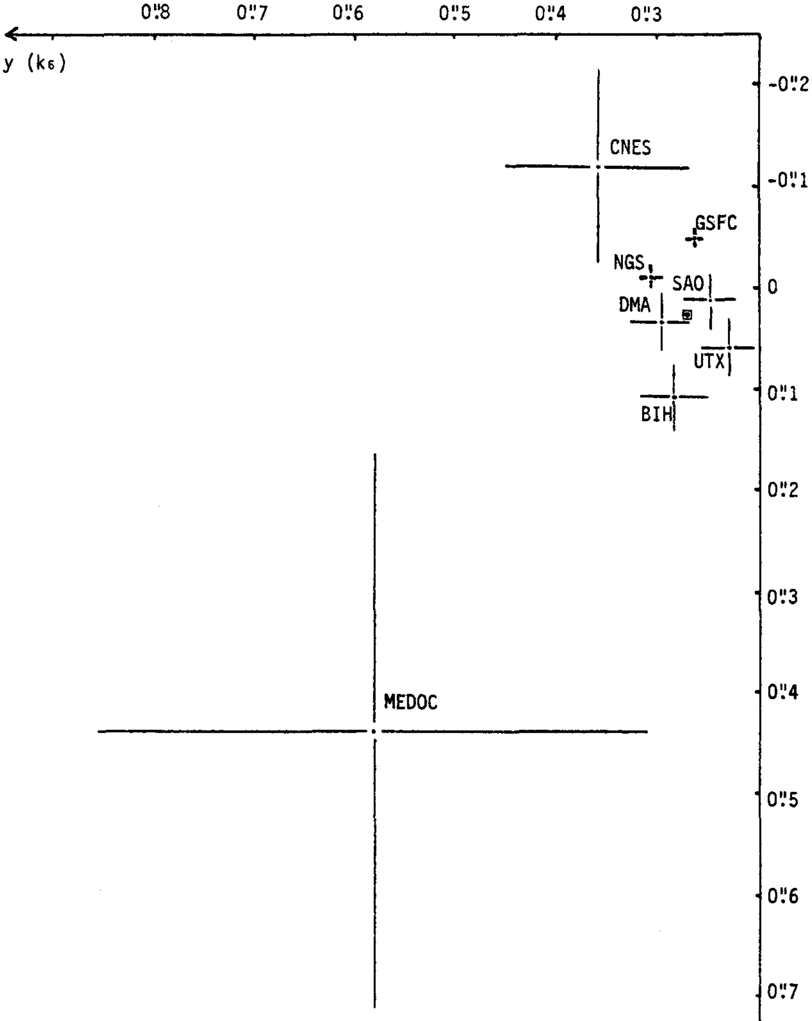
[1] See Section 2.

[2] $\sqrt{k_2^2 + k_3^2}$

[3] $\sqrt{k_4^2 + k_5^2}$

[4] Computed with k_2 - k_5 constrained to their predicted values.

[5] Standard deviations not given due to lack of such information on the data.



Relative Polhode Centers from the MERIT Short Campaign with Standard Deviations
⊠ predicted center

laser data and the VLBI information obtained from the National Geodetic Survey (NGS).

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PROGRESS REPORT ON PROJECT MERIT

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The origin, objectives and programme of Project MERIT, which is a special programme of international collaboration to Monitor Earth-Rotation and Intercompare the Techniques of observation and analysis, were described briefly at IAU Colloquium No. 56 (Wilkins, 1981). Further details of the project and reviews of the techniques to be used were published in a special report (Wilkins, 1980). The MERIT Short Campaign of observations was held during the period 1980 August 1 to 1980 October 31 and the preliminary results obtained will be published by the Bureau International de l'Heure in its Annual Report for 1980. The main objective of the campaign was to provide a realistic test of the operational arrangements that will be required during the MERIT Main Campaign in 1983/4. The first MERIT Workshop was held at Grasse on 1980 May 19-21 to review the operational aspects of the short campaign and to continue the planning for the main campaign. Some of the results obtained during the short campaign were presented on the following day at IAU Colloquium No. 63, and are reported in this volume. The proceedings of the Workshop will be published by the Working Group in a report that will also contain the principal results of the short campaign and information about the availability of the observational data.

Many observing stations and computing centres contributed to the short campaign. Observational data were obtained by classical astronomical techniques, by the doppler-tracking of satellites, by satellite and lunar laser ranging, and by connected-element and very-long-baseline radio interferometry. It is clear that the campaign stimulated extra and faster activity in both SLR and VLBI, and that these techniques are capable of providing results of much higher precision and at shorter intervals than those previously available. The campaign has also led to improvements in the quality of the data and in the speed of transmission of the results for the techniques that were already in regular operation. Each dataset has been analysed by at least two groups, and the attempts to understand the

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differences between the results has led to new exchanges of information about both the observational and the processing techniques. As a result the groups are better aware of the strengths and weaknesses of the different techniques and models that have been used. The importance of determining universal time and polar motion together has become apparent. Several groups obtained their first experience of the use of a computer-based communications network for the transfer of data between the coordinating centre (at the BIH in Paris), the operational centres and the analysis centres.

It was decided at the Workshop that the MERIT Main Campaign will take place between 1983 September 1 and 1984 October 31. This allows over two years for the upgrading of current equipment, for the procurement and commissioning of new equipment, and for the development of regular operating procedures for new networks. The campaign will provide an extremely valuable dataset for scientific analysis and a sound basis for recommendations about the future international service for earth-rotation. Special observations may be made to ensure that the terrestrial reference systems used by the various techniques may be accurately linked together to provide a firm basis for a new conventional Terrestrial Reference Frame based on a catalogue of station coordinates.

Project MERIT will continue to be organised through the informal cooperation of the participating groups under the general direction of a Steering Committee on which each technique is represented by a principal coordinator. Information about the further progress of the project will be issued from time to time in the MERIT Newsletter. The project has received the generous support and cooperation of scientists and organisations in many different countries. The progress made and results obtained since the project was first suggested three years ago have clearly demonstrated its value and viability, and, given the continuation and extension of this support over the next few years, there is every reason to believe that the project will achieve its scientific and operational objectives.

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