COMPARISON OF THE COORDINATES OF THE POLE AS OBTAINED BY CLASSICAL ASTROMETRY (IPMS, BIH) AND AS OBTAINED BY DOPPLER MEASUREMENTS ON ARTIFICIAL SATELLITES (DAHLGREN POLAR MONITORING SERVICE)

M. FEISSEL, B. GUINOT, and N. TATON

Observatoire de Paris and Bureau International de l'Heure

Abstract. Before combining the coordinates of the pole obtained by the Dahlgren Polar Monitoring Service (DPMS) with those of the Bureau International de l'Heure (BIH) we investigated the systematic differences between the two series and their relative weights.

1. Periodic Terms up to the Period 30 Days

For these short periods, the analysis is performed on the residuals between the raw data of the observations and a smoothed curve adjusted by fitting sine terms of periods 1 and 1.2 yr.

(a) The raw data of the BIH are obtained every 5 days from all the series of measures of the astronomical latitude and universal time (Guinot *et al.*, 1971). The aliased terms due to the Earth-tides, as well as those due to the diurnal nutation, do not appear in x and y: they affect only the common z term (Figure 1). It is surprising to find terms of semi-amplitudes 0.″006 with periods of 16.2 d for x and 15.5 d for y. No explanation was found for these terms. The standard deviations of one 5-day value of x or y is 0.″016 for x, 0.″014 for y.

(b) The raw data of the DPMS were given every 2 days for 1967/1968 and every day for 1969/1970 (Anderle, 1970). For the satellite 1967.48 A (data every 2 days), the analysis reveals two significant periodicities of 2.43 d. and 11.2 d., one being real, the other being its alias (Figure 2). The period of 2.43 d. is close to the period of the resonance term (order 13 harmonics): 2.41 d. It must be noted that, for the satellite 1967.92 A, a periodic term in x and y also appears with a period close to the resonance period: 2.23 d. Table I collects the results.

TABLE I

Satellite	Period of resonance (harmonic 13,13)	Observed periods in days		Observed semi amplitude in 0.″01	
		x	y	x	y
1967–92 A	2.23	2.27	2.27	1.2	1.9
1967–48 A	2.41	2.44	2.43	2.3	2.5

It is almost certain that the defects of the Earth's potential developments are responsible for these terms and also probably for a part of the noise of the spectrum and other lines which seem to be significant. The standard error of one 5-day value of x or y is about 0.″02 in 1970.

P. Melchior and S. Yumi (eds.), Rotation of the Earth, 104–111.

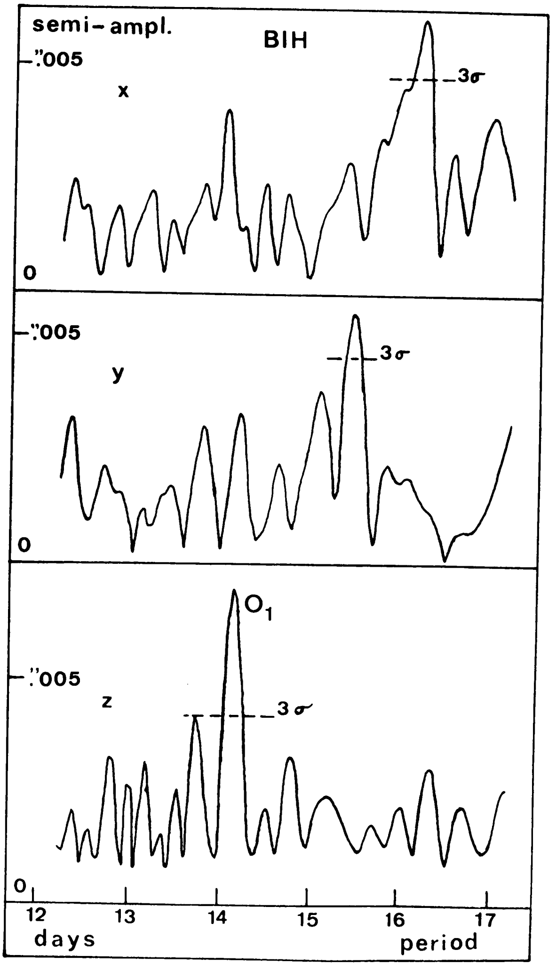

Fig. 1. Periodograms of the BIH coordinates of the pole and of the BIH z term.

2. Long Term Comparisons

In this section, the DPMS results are averaged for every 1/20th of a year and are compared with the corresponding data of the IPMS *(Annual Reports, Monthly Notes)* and of the BIH *(Annual Reports)*. The studies are made on the differences $D_1 = x_{\mathrm{DPMS}} - x_{\mathrm{BIH}}$, $D_2 = y_{\mathrm{DPMS}} - y_{\mathrm{BIH}}$, $D_3 = x_{\mathrm{DPMS}} - x_{\mathrm{IPMS}}$, $D_4 = y_{\mathrm{DPMS}} - y_{\mathrm{IPMS}}$. The periodograms of the D_i (Figure 3) show no salient features (above 3 $\sigma \approx 0''.012$), except broad lines with maxima between 1 and 1.2 yr, with semi-amplitudes of the order of 0''.03. As annual errors exist both in IPMS and BIH results (Figure 4), we tried to represent the D_i by annual terms (due to IPMS and BIH) and a periodic term with larger period due to DPMS. We found that this last term might be circular, with the same period and amplitude as the chandlerian wobble. The least squares

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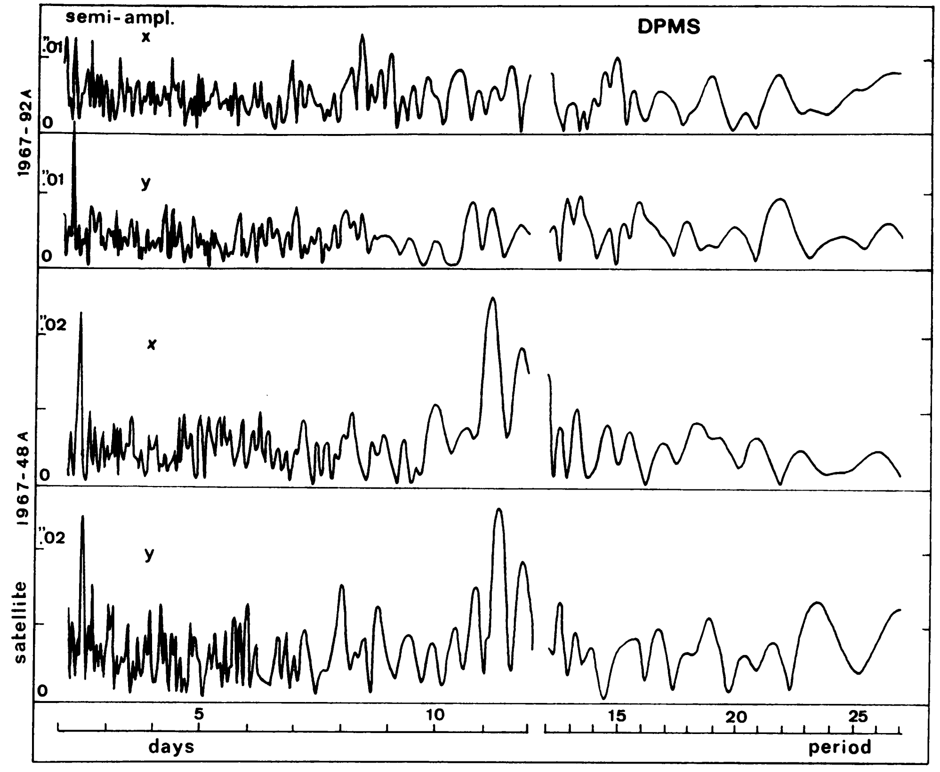

Fig. 2. Periodograms of the DPMS coordinates of the pole for the satellites 1967–48 A and 1967–92 A.

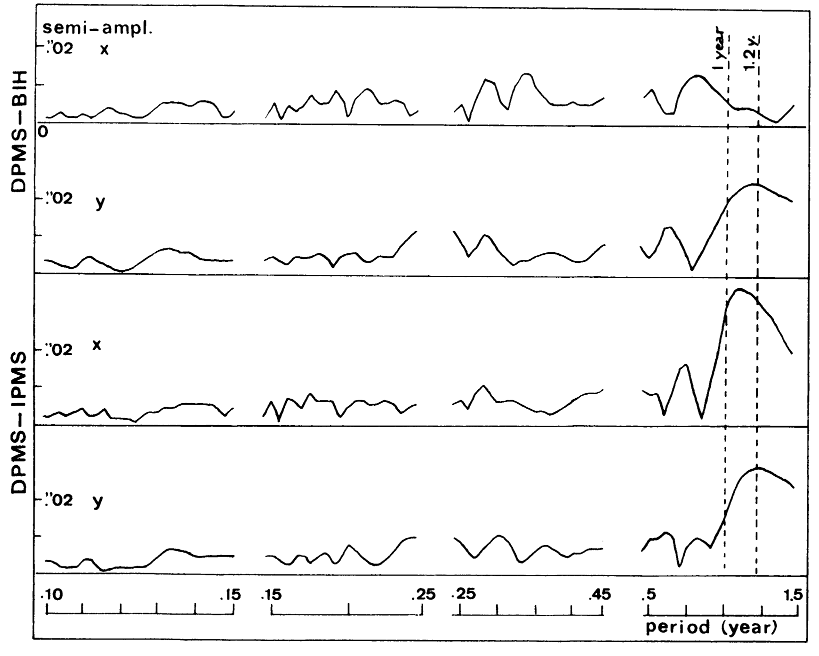

Fig. 3. Periodograms of the differences of the coordinates of the pole DPMS–BIH and DPMS–IPMS.

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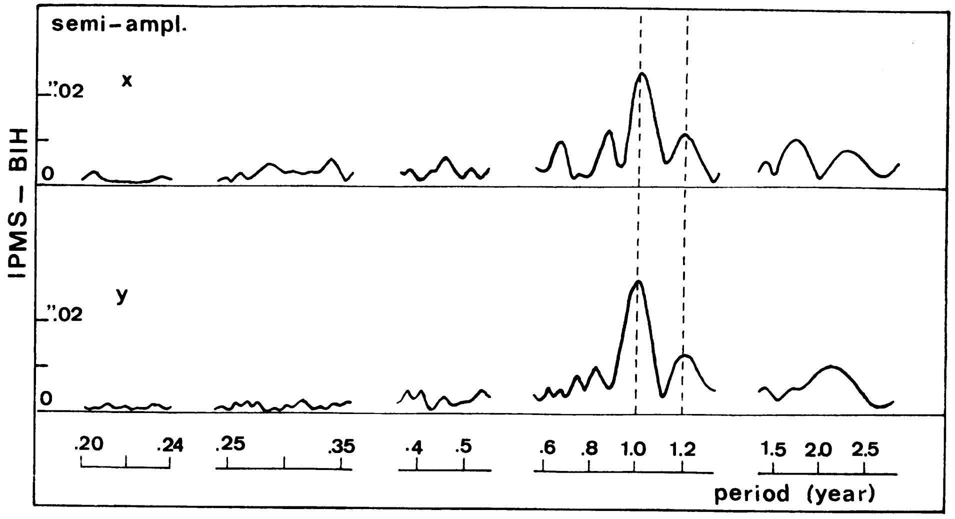

Fig. 4. Periodograms of the differences of the coordinates of the pole IPMS–BIH.

fitting of:

$$D_i = a_i + b_i \sin 2\pi (t - t_0) + c_i \cos 2\pi (t - t_0) + \\ + d \sin \frac{2\pi}{1.2} (t - t_0) + e \cos \frac{2\pi}{1.2} (t - t_0), \quad i = 1,3,$$

$$D_i = a_i + b_i \sin 2\pi (t - t_0) + c_i \cos 2\pi (t - t_0) + \\ + d \cos \frac{2\pi}{1.2} (t - t_0) - e \sin \frac{2\pi}{1.2} (t - t_0), \quad i = 2, 4,$$

(t and t_0 in years) leads to the following values of the coefficients:

	Annual terms DPMS-BIH						DPMS-IPMS						Term of period 1.2 yr	
	x			y			x			y			d	e
coef.	a_1	b_1	c_1	a_2	b_2	c_2	a_3	b_3	c_3	a_4	b_4	c_4		
Value (0".001)	+41	+16	−15	−68	0	−2	+30	0	+18	−74	−7	−25	+17	−3
error (0".001)	6	9	9	6	9	9	6	9	9	6	9	9	6	6

Moreover, although the phase of the circular term is poorly determined, it does not disagree with the phase of the Chandler wobble, so that the Chandler wobble of the DPMS should be 20% larger than the one of classical methods. It is interesting to note that the above representation of the D_i remains good in the second part of 1967 and for recent results (Figure 5). No explanation can be offered for these effects*. This possible correlation with the Chandler wobble is indeed very uncertain, but it is very probable that long term oscillations of about 0".02 of semi-amplitude exist in the DPMS data.

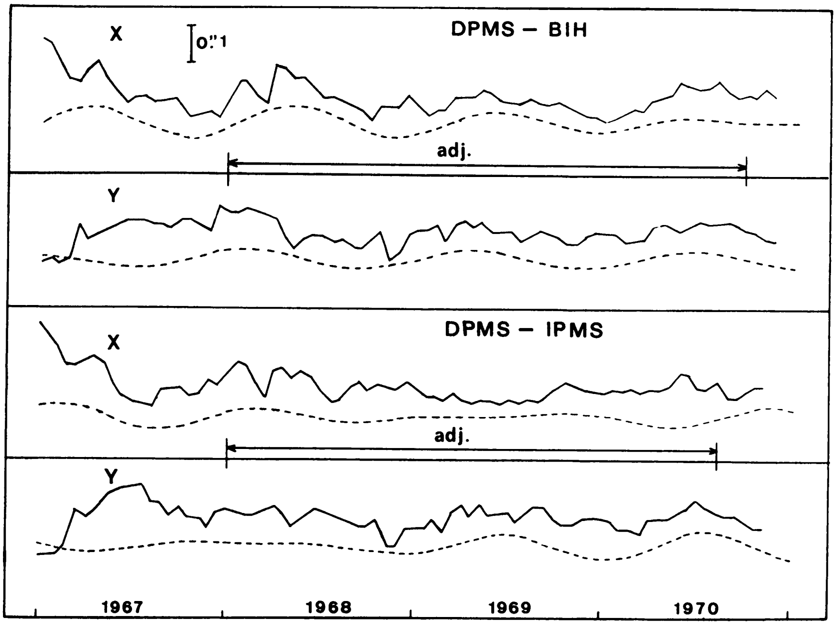

Fig. 5. Differences of the coordinates of the pole DPMS–BIH and DPMS–IPMS. The dashed curves are least square fittings (over the intervals indicated by 'adj.') of annual terms and of a common term with period 1.2 yr. The origins are arbitrarily chosen.

3. Introduction of the DPMS Data in the BIH Computations

The data of DPMS were first corrected for the empirical term of period 1.2 yr. They were then considered as latitude observations for two observatories with longitudes 0 and 90° W to which the usual methods of the BIH apply. A test was performed on the 1970 data (Figure 6). DPMS daily values of x and y were used. The following results apply to the *precision* of DPMS data, not to their *accuracy*:

(a) The standard errors published by DPMS are in agreement with those computed from the discrepancies with respect to the smoothed BIH results.

(b) The weight of one daily value of x or y from DPMS is about the same as the weight of the results in latitude obtained by one complete night of observations with the best PZT; however as the DPMS has no meteorological limitations, its results are equivalent to those of at least 3 PZT's for each coordinate.

* A preliminary investigation of the DPMS results in NWL 9 system show that these effects still appear.

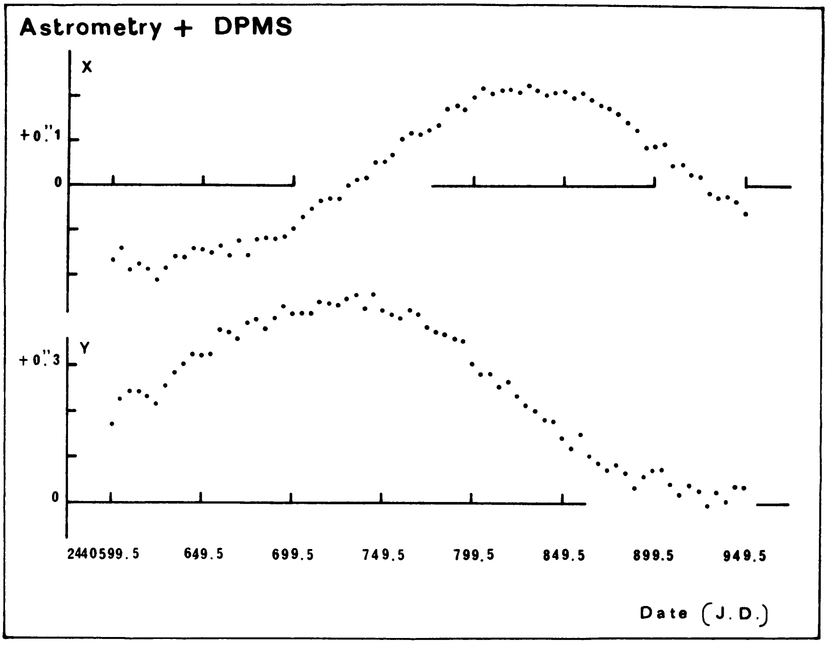

Fig. 6. 5-day values of x and y obtained with inclusion of DPMS in the BIH computations.

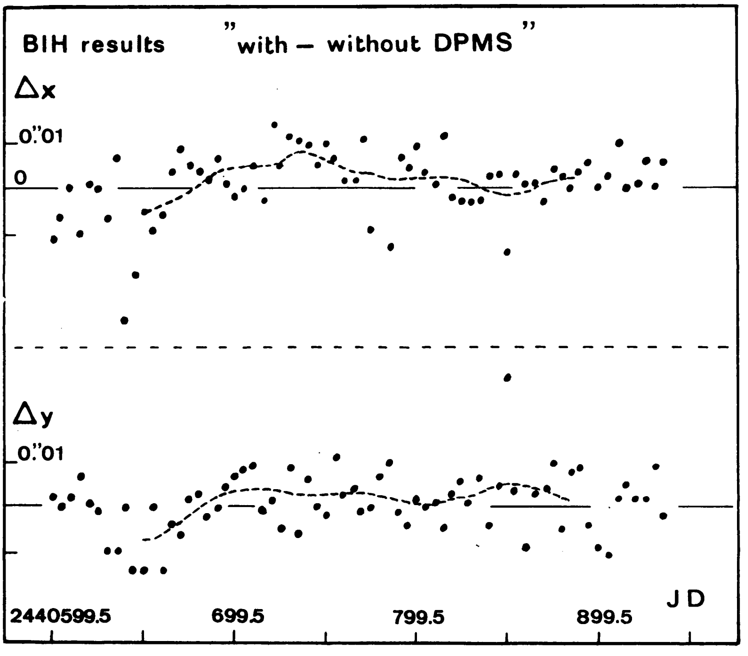

Fig. 7. Differences of the BIH results computed with and without DPMS. Dots are 5-day values, dashed curve, smoothed values.

(c) The standard errors of the 5-day values of x and y were first computed by the internal agreement of all the measurements made during the 5 days. They were found to be reduced by 1/1.13 (averaged value) when DPMS is added to the classical data. It is thus possible to deduce the relative precision of the DPMS and BIH coordinates of the pole (see below 'Conclusions').

(d) Figure 7 shows the differences of 5-day values of x and y obtained with and without DPMS. A smoothed curve of these differences is drawn (computed by adjustments of cubic over 21 points). The smoothed differences are of the order of a few $0\overset{''}{.}001$, but may exceed $0\overset{''}{.}005$ in some cases.

(e) The standard error of the 5-day values obtained after inclusion of DPMS may be computed from the deviations with respect to a smoothed curve. They are $0\overset{''}{.}010$ for x, $0\overset{''}{.}013$ for y. These values are almost equal to the ones computed from internal scattering, as explained in (c).

4. Conclusions

The *precision* of the DPMS results is about 45% the precision of the BIH results (obtained with all the classical astrometric instruments).

Some difficulties remain about the *accuracies*. Unexplained long term oscillations of about $0\overset{''}{.}02$ of semi-amplitude prevented the BIH from taking DPMS measures into account in the current computations. Short term oscillations exist also, but they do not affect seriously the results with the present time resolution of the BIH.

It is clear that satellite observation is one of the methods which could make obsolete the classical measurement of the polar motion in the future. However we stress the importance (1) of obtaining the new data on a regular basis and in homogeneous systems, (2) of comparing the data of various methods on a sufficiently long basis before taking any decision on the cessation of one type of observations (at least 6 yr).

References

Anderle, R. J.: 1970, NWL Technical Report TR 2432 (subsequent data were also used before the introduction of the NWL 9 system).

Guinot, B., Feissel, M., and Granveaud, M.: 1971, BIH Annual Report for 1970.

DISCUSSION

C. Sugawa: I analysed the annual and Chandler components for both DPMS and ILS during the same interval. For the Chandler motion, both results give nearly the same Chandler ellipses. But for the annual motion, the DPMS shows more elliptic motion. What do you think about this difference of the annual motion from both services?

B. Guinot: Annual errors, either due to star catalogues or to local effects, or both, exist on every time or latitude series. These errors strongly affect the annual motion of the pole as derived from classical astrometric observations. It is therefore not surprising that different combinations of the data show different annual motions.

H. Jeffreys: I was not very satisfied with my analysis covering 70 yr, and thought twice the time would be needed for great improvement. I consulted Andrew Young, who suggested 200 yr.

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P. Melchior: I think it is most dangerous to speak yet about any decision on the cessation of the optical observations we made since the beginning of astronomy. A strict minimum should be in my opinion 3 times the 6 yr interval, that is practically till the end of this century.

B. Guinot: To the comments of Melchior and Jeffreys: I indicated 6 yr as a minimum interval. I agree that a much larger overlap of classical and new methods is desirable.

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