IRREGULARITIES OF THE POLAR MOTION

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The independent series of coordinates of the pole obtained by the Defense Mapping Agency by observations of Transit satellites (DOP) and by the BIH using classical astrometry only (AST) are considered. They mainly differ by a periodic annual term. After removal of the mean annual difference from AST, the two series are compared. They show common and remarkable irregularities. A derivation of the excitation functions from DOP and AST shows also a good correlation. In the course of this study the constant improvement of DOP, which is now much better than AST, was noticed. The author expresses the opinion that the annual difference between DOP and AST is due to AST, which should therefore be calibrated against DOP.

1. INTRODUCTION

We will consider the irregularities of the polar motion which remain after filtering out the short term noise, up to about three months. The study of the independent series of pole coordinates obtained by classical astrometry and by Doppler observations of artificial satellites will show whether these irregularities are real or due to systematic errors in the observations or in their processing.

It is well known that classical observations of Universal Time and latitude are subject to annual errors. The semi-amplitude of these errors is typically of the order of 0.003s and 0".05, but cam reach 0.010s and 0".10, even for good instruments. This fact has to be taken into account when deriving the coordinates of the pole, x and y, from these observations and when comparing them with the data of other techniques.

2. THE COORDINATES OF THE POLE SUBMITTED TO THE STUDY

The data for astrometry (AST) are the coordinates of the pole of table 6 (until 1972.0) and 6B (after 1972.0) of the BIH Annual Report, where the Doppler data are not used for computing the raw 5-day values of x

D. D. McCarthy and J. D. Pilkington (eds.), Time and the Earth's Rotation, 279–285.

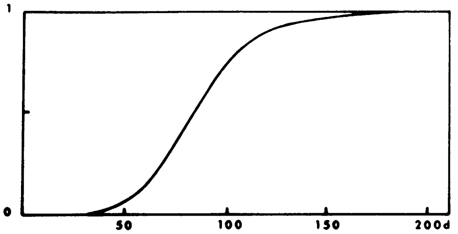

Figure 1. Relative amplitude of a sine wave after filtering, as a function of the period.

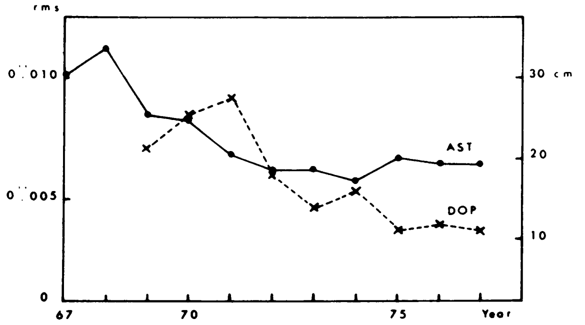

Figure 2. Rms differences between filtered and raw values.

and y. However, the Doppler data enter in the determination of the systematic corrections to astrometric measurements of latitude by the following amount:

until 1972.95	0%	for 1975	14%
for 1973	14%	" 1976	13%
" 1974	16%	" 1977	24%.

AST is therefore slightly dependent on Doppler, concerning the mean values of x and y and their annual variations. The 5-day raw values of Tables 6 and 6B are filtered using the Vondrak's method (Vondrak, 1969, 1977). Figure 1 shows the ratio of the amplitude of a sine wave after filtering to the one before filtering, as a function of the period, in the present study. Normal points for x and y are then interpolated for every 0.05 year (normal dates).

The rms differences between filtered and raw values at normal dates are of the order of 0".010 (for x and y) in 1967, then decrease to 0".007 until 1971 and remain fairly constant (Figure 2).

The data for Doppler (DOP) are the coordinates of the pole obtained by the Defense Mapping Agency (USA) from Doppler observations of Transit satellites. The bi-daily solutions are first averaged over 0.05 year intervals, any bias being avoided by the use of a model of the polar motion before averaging. Then a filtering with the Vondrak's method is applied with the same characteristics as for AST. The rms differences between filtered and raw values are shown in Figure 2. The progressive improvement of DOP is remarkable.

3. EXPRESSION OF AST AND DOP IN THE SAME SYSTEM

Table 1 gives the development of DOP - AST in constant, annual and semiannual terms for each year. The averages of the coefficients are

https://doi.org/10.1017/S0074180900036354 Published online by Cambridge University Press

Table 1. Annual developments of DOP - AST, in 0".001: (t in years)
DOP - AST = a + b sin 2πt + c cos 2πt + d sin 4πt + e cos 4πt.

	x					y				
year	a	b	c	d	e	a	b	c	d	e
1969	- 5	+ 9	- 6	+ 4	-16	+66	- 8	+ 2	+ 2	0
1970	- 7	+25	-22	- 5	+ 4	+14	- 4	+10	+14	+22
1971	- 1	+23	-11	- 3	- 7	-14	-26	-15	-11	+ 3
1972	- 9	+ 3	-21	-12	0	+ 4	+ 6	- 1	+ 5	+ 8
1973	-13	+ 7	- 6	- 5	- 5	- 8	+ 6	- 6	+ 5	+ 4
1974	-14	+ 8	-12	+ 1	+ 7	- 5	+ 9	- 1	- 1	- 2
1975	-24	+18	-22	- 5	+ 8	+ 2	+11	- 1	+ 2	- 4
1976	-27	+14	-25	- 9	+ 6	+10	+ 5	+ 5	- 5	+ 3
1977	-20	+16	-25	0	0	+ 7	+13	+ 4	+ 9	0
1972-77	-17.6	+11.0	-18.4	- 5.0	+ 2.4	+ 1.6	+ 8.4	0.0	+ 2.5	+ 1.7
st. dev.	2.8	2.4	3.2	2.2	2.0	2.9	1.3	1.6	2.0	1.8

computed over 1972-1977, eliminating the first data of DOP which were not homogeneous. The standard deviations agree fairly well with what can be expected from the uncertainties of DOP and AST, and there is little evidence of systematic variations. The expressions of Table 1, where a, b, ..., e are replaced by their mean values, are used as periodic annual corrections to express AST in the system of DOP.

Figure 3 shows the motion of the pole by AST, after correction. This motion is much more irregular from 1972.0 to 1978.0 than from 1967.0 to 1972.0. These irregularities are also found in DOP, as shown by some examples in Figure 4. Local, relatively small, curvatures appear in particular in 1972.60, 1972.85, 1975.00, 1976.35, 1976.65, 1977.25, in both AST and DOP. The time resolution is not sufficient to decide whether these local curvatures are the result of smoothing angular points. This is one of the reasons why more precise methods are needed.

4. EXCITATION FUNCTIONS OF THE POLAR MOTION

It was attempted to derive numerically the modified excitation functions for the motion of the pole (Munk and MacDonald, 1960), separately for DOP and AST. The normal values of x and y were derived using third order differences and the Chandler period was assumed to be 1.19 year. Figure 5 shows these functions, the signs being those used by Munk and MacDonald. They exhibit many common features, especially for ψ_2 which has larger variations than ψ_1. Remarkably large excitation in ψ_2 appeared in 1976/1977.

The modified excitation functions were computed since 1967.0, from AST, but in the system of DOP. Their values can be sent on request. Using

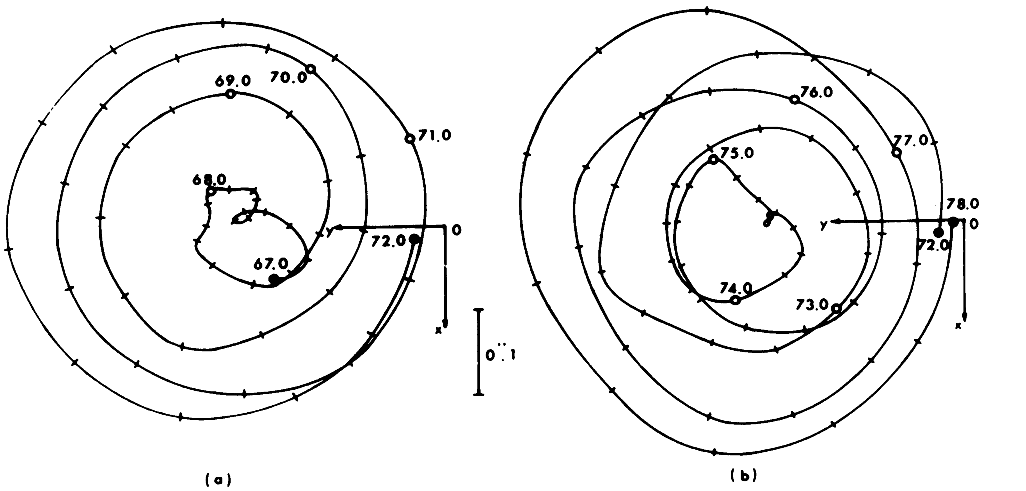

Figure 3. Motion of the pole from astrometry only.

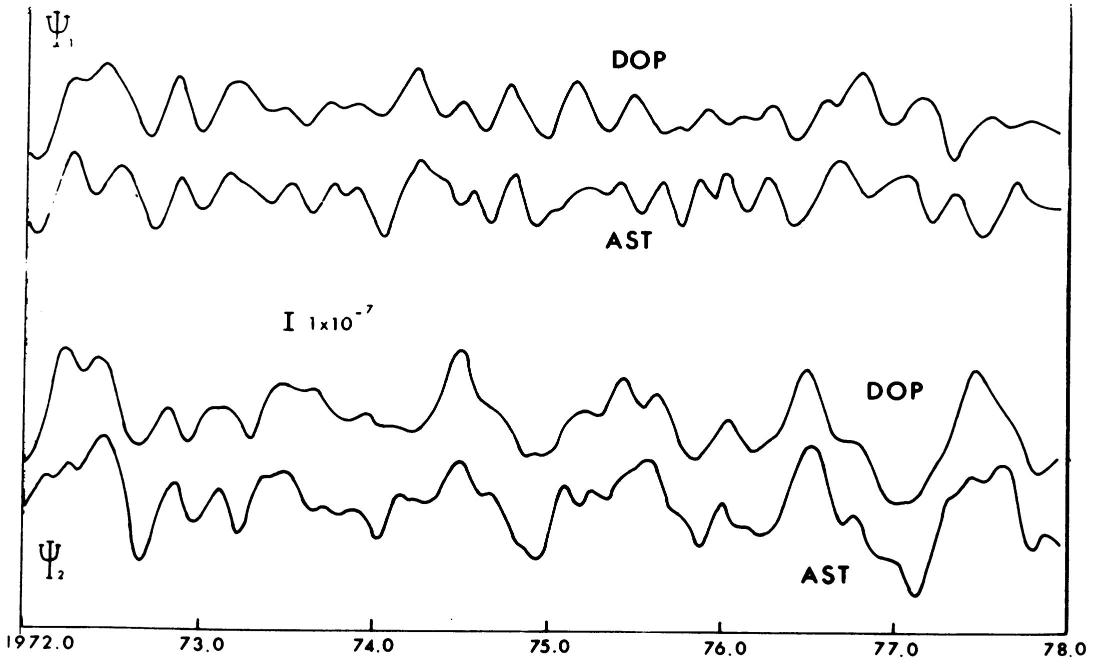

Figure 5. Excitation functions derived separately for Doppler and Astrometry.

as time argument the longitude of the Sun ʘ, the mean annual functions develop into (in units of 10^{-8}):

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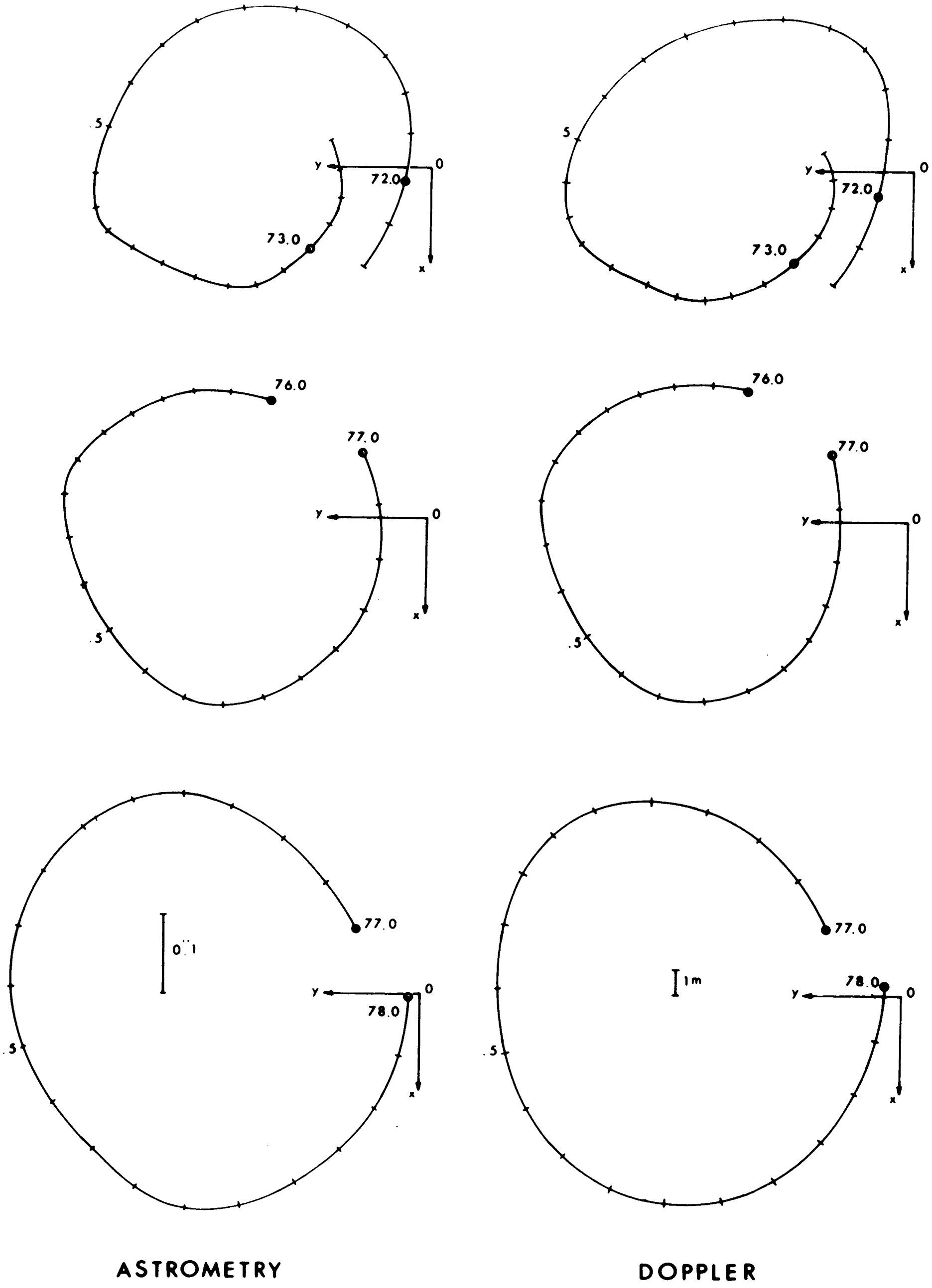

Figure 4. Examples of irregularities of the polar motion.

$$\psi_1 = 5.0 \cos\Theta + 0.1 \sin\Theta + 3.0 \cos 2\Theta + 2.2 \sin 2\Theta.$$
$$\psi_2 = 2.6 \cos\Theta + 13.1 \sin\Theta - 2.8 \cos 2\Theta - 1.0 \sin 2\Theta.$$

4. CONCLUSIONS

Concerning the geophysical aspects, we conclude that large and short-lived (less than a month) disturbances of the polar motion occur from time to time. The study of their fine structure justifies the efforts for obtaining more precise measurements. It was shown also that reliable values of the excitation functions of the motion of the pole can be found experimentally from the coordinates of the pole.

Concerning the operation of services dealing with the coordinates of the pole, we make the following remarks. The agreement of Doppler with astrometry is good, taking into account the specific annual errors of the latter. If the aim is to provide users with the best coordinates of the pole (and not to study some particular problems attached to each method), it is permissible to mix the data of these two sources, with the relative weights they deserve. The Doppler results are much more precise nowadays than the results derived from the whole set of 80 astrometric instruments; a fair weighting would give weights 3 to 4 to Doppler and 1 to astrometry. We also believe that the accuracy of Doppler results is better for the annual terms, and that it is at least as good as astrometry for the progressive variations. This opinion is based on the long-term consistency in positions of sites determined from Doppler observations (Anderle, 1975) and on the comparison with astrometry.

Therefore, astrometric measurements of the pole appear mainly as a safeguard against possible interruption of the Doppler data. It would be logical to calibrate the astrometric annual terms against Doppler. At the BIH, it was safer to wait until other techniques considered confirm the accuracy of Doppler results before doing so. But on account of the delays in the implementation of new techniques and the constant improvement of the Doppler results, the question arises whether the astrometric system should be immediately converted into the Doppler system.

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DISCUSSION

Ya. S. Yatskiv: When calculating the excitation function, did you use the complex Chandler frequency?

B. Guinot: No. I used the real value of the Chandler frequency.

S.K. Runcorn: It is important for the geophysicist to know what is the minimum disturbance, in amplitude and time scale, which would be definitely detected by present techniques.

B. Guinot: I have not attempted to find the minimum disturbance which is observable, because it depends on the duration of the disturbance.

A.R. Robbins: You said that if Doppler satellites would continue operating for ever then astronomical observations could be discontinued. How about maintaining the reference frame?

B. Guinot: The classical observations do not seem better than Doppler for maintaining the reference frame. They are affected by changes in the location of instruments, and by changes of programs. Even in the case of the ILS organization, a spurious drift of the pole is suspected by many authors. The spurious drift of the Doppler pole does not appear worse.

F.P. Fedorov: Can you say something about the secular term, or is the interval of concurrent classical and Doppler observations too short?

B. Guinot: Precise comparisons have been made only from 1972; the interval is too short.