POLAR COORDINATES AND UT1 - UTC FROM PZT OBSERVATIONS

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1. INTRODUCTION

Use of new techniques (Doppler, laser, VLBI) has yielded such results that many astronomers believe that in the near future these techniques will replace classical instruments for observations of the Earth's rotation. None of the modern techniques has furnished observational series which demonstrate that systematic errors in the polar coordinates and UT1 are stable over sufficiently long intervals. Investigations of known phenomena such as sudden changes of the secular term in UT1 - UTC (Munk and MacDonald, 1960), changes of the amplitude and phase of the seasonal irregularities (Fliegel and Hawkins, 1967; Pavlov and Staritzin, 1962), secular motion of the mean pole (Mihailov, 1971; Markowitz, 1960), continental drift (Stoyko, 1938; Djurovic, 1976), quasi-diurnal nutation of Molodenskij (Popov, 1963; Toomre, 1974; Rochester et al., 1974), etc., are complicated by the existence of systematic error variations (accuracy), and to a smaller degree, on the accidental errors (precision). The BIH and IPMS make use of individual series of astronomical latitude, ϕ_i, and (UT0 - UTC)$_i$ from up to 82 classical instruments (Guinot, 1976). If the systematic errors in these series are independent, the polar coordinates and UT1 - UTC determined from a combination of observational series would result in an improvement of accuracy by at least one order of magnitude through the mutual compensation of the variation in systematic errors. At present, however, it is uncertain whether mutual independence of modern observations (a basic condition for mutual compensation of errors) will be better than that of the classical instruments.

Accordingly, the continuation of parallel observations by new and classical techniques remains indispensable as long as there is no definite proof that x, y, and UT1 - UTC obtained by the new techniques are more homogeneous than the results achieved by classical methods.

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2. POLAR COORDINATES AS OBTAINED BY THREE TYPES OF INSTRUMENTS

Observational data used for the computation of x and y are the instan-
taneous latitudes, ϕ_i, observed in the period 1967–1971 and communicated
to the BIH by 42 observatories. Table A of a previous paper (Djurovic,
1975a) lists the observatories considered. The polar coordinates are
computed according to methods described previously (Djurovic, 1975a;
Djurovic, 1975b). The only difference is that the computations are car-
ried out separately for three types of instruments (astrolabe – A,
photographic zenith tube – PZT, and zenith telescope – lz).

Yearly means of the differences of our results and the corresponding re-
sults of the IPMS, smoothed using Vondrak's method, $\Delta x = x - x(\text{IPMS})$ and
$\Delta y = y - y(\text{IPMS})$ are given in Table 1. Variations of the differences,
$\Delta x(\text{PZT})$ and $\Delta y(\text{PZT})$, appear somewhat larger than those of the other two
types of instruments. This is explained by the fact that the number of
PZTs (8) are lower than that of the astrolabes and zenith telescopes.
With 15 PZTs in operation in 1975 it is surely possible to attain a
stability of $\pm 0\overset{''}{.}01$. The same conclusion results from the analysis of the
stability of the reference system by the Wilcoxon method (Djurovic, 1978).

The second important condition satisfied by x(PZT) and y(PZT) is that
their deviations from x(IPMS) and y(IPMS) do not contain periodic terms
with periods close to that of the Chandler or annual period as, for
example, $\Delta x = x(\text{BIH}) - x(\text{IPMS})$. Standard deviations ε_x and ε_y for the
PZT solutions are somewhat less than those for the BIH coordinates, but
it should be kept in mind that the former are associated with 20-day
intervals while the latter are related to 5-day intervals. The values
for the period 1967–1971 are:

$$\varepsilon_x(\text{PZT}) = \pm 0\overset{''}{.}015, \qquad \varepsilon_x(\text{BIH}) = \pm 0\overset{''}{.}017,$$
$$\varepsilon_y(\text{PZT}) = \pm 0.014, \qquad \varepsilon_y(\text{BIH}) = \pm 0.018.$$

3. THE ACCURACY OF THE MEAN SYSTEM $(\text{UT1} - \text{UTC})_{\text{PZT}}$

Observational material used in the present analysis is from the obser-
vations of UT0 – UTC at 56 observatories reported to the BIH for the
period 1967–1974. All details of the data processing and of the mean
system $(\text{UT1} - \text{UTC})_u$ are set forth in a previous paper (Djurovic, 1975b).
For the observatories H, G, MS, MCP, N, TO, and W, whose series are un-
interrupted in the interval 1967–1974 we have computed a system of dif-
ferences,

$$d_{ij} = (\text{UT1} - \text{UTC})_{ij} - (\text{UT1} - \text{UTC})_u,$$

where $(\text{UT1} - \text{UTC})_{ij}$ is the result of observatory, i, on the night of
observation, j. From 1971–1974 three more observatories, CL, OS, and
RCP, were included. Mean values of d_{ij}, denoted by D_i, have been cal-
culated for 30-day intervals for each observatory, i. Two mean systems
of D_i were calculated: for the group of the first 7 observatories (Z),
and for the group of all 10 observatories (Z'). The results obtained
reveal that Z and Z' are varying within the limits of a few milliseconds.

They do not contain periodic components with periods close to the annual or semiannual terms which would impede the study of the seasonal irregularities in the Earth's rotation.

Table 1. Differences in the polar coordinates for different types of instruments.

	$\Delta x(A)$	$\Delta x(PZT)$	$\Delta x(LZ)$	$\Delta y(A)$	$\Delta y(PZT)$	$\Delta y(LZ)$
1967	-0".049	-0".032	-0".030	0".055	0".025	-0".009
1968	-0.044	-0.075	-0.016	0.056	0.034	-0.023
1969	-0.046	-0.086	-0.022	0.077	0.037	-0.014
1970	-0.047	-0.058	-0.010	0.088	0.062	-0.033
1971	-0.033	-0.034	-0.014	0.071	0.089	-0.026
mean	-0.044	-0.057	-0.018	0.069	0.049	-0.021

Accidental errors were estimated by the expressions:

$$\sigma^2 = \frac{1}{2(N-1)} \sum_{k=2}^{N} (Z_k - Z_{k-1})^2, \text{ and}$$

$$\varepsilon_i^2 = \frac{\sum_j p_{ij} (d_{ij} - D_i)}{\sum_j p_{ij}},$$

where k refers to the 30-day interval, and p_{ij} is the weight of d_{ij}. The results obtained for σ and ε (mean of ε_i) are $\sigma = \pm 0\overset{s}{.}0013$ (the corresponding values for Z' is $\sigma' = \pm 0\overset{s}{.}0011$), and $\varepsilon = \pm 0\overset{s}{.}0072$. Standard deviations of $(UT1 - UTC)_u$ (resolution interval is one day) and $(UT1 - UTC)_{BIH}$ (resolution interval of five days) are $\sigma_u = \pm 0\overset{s}{.}0027$ (Djurovic, 1975b), and $\sigma_{BIH} = \pm 0\overset{s}{.}0018$ (Guinot, 1976). From the comparison of σ and ε with σ_u and σ_{BIH} it appears that $(UT1 - UTC)_{PZT}$ is equivalent to the mean systems of $(UT1 - UTC)_u$ and $(UT1 - UTC)_{BIH}$ with respect to accidental errors.

4. CONCLUSION

With the present number of PZTs the accuracy of the BIH five-day mean of polar coordinates is greater than that obtained from a solution using PZTs only. The present accuracy can be attained with a PZT solution if a longer averaging period were used (approximately ten days).

As individual PZT systems of $(UT0 - UTC)_{ij}$ are more homogeneous than $(UT0 - UTC)_{ij}$ obtained from the observations of transit instruments and astrolabes (Djurovic, 1978), the mean system $(UT1 - UTC)_{PZT}$ is equivalent to the $(UT1 - UTC)_{BIH}$. The continuity of the classical observations of the Earth's rotation can be preserved by existing PZTs only.

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